MAINTENANCE OF EQUIPMENTS IN PULP & PAPER MILL

A DISSERTATION
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT
FOR THE AWARD OF THE DEGREE OF

MASTER OF ENGINEERING
IN
PULP & PAPER TECHNOLOGY

BY

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled "**MAINTENANCE OF EQUIPMENTS IN PULP & PAPER MILL**" in partial fulfillment of the requirement for the award of the Degree of **master of engineering** submitted at Institute of Paper Technology, Department of University of Roorkee, Saharanpur, is an authentic record of my own work carried out during the period from july 1992 to January, 1993 under the supervision of Mr. S.S.S. Govil, Reader (Mechanical Engineering at Institute of Paper Technology (University of Roorkee) Saharanpur.

The matter embodied in this thesis has not been submitted by me for the award of any other degree.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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I am highly indebted to Sri S.S.S.Govil for his invaluable guidance and co-operation throughout the course of this thesis which has helped me in completing this work successfully.

I would like to express my deep felt gratitude to Mr. Ashok Kumar, (Manager, Maintenance), Mr. K.K. Mohanan (Plant Engineer Pulp Mill) and Mr. Parameswaran (Plant Engineer Paper Machine) of Hindustan Newsprint Ltd. Kerla for their unfailing support in making this work successful.

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high density pump is used because it is economical to transfer high consistency pulp.

But the presence of tramp metal often blocks the pulp passage and causes damage to the impeller. This causes down time in CMP Plant.

Here a suggestion for improvement is the usage of Low consistency pump as a by-pass mechanism. This pump needs to be connected prior to the centricleaning section. Whenever the high density pump is in repair, this low consistency pump may be used for pumping pulp directly to the high density tower. This method has been described with the detailed cost calculations.

Unbleached Pulp Washer:

In the unbleached washer, the upthrust of the vacuum drum causes the leakage of water to the drive mechanism. The gear chamber and accessories often get flooded with water This causes the gears to be driven by higher torque for the rotaion of the drum. This results in drive failure. Besides this the frequent flooding in the gear chamber causes corrosion. The suggestions for improvement are:

- Higher H.P. motor should be installed to drive the washer drum replacing the present one.
- Mild steel gears need replacement by cast steel gears.

Paper Machine Section:

The down time may be sub-dividied under the following categories.

- Breakdowns
- Planned shut
- Improper functioning of machine parts
- All other reasons combined.

The breakdown on paper machine may be reduced by proper implementation of vibration measurements. The main problems on the paper machine are specifically with the dryers and the alender doctor blades. Here the blades used at present may e replaced by superior quality.

The complete maintenance system in the mill has been iscussed and improvements suggested.

Critical equipments like refiners and paper machine have een studied and the maintenance procedure usually adopted as been described in detail in the appendices.

ABSTRACT

An attempt has been made to study the various aspects of maintenance practices. The thesis entitled "**MAINTENANCE OF EQUIPMENTS IN PULP AND PAPER MILL**", mainly comprises of a case study in the Hindustan Newsprint Ltd., Kerala from where the practical data were collected and then the suggestions for improvement have been made.

Based on the data available from April 1991 to March 1992, the down time details for the chemi-mechanical pulp mill has been collected. The equipments that caused the maximum down time has been listed. These are: Raffinators, High Density Pump and Unbleached Pulp Washer.

The suggestions on reducing the down time have been made.

Raffinators:

In the case of Raffinator the seal rings called 'O' rings which prevent the mixing of oil in the bearings and the pulp in the refining chamber often fails without prior warning. On Analysing the frequency of failures it may be observed that the 'O' rings fail in six months duration. Since the 'O' rings are not very costly, they may be replaced every six months during a minor production break, to avoid precious down time, even if they remain perfect.

High Density Pump:

High density pump is used for pumping pulp at 10 % consistency from the thickener to the high density tower. Here a

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LIST OF ABBREVIATIONS

1.	CBM	Condition Based Maintenance
2.	CM	Cost of Maintenance
3.	CMP	Chemi-Mechanical Pulping
4.	CO	Cost of Operation
5.	CP	Chemical Pulping
6.	DKP	Double conical Press
7.	FAST	FAST Ferrographic Analysis Software Technology.
8.	FTM	Fixed Time Maintenance
9.	HD Pump	High Density Pump
10.	HNL	Hindustan Newsprint Ltd
11.	HP Shower	High Pressure Shower
12.	LP Shower	Low Pressure Shower
13.	LCC	Life cycle cost
14.	MDT	Mean Down Time
15.	MTTF	Mean Time to Failure
16.	MTTR	Mean Time to Repair
17.	MWT	Mean Waiting Time
18.	SPM	Shock Pulse Measurement
19.	Tup	Machine Up Time
20.	Tdn	Machine Down Time
21.	UW factor	Unplanned work - Wasted Time factor
22.	R_1, R_2, R_3	Raffinator number
23.	PM	Preventive maintenance

UNITS

1.	Cm	Centimeter (10^{-2}m)
2.	mm	Millimeter (10^{-3}m)
3.	lbs	Pounds (.48 Kg)
4.	psi	Pounds per Sq.Inch(.07 Kg/cm^2)
5.	ft	Foot (.30 m)

ADDITIONAL LIST OF ABBREVIATION

1.	EP Lubrication	Extreme Pressure type lubrication
2.	CI	Cost of investment
3.	Co	Cost of Operations
4.	CM	Cost of Maintenance
5.	CS	Cost of Downtime
6.	NY	Number of Years
7.	APPITA	Australian Pulp & Paper Industries Technical Association
8.	TAPPI	Technical Association of Pulp & Paper Industry.
9.	CPPA	Canadian Pulp & Paper Association
10.	Fig.	Figure

CHAPTER I

INTRODUCTION

In recent years we have witnessed a phenomenal growth of the world-wide chemical industries in general and pulp & paper industry in particular. Industry's appetite for sophisticated products continues to grow in spite of occasional stagnation. This increasing global demand for speciality products requires a corresponding increase in new constructions and plant expansions. The investments for new manufacturing facilities today has become staggering, and the daily financial penalty for having a plant "down" can at times be well in excess of Rs. 50 lakhs.[1]

Obviously, the plant maintenance responsibility has grown dramatically. No longer can the mill management afford a luxury of an inactive maintenance philosophy. Planned and tightly supervised maintenance is the only alternative to counter financial damage. In some cases it can be the deciding factor between making and not making a profit. Further there is an increasing awareness on the part of management that they can no longer determine the most economical type of maintenance on the basis of maintenance costs alone. Instead they must engage in active dialogue with their collegues on the production side to determine the "trade-off between slightly increased maintenance cost and considerably reduced profits through plant stoppage. To understand the value of maintenance the fig. 1.1 shows allocation of revenue in a modern newsprint plant.[1]

The primary function of the maintenance management is to keep a plant operating at maximum efficiency for a desired period of time. Here we define "plant" as meaning boilers, furnaces, pumps, pipings, raffinators, the complete paper machine, Instrumentation as well as buildings and grounds. While each of these component is important in its own way, items such as piping, valves, heat exchangers and strainers are easy to maintain. Nearly all journeymen craftsmen, whether staff or sub-contract can handle most normal maintenance. When it comes to the critical equipments, machinery which by economic necessity has no stand-by and which is in many instance is the very heart of the plant - maintenance supervision must continuously evaluate practical alternatives to ensure minimum down time.

CHAPTER 2

MAINTENANCE - DEFINITIONS

The term maintenance covers all activities undertaken by the plant to keep equipment in working condition or return it to that condition. Maintenance takes place in three categories.

- Corrective maintenance
- Preventive maintenance
- Predictive maintenance.

CORRECTIVE MAINTENANCE [1]

Corrective maintenance covers all maintenance which is carried out in order to correct a fault in the equipment.

Corrective maintenance has two classifications.

1. Unplanned corrective maintenance.
2. Planned corrective maintenance.

Unplanned corrective maintenance

It is the maintenance which cannot be planned eg. a break down. In this case work force, spare parts and technical documents must be planned simultaneously with the job and not beforehand. Unplanned correctve maintenance is often costly compared to planned maintenance. Breakdowns are unexpected and results in the loss of production and quality causing high direct costs. At the same time indirect costs are also increasing due to consequential damage caused by breakdowns. The workload for maintenance crew also increases.

Hence it is essential to have a large part of the corrective maintenance planned. In planned maintenance, what needs to be done on an equipment is already known. So getting spare parts, required documents and personnel is easier.

If maintenance is planned the maintenance stoppage can be integrated into production stoppage thus lowering the direct as well as indirect losses.

How to get unplanned repair jobs planned

By planning, the maintenance costs can be decreased, availability increased, the work load lowered and the quality of product bettered. But how unplanned jobs can be planned? Nobody has yet succeeded in planning without sufficient data. So it is important to find out the condition of equipment by detecting failures which are developing gradually.

Planned maintenance Schedule

Planned maintenance is done during any of the "maintenance windows".

Maintenance window refers to any plant stoppage for production reasons. Eg. in a paper industry wire changing and felt changing offers 15 to 20 minutes for small scale maintenance work.

In an integrated pulp and paper mill, the shut down in any other section also becomes a maintenance window. Consider the case of the fan-pump breakdown in paper section. This offers opportunity for changing the raffinator blades in the Chemi-mechanical section, if time is already due for that.

PREVENTIVE MAINTENANCE

In preventive maintenance the equipment is taken for maintenance in prefixed intervals to avoid breakdown.

If the cost of preparation for preventive maintenance is same as the cost of repair, preventive maintenance cannot be justified. But if on the other hand, the breakdown results in severe damage to equipment and a far more costly repair, the scheduled inspection should be considered.

Preventive Engineering: While most engineers keep their eyes open to details like better and longer life bearing and improved lubrication in their maintenance job, Preventive engineering goes a step further.

They investigate the breakdown and determine where the real effort is needed. Then through redesign, substitution changes and specification reduces the frequency of failure and cost of repair.

FIxed time maintenance (FTM)

When maintenance is done in a fixed time frame (time can be calender time, number of Kms etc). It is called fixed time maintenance. It is associated with all preventive maintenance schedules.

PREDICTIVE MAINTENANCE

This is the maintenance based on specific equipment related data obtained from transducers and supporting instrumentation. The major requirement include rotating equipments,like motors, pumps gear boxes, where m/c failure occurs frequently.

By having preplanned procedures scheduled and co-ordinated with the various equipment owners and executed by mechanical department, faster repairs can be executed. Only work indicated by analyzer check will be done and general level of machine availability is raised.

Condition based maintenance (CBM)

CBM can be done in two ways.

1. Subjective condition monitoring
2. Objective condition monitoring.

Subjective condition monitoring is when the monitoring is done by means of senses such as listening, look, touch, taste and smell and from estimate of condition. This type of monitoring is putting great demands on the individual performance. For results to be reliable, the technician doing condition monitoring requires good training and experience.

Objective condition monitoring

When the condition of equipment is objectively monitored with the help of equipments, it is termed objective condition monitoring. Two most successful methods used in industries are

1. Ferrography
2. Vibration Analysis

These two topics are discussed in detail on the chapters 8 & 9.

CHAPTER 3

OBJECTIVES OF MAINTENANCE AND MAINTENANCE COSTS

The maintenance function has not, during the past years, been seen as a condition for production. Instead the previous approach was that maintenance was a necessary evil which only consumed a lot of money.

This way of seeing maintenance means that the only objective of maintenance was to repair and mend broken equipments. This is the old fashioned way of maintenance management. Modern maintenance management is to keep the equipment into operation and produce quality products meaning that every time we need to do an unplanned repair work, we have not succeeded with the maintenance strategy.

The objective of maintenance can be mentioned as follows:

To keep up the plant availability performance at the lowest cost and within the safety prescriptions.

Planned availability performance means the agreed on availability performance for a certain period of time in the future. It is essential to mention that the target of availability performance is decided first. Secondly the cost factors are taken into consideration.

MAINTENANCE COST

All enterprises and organisations are interested in lowering the maintenance costs. Many enterprises are operating a cost controlled maintenance management meaning that the maintenance section is just controlled by the money which is available in the budget. The cost controlled maintenance is not connected to modern maintenance management. It is the long term result which must be taken into consideration. The maintenance cost must be just in relationship with the planned availability performance. The problem is that it is very easy to find the cost for maintenance but it is difficult to convincingly qualify the results.

The maintenance cost can be split up into different catagories ie. direct and indirect maintenance costs.

The direct maintenance costs can be directly related to the performance of the maintenance work ie. cost of spares, labour modifications, administration, training etc. as shown in Fig 3.1.

The indirect costs are losses due to maintenance. In the result controlled maintenance management, it is always the direct costs plus the indirect costs, that is accounted for. as shown in Fig 3.2.

Life cycle cost and its importance in maintenance.[2]

LCC - Life cycle cost is commonly understood to be the customer's total cost and other sacrifice during the actual life time of the product. Hence LCC includes the acquisition cost as well as all future costs for operation and support of the product untill it is finally discarded.

LCC is closely related to the product availability performance characteristics which costs money during the phase of operations and support.

Maintenance aspect should be taken into consideration in a very early state of the project.

When 50% of the time of the project has elapsed, decisions have been taken on 85% of the life cycle cost. By properly selecting the equipment and proper plant lay-out the mean time to failure (MTTF) and maintainability performance (mean time to repair (MTTR) can be improved.

This will result in the improved availability of the equipment. This in turn will reduce the life cycle cost. For equipment of better performance, the initial cost will be more but the total life cycle cost will be less when compared with a cheaper proposition. Hence LCC is to be calculated before deciding an equipment for a project.

LCC Calculation model

Life cycle cost = CI + NY (CO + CM + CS)

CI = Cost for investment

CO = Yearly cost of operation

CM = Yearly cost of maintenance

CS = Yearly cost for down time

NY = Number of years in the calculation.

A pulp mill example is chosen to show the effect of LCC calculation in making the right choice (Data from Hindustan News Print Ltd.)

Alternative 1

Fig. 3.3. shows a layout of the chipper house which cuts wood into chips. On the basis of this a block diagram is drawn. The figure corresponds to the units in the diagram.

A. If the rechipper No. 7 does not work due to failure or for maintenance purpose of chips can be cut, but of poor quality.

B. If there is a failure in the factory, it is possible to do maintenance work in 8 hours without production interruption. That is, starting from feed transport belt No.1 to transport belt No. 9. This facility of buffer capacity in silo allows small break in the production time.

Alternative 2

Also for alternative 2, a schematic diagram of the equipment and the production flow is made. On the basis of this diagram a block diagram is drawn. The figures corresponds to the units in the diagram.

A. If the rechipper does not work, chips can be produced but of not good quality.

B. The buffer capacity in the silo allow failures in the production line 1, 14 and 15 for a maximum 8 hours.

C. Chips can as an alternative be transported directly from the chipper to the transport belt.

Calculations

Costs which are estimated to be true are calculated with the aid of the LCC model . The reliability has been estimated by interviewing experts from the pulp mill of Hindustan Newsprint Ltd. Only the figures which will differ between the alternatives are taken into consideration.

TABLE 3.1. COSTS OF CHIPPER HOUSE

Cost element	Alternative 1 in Thousands of Rs.	Alternative 2 in thousands of Rs.
Cost of investment in machinery	7210	6420
Cost of investment in electrical installation	1440	1240
Sum C1	8650	7660
Yearly operation Cost CO	940/yr	955/yr
Yearly maintenance Cost = CM		
Cost of personnel (Corrective maintenance)	271	100
Cost for material	236	136
Cost for personnel	170	118
Cost for equipment and material PM	289	261
Sum C1	966/yr	615/yr

Yearly down time costs

The yearly down time cost caused by maintenance is calculated using the block diagram for each alternative. Fig 3.3 and Fig. 3.4.

Down time cost arises when chip delivery to the transport belt of digestor stops.

The chip silo can store chips enough for 8 hours of chip consumption. The buffer stock in the chip site is built up in two shifts in order to supply chips to the digester during third shift. During the third shift chip production is stopped.

MTTR (Mean Time To Repair) in most cases is less than 8 hours per failure.

In alternative 2: There is an alternative way to transport chips direct from the chipping machine to the transport belt. The quality of chips will not be same but in a simplified calculation the down time for alternative 2 can be considered zero.

Summary of LCC analysis

$$LCC = CI + NY\ [(CO + CM)\ CS]$$

Cost element	Alternative 1	Alternative 2
CI	8650	7660
CO	945/yr	995/yr
CM	966/yr	615/yr
CS	732/yr	0/yr

All costs in thousands of Rupees.

Since CS=0, It is evident that alternative 2 is better. This type of calculations can be done on individual equipments also. The mean time to failure can be had from the suppliers of the equipment. In industrialised countries like Sweden, the performance guarantee for MTTI is obtained from the supplier. In India due to economical constraints this will be difficult. But the modern trend is to get a maintenance performance guarantee from the equipment supplier and equipments are selected on the life cycle cost (LCC) rather than the initial investment costs.

CHAPTER 4

MAINTENANCE SYSTEMS

One way of considering industrial maintenance is as a subsystem of an industrial organisation, with the function of adjusting repairing, replacing and modifying the parts of industrial plants in order to perform the production functions for the specific period of time. (Fig 4.1)

Maintenance system requires inputs of finance and information and provides outputs in the form of plant useful life, •availability performance and safety.

In addition, a management activity aimed at the maintenance resources so that they are used in the best way, is required.

A methodology of identifying the element of a maintenance management system is shown in fig 4.2.

The function of a maintenance system and the way in which this function might be affected by the dynamic relationships between the maintenance system and production system needs to be analysed.

From this a definition of the maintenance objective and production objective can be identified by forcasting the way in which the plant is to be used. (Production strategy often drives the maintenance strategy).

The maintenance work planning and work control system should be built around the resource structure. A maintenance control system is needed to ensure that the system is working towards the objective and to provide the corrective action.

The (Fig.)4.2 indicates the methodology for establishing a maintenance management system. in the mill). In addition decisions affecting each element are influenced by factors external to the maintenance system. There are manual operating systems and computer operating systems.

Manual operating system is described below:

Computerised maintenance system[7]

The maintenance department in any company must have an efficient maintenance management system. The basic function in planning such system can be

1. Preventive maintenance
2. Plant and unit record
3. Inventory and spare parts record
4. Purchasing system
5. Document record
6. Planning system for maintenance and work order routine.
7. Technical/Economic analysis of plant History, maintenance work and machine available.

The emerging trend is to use computer models for the above. Different manufacturers are supplying these systems. A study based on Idihamor System is given below. These modules include [7]

Preventive maintenance

What is to be done?

Who is to do it?

When should it be done?

At what intervals?

How?

Plant and Unit record

- Provides technical data and associated spare parts for each item of equipment.
- Can be interrogated in a number of ways
- Provision of information for insurance and valuation purposes.

Inventory and spare parts control system includes the following features.

Parts supplied from the stock

Goods received

Inventory control

Label production

Catalogues

Shopping lists

Accounting Functions

Purchasing system

Includes the following features

- Check of order acknowledgement and invoices
- Monitoring of incomplete deliveries
- Delivery monitoring
- Goods returned

Document record

For recording and storing drawings, instructions and other documentations.

Planning systems for maintenance

- Work order routine
- Resource allocation
- Assignments priority
- Working schedules
- Progress and cost monitoring.

Technical/Economic Analysis or Plant History

This includes the folowing features

- Plant Statistics
- Distribution of work categories
- Units with high maintenance costs
- Machine causes high production losses
- Indication of units with high maintenance frequency.

Preventive maintenance system

Preventive maintenance requires collection and organisation of thousands of actions and operations in terms of what is to be done. When it is to be done, how it is to be done and by whom it is to be done. It would be practically impossible to do this without the help of a computer to co-ordinate and process all the above mentioned information.

The basis of preventive maintenance module is a thorough inventory and review of the company's machinery and equipment and of its maintenance requirements. This work can be carried out jointly by the computer software manufacturer and the company 's maintenance engineer. All the data collected will be entered into a PM system to produce a main schedule which is a summary of all preventive maintenance work to be carried out. This gives an overall picture of the preventive maintenance requirements.

The main schedule is prepared and stored in the computer. It can be printed out or displayed in full on the screen. It can also be sorted or displayed by a number of different sorting or search criteria depending on the information required. The information includes details like whether a stoppage is required for doing the job.

The system gives routine maintenance list for daily checks, activities which require special planning, job cards or planning lists.

The PM system also include detailed instruction on how activities are to be carried out. The system ensures that right work is carried out at the right time by the right personnel in the right way.

Planning system

An efficient maintenance system requires detailed planning of repairs, overhauls and. inspections. Following the main criterion of causing as little interruption as possible to production, work is structured. It is possible to produce a schedule of planned work to be carried out whenever production stops. This allows maximum use to be obtained from every plant stoppage that occurs.

Work order routines

A smoothly operating work order system can save considerable sums of money for the maintenance department through improved use of resources.

Each work order can be entered into the system immediately either completely or in part, and can be amended if necessary.

Parts and materials can be reserved through the stock control system. The work planning and preparation system for routine is central to the maintenance system. Personnel involved can easily monitor their own jobs. As various stages of the work are completed, they are reported back into the system and is updated. The system also stores details like

- Personnel
- Time cards
- Hourly costs
- Contractors
- Budgets.

Plant and unit record

The majority of work generated by the PM system has to be planned and prepared before it can be carried out. If this is to be done efficiently it is necessary to have access to data concerning the machine. Plant and unit record provides these data. Some of the benefits associated with plant and unit record are

- Repair time, planning time and preparation costs are reduced.
- There is less dependence on specific individuals.
- Standardization is improved
- Book values and insurance values can be automatically calculated.
- The plant and unit record module also contains the fixed assets information.

Inventory and spare parts control system

For effective corrective maintenance the required spare parts and stock items should be efficiently arranged. This highlights the need for an efficient control system for stock and spare parts.

Spare parts statistics reduces excess stock holding. The stock control system is based on continuous updating of stock levels. The system also gives information about the repairable spare parts.

Since the system gives accurate stock levels the excessive stock levels and stock outs can be avoided. The system helps in identifying slow moving and fast moving items and both quantity and cost. This will help in inventory control. For efficient working of the systems, correct numbering of spare parts is a pre-requisite.

Purchasing System

The purchasing system is closely linked with the stock control system. When the recorder level is reached, the purchasing department is notified that new stock is required. The purchasing procedures are further assisted by practical details such as printing of purchasing order, order confirmation, delivery monitoring, invoice checking, etc. Cost information also is available from this module.

Technical and Economic Analysis

One of the strength of a computer based system is that the system is a powerful aid to continuous improvement by technical and Economic analysis.

Many maintenance system produces reports of the total number of faults occurring each week and of the proportions of preventive and corrective maintenance, serving as immediate indicators of the success of the work.

Perhaps the most important aids are the top ten lists which are ranked comparison between events and the activities. These lists can be structured in many different ways. A top ten lists indicates which items of equipments require the most maintenance during the given period, or caused the most down time. Personnel carrying out maintenance work fill in a report on completion of the work, which is then entered into the computer. The file of finished work can be utilised for the preparation and planning of new work.

Maintenance System Relation

The inter-relationships between the various elements of a maintenance system is illustrated in fig 1-3.

The maintenance system itself can be roughly divided into system for preventive and corrective maintenance .

Administration of preventive maintenance requires application of a PM System to ensure that the correct work and condition checks are carried out at the right time by the right personnel in the right way. The PM system is intended to result in faults and these fault trends as detected. The system produces fault reports which are sent to the maintenance planning and preparation department

The fault and fault trends detailed in the fault reports must be dealt with. Planning for corrective maintenance requires the existence of a purchasing stock control system a plant and unit file and a system for documents location .

The maintenance planning and preparation department also receives orders for maintenance work directly from production departments

The departments co-ordinates the company's production planning and the various maintenance departments (Mechanical, Electrical and Instrument maintenance).

Information must be rapidly accessible, if maintenance planning and preparation is to be efficient, making optimum use of every planned and unplanned production stop to carry out maintenance work. It is necessary to know, for example, which spare parts are available, who can supply those not in stock and such information is available from the stock control system .

It is also necessary to know the up-to-date situation concerning special tools, parts incorporated in equipments etc. This information is obtained from the plant and unit file.

Preparation of drawing instructions and documentations become simplified of there is a system for document location .

Maintenance planning and preparation produces work orders . tThe work order is complimented by work report .

Experience from the work reports is extracted and recorded for subsequent analysis system . Various top ten lists can be prepared from this system. Technical and economic analysis is also used in current planning and preparation work to improve future maintenance

The points described here should be seen as a general description of systems necessary in a complete Operational reliability system. FIG 4.3.

CHAPTER 5

MAINTENANCE PRACTICE

- A STUDY BASED ON HINDUSTAN NEWSPRINT LTD.

HINDUSTAN NEWSPRINT LTD. (HNL)

HNL is a subsidiary of Hindustan Paper Corporation. This is an integrated pulp and newsprint mill situated in the Kottayam District of Kerala State.

HNL has an installed capacity of 80,000 tonne of Newsprint and had gone into commercial production in February 1982. There are about 1800 employees including 200 officers in the company. There are nearly 600 employees in the operation and 350 employees in the maintenance department. Under the chief executive the different departments working are Forest, Finance, Commercial, Personnel and Administration and works.

General Manager (works) has the following departments under him. production, Engineering maintenance, Effluent treatment & Civil, Planning & Development and projects.

TABLE 5.1. Production performance of the Past three years

Year	Production (MT)	% installed capacity
1988-89	78635	98.29
1989-90	86840	108.55
1990-91	90386	112.98

The company is making a steady profits for these periods and had reached a record height during the last year.

The Process of making newsprint

Newsprint is made by mixing 75% chemi-mmechanical pulp and 25% chemical pulp. Pulp from the pump mill is stored in the high density towers. From these it is drawn and further refined for fine adjustment of the freeness. It is then fit to a twin-wire duo-former machine. This machine is having a speed of 700 meters/min and a deckle of 7.6 m.

Paper sheet is formed in between the twin wire. Then it is pressed in a tripple press. After that the paper wets in fed to drying cylinders for drying. These cylinders are under steam pressure and paper gets dried. It is then calendised for a smooth surface and reeled. Normally 49% GSM newsprint is made in HNL. The paper cut and removed in a rewinder to the marketable size and packed in a packing machine. It is then sent to godown for despatch.

Pulp mill in HNL

The pulp mill in HNL has three wings viz. Chipper, pulp mill and chemi-mechanical pulp mill.

Chipper house is a place where the raw materials, etc reeds and Eucalyptus are cut into chips, screened and stored in silos. Chips from silos are sent to both the pulp mills as per requirement.

Since we are dealing with the maintenance study of the pulp mill, it is better to know about the machinery in general in the pulp mill.

In chipper house there are two streams for chipping, one for wood and one for reeds.

In the wood stream, Eucalyptus wood is fed to the breakdown rollar conveyer by the help of poclain (Fork lift truck). The wood is transported to the KMW Wood chipper through belt conveyers. These are two KMW disc chippers and two separate feeding systems. The wood is cut into chips in the chippers which is then screened in a chip screen. The chips are then sent to the wood silo for storing via conveyors. It is then fed to the discharge conveyors with the help of extraction screws.

In the reed system, there are three balliman drum chippers. Reeds are fed to the chippers by using belt conveyors. The chips are screened and sent to the reed silo from where it is extracted with the help of screws and sent to chemical pulp mill as per requirement.

The chemical pulp mill has three sections and a capacity of 100 tons of pulp per day. The sections are digestor house including four stationery digestors and a blow tank, washing and screening sections and the bleach plant. There are equipments for washing; three drum washer and its accessories, screening and cleaning equipments and a thickener in the washing/screening section. In the bleaching section there are three drum washer for the three stage bleaching and mixers and conveyors for mixing and transporting the pulp. There are a number of pumps for pulp and different liquors and water in the system. Belt and screw conveyors are also in operation. Due to availability of intermediate storage systems and the pulp requirement is much below the installed capacity, the plant operates intermittently. Hence maintenance in this area is critical and hence chosen for the study. Refer Fig 5.1.

CHEMI MECHANICAL PULP PLANT(CMP)

Chemi Mechanical Pulp Plant (CMP) is the most important section in the Pulp mill. This is a continuous pulp plant. Wood chips from the silo is transported to the plant Via belt conveyors. The chips are then washed in a chip washing system. The washed chips are preheated in a steaming vessel and fed into an impregnator with the help of a screw press. The impregnator is a 16m tall vessel having 6 percent caustic bath and is kept at temperature of 80 to 90°c. The chips are pushed up the vessel with the help of a screw. The impregnated chips are then fed to a buffer vessel. From there it is extracted and fed to a screw press for pressing out the excess chemicals and then fed to No.1 Raffinator. The raffinators are heavy disc refiners with disc diameter of 1.48m. They are driven at 1500 RPM with the help of 6.3 MW, 11 KV motor. This equipment is a key part in the plant with heavy loading and built in protection systems like vibration monitoring, etc. The motors are continuously monitored for oil flow, temperature, etc. apart from electrical parameters. There is a hydraulic starting device for the raffinator comprising of hydraulic pump, hydraulic motors and different hydraulic systems.

The first stage refined chips are then pumped with the help of a high density pump to a disc press where liquor is pressed out of the pulp. The pulp is then refined in the second raffinator similar to the first one. The refined pulp is then diluted and pumped for washing and bleaching.

The washing is done in a continuous drum washer of 4.12m dia. x 6.7m long. Vacuum pumps are used to develop vacuum required for washing. The washed pulp is bleached with Hydrogen Peroxide (H_2O_2), then washed to remove the chemicals in a drum washer similar to unbleach washer. Pulp is then fed to a similar type of refiner as explained earlier for further refining.

The final refined pulp is cleaned by screening and centricleaning and thickened in a disc filter. The final pulp is again pumped with the help of a high density pump to a storage tank from where it is taken to the paper machine. The plant has a capacity of 190 tonnes per day. The paper production depends on this plant and a continuous trouble free operation of the plant is a must. Hence maintenance in this area is critical and hence chosen for this study. The complete flow diagram is shown in Fig. 5.2.

Collection of data

Data collection is done by interviewing the following persons. Deputy General Manager (Engg), Senior Manager (Elect & Instn), Manager (Mech), Manager (Pulp), Senior Plant Engineer (Chipper House), Senior Plant Engineer (CMP) and process in charge (CMP). Maintenance data sheets, plant log books, layout drawings etc. were also used.

The following functions are carried out.

Maintenance systems in pulp mill

At HNL pulp mill, a manual maintenance system is in operation. The following functions are carried out.

1. Preventive maintenance System
2. Plant Documentation System
3. Inventory and spare parts system
4. Planning system for maintenance.

Preventive maintenance system

Mainly two types of maintenance systems are being followed
1. Condition Based Maintenance (CBM) and 2. Fixed time maintenance

Condition based maintenance

All the equipment are listed out and regular periodic check-up schedule is fixed. The periodicity is fixed depending on the nature of the equipment. These observations are mainly checking for temperature, vibration, noise and checking of lubrication. They are either objective or subjective, type condition monitoring

Again depending on the nature of the equipments, these examinations are classified into two groups. Examinations that can be done while the equipment is in operation and those which can only be done while the equipment is stopped.

For objective examinations, vibration analysers (SPM), Shock pulse measurements, Thermometers etc. are used. Objective types of measurement are done by engineers and recorded in the data book. Any abnormalities are noted and corrective maintenance planned and executed during a maintenance window or in a planned shut down. An SPM measurement sheet is shown below. The equipment used for measurement is bearing analys...

Table 5.2.

Bearing No. 29440 Skf

Location: CMP Plant

SPM type 7

Machine: No. 3, Raffinator drive side bearing

Date	Code	Lub	Cord	Measu-red by	Om 300	1500 rpm
14-10-1990	70	10	OK	Sd	Non	No.55
20-7-91	78	10	Expected Failure	Sd		

It can be observed that a warning is obtained well ahead of failure and necessary maintenance can be carried out before failure.

In few equipments in CMP plant there are built in probes for connecting and checking the bearing conditions, raffinators, screw presses etc.

Some important equipment vibrations are regularly checked and recorded. These data are analysed to detect probable failures and corrective steps taken before a break down occurs.

Vibration date-sheet for Raffinators is shown in Table 5-3.

Check up of equipments like digestors are done by measuring the thickness of the plate periodically.

Couples are checked while running itself with stroboscope.

The performance level going down also gives indication about a forthcoming failure. A lowering in the output of a certain pump gives information that the pump needs maintenance. It can be planned and performed well ahead of a failure. This is also being done in HNL for high density and pulp pumps.

There is a cleaning and lubrications schedule. This is followed up regularly. A sheet which is normally followed for the schedule of lubrication is normally of the type as below: Fig 5.6.

Fixed time maintenance [5]

For equipments and parts which have no failure development time and the nature of failure is regular, fixed time maintenance is used.

Raffinator "O" rings are replaced every year during the annual shut down. Screw press's screw is replaced in every six months of running.

Generally maintenance is done during the process shut downs. Every year the plant is to be shut for cleaning and pressure testing of the recovery boiler. During this time all the plank are shut for 15 days. Main preventive maintenance jobs are taken up during this time.

Overhauling of equipments are also done at this time.

TABLE 5.3. VIBRATION DATA SHEET OF RAFFINATOR.

Date	Position	Non drive End body		Non drive end big		Drive end Body		Drive end Body		Load condition	Remarks
		Frequency mm/s	Amplitude micron	Frequency mm/s	Amplitude micron	Frequency mm/s	Amplitude micron	Frequency mm/s	Amplitude micron		
10-8-1991	Vertical	1	15	1.4	17	0.5	8	0.8	10	No load	
	Horizontal	1	14	1.6	18	1.2	15	0.9	12		
14-12-91	Vertical	3	40	2.4	30	0.6	7	1.1	10	On 4 MW load	Vibration increased due to segment wear
	Horizontal	1.3	17	2.9	32	0.9	5	1.1	14		

Plant documentation System

Card Index is used for this purpose. There was three types of documents.

1. Equipment details
2. History card
3. Spare parts record

Equipment details

This card contains details like area, equipment number, date installed and date of commissioning. Equipment specification electrical motor details, drive details and lubrication details are also included. There are columns for special informations where drawing numbers and any other special informations like modifications done, if any, are included.

In the machine specification, name of equipments, manufacturer, mode and some engineering detail like head, capacity, rpm, net-weight etc. are shown, in Fig. 5.3.

Electrical deails contain more specifications KW rating, normal running load etc. Drive details contain gear box details, coupling specifications pulley and sproket details.

In the lubrication details, type of oil/grease to be used in each part and quantity is specified.

History card

Another document kept in the plant is the equipment history card. This card contains a schedule for the fixed time maintenance. In this card corrective maintenance both planned and unplanned already done are recorded. The time taken, man power used, details of the maintenance work, spare parts used, machine down time etc. are recorded. This is an important document for planning and scheduling the future maintenance work. This will help in analysing the maintenance work and gives an idea on how the maintenance down time can be reduced. This record also gives an information about the use of spare parts and man power. With the added information about the machine down time, the maintenance cost also can be calculated, shown in Fig 5.4.

Spare parts records

For each equipment a spare part record is made and maintained. This contains the part number, drawing number, stores code number of the parts, description, update quantity available etc. Re-order level and the possible suppliers are also included. The document will help in knowing the quantity of spare parts available and to keep back of the spares. By ordering at the proper time and making the follow up, the possibility of stock out can be minimised. (Fig 5.5)

Inventory and spare parts System

The inventory and spare parts system is a joint responsibility of the stores and the engineering departments. Most of the common items are listed in the mill basis and the minimum quantity required is fixed. The inventory level is kept by the stores department. By raising an indent at the reorder level specific spare parts are ordered by the maintenance department. This is done after taking into consideration its frequency of requirement and cost of stocks outs.

Some important spares which are sparingly used (say once in five years). But the non availability is costly due to down time are categorised as insurance spares.

Since most of the important equipments are imported, there are a number of improted spares used. Due to the long lead time and the Government regulations it often becomes necessary to keep a high inventory of these spares. So there is a systematic effort to indegenise the spares. Drawings are made and Indian suppliers are located for these items. Sometimes the company is helping the suppliers to jointly develop these spares.

Planning system for maintenance [6]

Maintenance jobs are often registered by the process department. As per the process requirement and observations from the product quality, the process department will recommend for some maintenance jobs. This is duly intimated to the maintenance department by a job list or note.

By monitoring the condition of the equipment the maintenance department will made a list of jobs. When there is a process stoppage or stoppage one in any other reasons these jobs are planned.

Planning is done taking into consideration the urgency of the job, the time available and the availability of resources (spares, manpower etc). The planning is done for each sections by the section engineers and is co-ordinated by the manager.

Planning is done to arrange all the material required before the shut down itself. Manpower required also is assessed and mobilised. Long shut downs (more than 8 hours) are planned nearly a week earlier. Daily work planning is rather routine. Overhauling pumps etc. are done in each sections. This will help in utilising the maintenance work force better. There is a team in each section for condition monitoring of the equipment. They go around the plant and will do the first line maintenance also.

Main planning work is done for the annual shut down of the plant. This is done even three months earlier than the actual shut down in April. All the jobs are listed out and spares required are assessed. Time duration for each job and man power requirement also are assessed. Materials are arranged well ahead and workmen are arranged even from outside. Jobs which can be sub contracted are listed out and contractors engaged. Suppliers engineers are also called wherever it is necessary. A planning cell works for this purpose. They co-ordinate all the jobs and report to the department in mobilising the resources.

Another improvement suggestion for pulp mill maintenance is that proper maintenance documentation is to be kept. Even though there are different card-index cards, it is often observed that they are not filled up at the right time. This causes lack of documents for analysis and improvement. A better maintenance documentation system is desirable for effective planning of the preventive maintenance.

It is observed that there is no work order system in HNL. From the point of view of planning and control, work orders are important documents. Hence a work order system is suggested.

Work orders due to production defects are to be raised in triplicate (figure 5.6) by the production supervisor who completes the top part of the order and thus can request maintenance work. In the case of an emergency the top copy passes direct to the maintenance plant engineer following a verbal request and the second progress copy is sent to the planning office. The bottom copy can be retained while the job is completed and then destroyed. For all the other works both top and progress copies are sent to planning office.

Work orders arising from inspection reports and to be raised in triplicate by the maintenance plant engineer with emergency jobs the top copy is to be passed to tradesmen and other copies held until work completion. In the case of deferred work, the top and progress copies are to be sent to the planning department who can integrate the work into the corrective back log schedule. Information from this back log schedule, from the preventive maintenance schedule and from priority assessment meetings can be used by the planning office to provide maintenance supervision with:

1. The weekly summary of preventive works plus job specification and blank inspection report.

2. A weekly summary of corrective maintenance plus the relevant work orders (also included is an indication of these corrective jobs that should be carried out while a machine is down for preventive work). For all the listed jobs the planning office carries out the necessary planning checks an availability of spares, special tools, plants etc.

The maintenance engineers can plan the work over the week and allocate the jobs by passing work order to the appropriate tradesmen.

Work control is achieved through the return of the work orders and inspection reports the updating of the allocation board and planning office schedules. The maintenance engineers should check and sign the work orders and inspection reports before returning them to the planning office.

Analysis of the work orders establishes the proportion of maintenance being spent on planned and unplanted work in each area.

Plant Condition control is achieved through the information on causes of failure, corrective action and down time entered on the work orders. Control of the first level is facilitated by the weekly summary of emergency maintenance issued to the engineers. Control at the second level is achieved by top ten analysis and grouped unit analysis. These analysis give a monthly indication of problem units and areas.

The work order system is suggested for improvement of maintenance control in HNL mill.

Maintenance organisation in HNL

Maintenance organisation in HNL is a functional one. There are mainly two maintenance sections ( ) Mechanical ( ) Electrical and instrumentation. Both these sections have both shift and day duty sections. Both the sections are similar so a detailed organisation chart of the mechanical department is attached for discussion.

The whole mechanical maintenance in pulp mill is headed by manager (Mech). Under him there are three senior plant engineers in three sections. There are plant engineers and technicians in each section.

The shift maintenance is also co-ordinated by the engineer in each shift. The front line maintenance is done by shift technicians. Preventive maintenance and condition monitoring is also the job of the shift men. They record their observations and the engineer in general duty plan the work for any scheduled shut down. He has to arrange spares and materials for the job. The general duty technicians are mainly engaged in corrective maintenance. While the plant is in operation, they are utilised for overhauling of spare units and preparing job charts for the scheduled work. The emerging trend in modern maintenance management is to have technicians with multi-trade. The process operators can be used for front line maintenance and observation. The centralised maintenance department can do the corrective as well as planned preventive maintenance.

It will be extremely difficult to transfer one job from a particular category to the others. It will be impossible to reduce strength by better allocation of jobs. Hence without reducing the work force some improvements can be thought of.

Case study of organisational improvement in chipper House

As mentioned earlier there are three reed chippers and two wood chippers in the chipper house. Each of these chippers and the accessories are operated by four process operators. These chippers require the changing of the cutter knives after eight hours of operation. The Knife changing job takes nearly four hours to complete. The knife changing job was done by maintenance technicians. At that time the process operators had no job since the maintenance technicians are engaged in the knife changing job. The important preventive maintenance jobs which can be done only during a machine shut is neglected.

Since knife changing is a repetitive job, with some training the process operators can be persuaded to do it.

This will help in two ways

1. Better utilisation of man power
2. Improved preventive maintenance resulting in reduced downtime.

There are other areas in pulp mill where this type of organizational change is possible which will result in better working of the section.

Pulp mill maintenance

Chipper section

The maintenance of a chipper has changed in detail as the design has changed over the years. But the elementary precautions which must be taken to keep silvers and saw dust at a minimum, are just as important now as it was in the past.

Six rules of chipper maintenance

1. Keep the disc knives sharp. Dull knives make saw dust. Silvers which are usually caused by dull knives can also be strikingly reduced when sharp knives are put in.

2. Keep the disc knife edges close to bed knife. This is the most common maintenances fault. The knife should have not more than .675 mm clearance from bed knife (Preferably .4 mm) sometimes foreign material gets under knife holders to make one or more knives stand out beyond others. This condition should be corrected as soon as possible so that the close clearance is maintained.

3. The bed knife should be kept sharp. It can be repaired and ground sharp. A weekly change is recommended.

When the edge is rounded more the bottom fibers of a log tend to bend down around the rounded edge. This results in 'ribbons' formation.

4. These should be no obstruction to the passage of logs down to the bed knife cutting edges.

Reducing spout wear

The floor of the spouts have strips of hard surfacing material welded on to reduce this wear. Also the bed knife cutting edge is higher than a straight line down the spout as shown in sketch.

Th. step reduces the wear on the spout and makes the bed knife edge bite into the log more effectively.

If the spout floor becomes worn it can be built up again. The hard-ships can also be built up and blended into the parent metal at the top.

Sometimes the bedknife seats become worn unevenly so that bed knife rocks. Liner plates underneath and behind the bed plate can be replaced when then trouble occurs. The trouble can be minimised by keeping the two cap screws tight that hold the knife horizontally against its seat and by keeping the spout clamped down hard on the bed knife top.

5. The surface against which the logs rub on the disk may become worn. It wears more slowly on the Norman chipper than on others. When these surfaces are worn, longer chips are cut.

WEAR PLATE ON DISC

The wear is more concentrated just opposite each knife. In some models we have removable plates, rectangular in shape set into these critical areas. These plates should never be higher than the surface into which they are laid.

The area back of these critical ones is protected by strips of hard surfaced material. When worn sufficiently they can be repaired in the factory.

If the hard surface is damaged by foreign material, the mill can repair it in its own maintenance department.

6. The thrust bearing clearance must be kept up within the limits prescribed by manufacturer. This helps to keep close tolerance with the bed knife by keeping the end play at a minimum. The tapered sleeve between the shaft and the inner race should be tightened by lock nut until a feeler gauge between top roller and outer race shows correct clearance.

Grease should be changed every six months.

These two are preventive maintenance. Neglect may result in damage of shaft.

Proper chipper knife care

A chipper knife to give best performance must be heat treated by its manufacturer. Knives that chip down or spall when cutting will lose too much life in grinding and will creat excessive saw dust.

Barking and using plenty of water are two important factors. Pulp wood that has been subjected to as nearly 100% removal of bark will contain much less foreign material such as sand, rock, nails to dull knifes. After debarking, plenty of water should be used to wash off sand grit, dirt etc. This can be accomplished by a high pressure (1.5 to 3.5kg/cm²) line spraying water over the logs.

A good scheme is the installation of an electronic device on the conveyor to pick out metal on the logs. When a log with metal in it passes through the device the conveyor is stopped and the log ejected.

CLEAN KNIFE POCKETS

Another way to cut costs is to be sure that the knife seats on the chipper are not worn. This is the principal cause of broken knives, irregular chips and saw dust.

The knife pockets or seats should be thoroughly cleaned of all wood, saw dust and any foreign material before knifes are seated. All knives should project the same distance from disk face. The knives should balance to minimise vibration.

The anvil plays an important role in the life of chipper knife. It should be composed of high grade tool steel and heat treated.

The faces on the wearing plates of chipper disc should be made of high quality wear resisting tool steel, hardened to 4.7 mm to 6.25 mm. These type of face plates can be ground several times before it has to be discarded. Standard size seats can be placed behind the plates to set them out to their original position.

TOO LITTLE ROTATION

Almost every mill rotates too few knives. Knife cost would be cut if a larger number of knives were rotated. Grinder operator can then select the various nicked knives in the set on the chipper and then grind them according to the depth of nick.

Great savings could be effected as there is no need in this case to grind no more metal than required to sharpen the knives. It has been proven that it is possible to obtain 8% more life out of chipper knife, by this method alone.

In determining the length of the bevel on the knife Care should be taken to see that at least 3 to 5° clearance should be allowed at the heel of the bevel. The long bevel is determined by the angle of the feeder spout.

Bevels that are too long will cause the chipper to hog the wood and cut irregular chips. They will also weaken the cutting edge.

GRINDING OF KNIVES

The grinding machine should be a heavy duty type, equipped with a magnetic chuck to hold the knives while they are being ground. The table or grinding head should reciprocate at 20 to 30 m/min. and it should be equipped with a power feed. The grinding speed should between 19 and 22.5 m/s.

While grinding plenty of coolant should be flooded over the knives. Every knife should be ground with cutting edge up. This action conducts the heat generated to the heel of the bevel and away from knife edge.

A bevel that has become light straw color from grinding will have a cutting edge softened two or three points (Rockwel hardness), and knife will last half the life time. A cutting edge that has been burnt blue or brown will be damaged to the extent that edge will turn over.

The wheel grit recommended for use

Most grinding wheels can use a G or H grade wheel of 40 to 60 grit. Generally the finer the grit the better is the knife's finish. By using proper grinding equipment and abrasive, the total time to grind chipper knife can be reduced by 25 to 30%.

Alkaline Digestor maintenance using stainless steel Overlay [12]

Eversince the induction of alkaline pulping methods, pulp mill engineers have been seeking methods to extend the service life of Digestors. Corrosion and Erosion attack ecountered during cooking cycle has measurably decreased service Life of digestors.

Many methods to extend service life have been tried.

The earlier methods was lining of digestors with carbon brick. This type of lining require considerable maintenance and does not fully guarantee against liquor seeping through joints or crevices. An out of round vessel expansion under pressure causes liquor to seep through the crevices. In addition 10 to 12% capacity reduction occurs due to the volume taken by bricks.

Lining with strips or sheets has been tried. In the majority of cases, the lining quickly failed due to cracking at the welded seams and the subsequent seepage of liquor behind the lining causes unseen and accelerated corrosion.

Lining by stainless steel overlay properly applied has been generally accepted as the most economical and durable method for protection of Digestor wall thickness.

In the 1950's manually welded overlay was applied to corroded areas in digestors. This methods has been considered successful and is still in use today. However due to low production costs and high costs per unit area manual overlay is used in smaller areas that have experienced greater corrosion, than the majority of vessel.

A western US Kraft producer was the first to apply automatic overlay using the sigma process. A fixture was designed to carry several welding guns on a circular back around the periphery of the vessel, each gun depositing a head of weld metal horizontally. Successive heads would be deposited overlapping previous ones by 50% thus providing a continuous layer of alloy deposit fused directly to the vessel.

The sigma process uses an inert gas Argon for shielding the arc from atmospheric Oxygen and Nitrogen. In order to obtain stabilised arc constant dc power source must be used. Also a fine diameter electrode is required to maintain high current densities at the arc - a necessity for stable arc.

Although sigma process requires less sophisticated fixturing it has disadvantages.

1. The envelope of argon is affected by drafts from arc blowers.

2. Due to high current density, wire size must be 2.35 mm dia or less. Therefore cost of material is higher, as finer wires are costlier.

3. Due to high affinity of Chromium for Oxygen, 4 to 7% Cromium loss is possible.

4. Argon gas is lost to atmosphere causing extra losses.

The submerged arc welding is also in practice since 1956. This process was chosen in spite of more sophisticated fixturing for the following technical reasons.

1. A large diameter welding rod can be used 4.7 or 8.3 mm, which provides less current intesity.

2. Shielding mechanism is an agglomerated flux which is not affected by air currents.

3. There is no alloy loss in submerged arc process.

4. Submerged arc process has higher deposition rate than sigma.

Overlay specification

Amount to be overlayed.

Overlay is applied to complete digestor than in patches. It is cheaper to complete the digestor in one stroke than in instalment, usually the cones and cylinders are overlayed. Domes are free from corrosion, due to high thickness.

Analysis of overlay

C - .2 max %	Si - 1.0 max %
Mu - 2 max %	Cr - 18.00 max%
p - .045 max %	Ni - 8.00 max.%
s - .03 max %	Thickness 3/7.5 mm

Scheduling overlay

Quite often mills will allow digestors to deteriorate below the minimum wall thickness required for their cooking pressure. In same cases digestors are condemned to operate at lower cooking pressures. Due to corrosion problems. Knowledgeable operators will schedule overlay work well in advance of estimated date of minimum thickness. It is wise to provide overlay at an early stage because it is necessary to preserve greater wall thickness.

Maintenance of Disc Refiner

Methods to get high yield pulp without breakdowns

Good maintenance is necessary to get the best results from disc refiners To get better stock quality here are same factors that will affect it.

1. Proper selection of plates
2. Not over extending plate use
3. Feed consistency.
4. Chip uniformity in size and impregnation.
5. Uniformity of feed.
6. Condition of refiner.

Feeding

Methods of feeding in high yield applications are

1. Pumping
2. Using screw conveyors

Pumping has distinct advantages in that feed can be very uniform and that the flow of chips or stock easily overcomes the entry restrictions Disadvantages are lower consistency and higher power required.

The screw conveyor is the more common method of feeding. It uses screw feeders to move stock into eye of the refiner. Where screw conveyors are used, Care should be taken to size them to avoid surging in discharge.

Records and inspection

Keeping records and scheduling inspection is important. Use records as indicators of future action.

Schedules must be frequent enough to catch any trouble at initial stages. Some use daily inspections and some weekly. It is best to provide inspector with check points.

1. Extremely hot or noisy bearings
2. Loose bolts
3. Oil leaks or stock leaks
4. Malfunctioning of hydraulic system
5. Unusual noise or vibration
6. Extreme motor temperature
7. Other unusual signs

Obviously a man cannot tell the exact condition of the bearings or oil seal by feeling or listening. But by routine check up of equipment, he will be to see the trouble before it develops into problems. Regular checks are a must for mill pushing their equipment to the limits.

During plate changes and overhauls check, wear on the other refiner parts like distributors , seal ring etc. In the electrical equipment, check the condition of synchronous motor brushes check for proper excitation of motor, check all starter contacts and test the oil pressure switch on hydraulic unit.

Lubrication

Three types of lubrication have been available on refiners, grease, oil mist and forced oil. However on large models forced oil or grease is important. Due to sliding friction in tapered roller bearing under high thrust load, the use of an extreme pressure type lubricant is recommended.

For forced oil lubrication specify EP type oil 320 SSU at operating temperature. For grease type, prefer EP anti-friction types. Do not overgrease or over oil. Much damage can be caused by an excess lubricant. The packing around the shafts should be greased every shift. A grease fitting is provided on the stuffing box where the shaft passes through the case. Sufficient grease should be added to prevent stock and liquor from following shaft out. Packing should be kept tight enough.

For grease lubricated bearings, bearing should never be filled with grease more than half-full. Bearings should be repacked every six months. Bearing housings are not provided with grease fittings and alteration is not recommended. If bearings began to run excessively, hot check for over grease condition by removing grease-fitting from bearing housing and allow excess oil to escape.

On oil lubricated bearings, quantity of oil going to each bearings should be no more than one quart/minute. When starting the refiner run oil spitter for no more than two minutes before starting refiner motors when shutting down allow the system to operate until the motors have came to a stop. Then shut off immediately to prevent oil from accumulating in bearings.

The oil hydraulic system and pressure should be checked daily. Under normal operating conditions, change oil at least every six months and clean suction strainer. If oil becames contaminated for any reason, change immediately.

The oil hydraulic system in double disc refiners lubrication the machines and controls the movement of disc. Oil pressure of the bearing should be between 2.5 and 3 Kg/cm^2. The pressure for hydrants cylinder should be in 20 Kg/cm^2 to 32 Kg/cm^2 range depending on difficulty of defibering.

As a safety device, should the oil pressure to the bearing fall below 1.5 Kg/cm^2 a pressure switch stops the main refiner motors to prevent bearing running without oil.

CHANGING PLATES

When asked about the time of change of a set of plates generally the answer is 2 hours. But there are mills where the job is done in half the time.

Using the same team of two men for each plate change seems to work best since they can learn to do the job best. One man lays the new plates out face down and arranges them in sequence indicated on the back of segment.

The other man removes both from one half of the upper case and both lift it off. Both men loosen all plate bolts and remove two of the three in each plate segment, one man working on each disc. In order to recover bolts or nuts dropped slip a canvas into the bottom of the case.

A wooden wedge will do nicely to hold the disc from moving after the first plate is removed. Slip it between the disc and the lower case.

After one or two plates are removed one disc start removing from the other to give maximum clearance.

When the plates are removed clean the face of disc thoroughly. Be nice that every bit of dried pulp rust or scale from force of disc and the flange has been removed before inserting the plates. Plates are ground to close tolerances so that no appreciable crack is left between segments.

When installing new set of segments put in 4 to 5 segments on one disc. Put in place the six segments of the other and finally furnish up the Ist disc. When putting the plates in place, sung up the bolts loosely so that the last plate will go in easily.

Replace the case and bolt it.

Major Overhauls

Major overhauls are covered thoroughly in the refiner's instruction book. Do not attempt a major disassembly without consulting the manufacturer's recommendation in the book.

In the mills extensive preventive maintenance, program a general overhaul is recommended. This should cover: Cleaning the motors, cleaning the bearings, and if they are grease lubricated, repack them, checking the level of machine, checking the parallelism of the disc and replacing the worn parts.

When refiners are being disassembled, leave the lower half of the bearings housings bolted and doweled in place., So that parallelism of disc will not be changed. Check parallelism after the refiner is assembled.

Rotating parts that we ship for replacement are balanced at the factory and therefore can be added to the rotating assembly without fear of unbalance.

Clearence between seal ring and renewable ring should not exceed .625 mm. In refining dry fiber and starch clearance should be 1.125 mm

Worn plug wipers may cause erratic surge loads on the refiners by not properly wiping the edge of renewable ring and erratically forcing the stock into the eye of refiner. If this condition exists, replaced the plug wiper.

If the refiner is damaged for some reason and an overhaul is necessary, be sure to check the following when reassembling.

1. Level of base
2. Parallelism of disc
3. Head run out
4. Clearance of seal renewable ring, plug wiper.
5. Instruction book for procedure. Replacement parts are readily

available from manufacturer, when replacing, always give serial number of machine and use repair parts description of the part.

For the spare parts inventory we should determine how much should be carried and what parts are most often required.

The following parts are recommended.

1. Refiner plates
2. Plate bolts
3. Bearings
4. Renewable ring
5. Sleeves
6. Oil seals
7. Oil pump repair kit

Role of maintenance

Many of the well organised maintenance programs are not limited to large corporations. Most comprehensible programmes are carried by medium and small tonnage mills.

Intensive training program of maintenance people and operators is necessary before mill start up.

Annual refreshner courses are recommended. The maintenance supervisor should keep in touch with manufacturer to get new information and for help in diagonisis of refiner problems.

Installation and Maintenance improve screen performance

The two most important factors in the operation of a vibrating screen are

1. Its installation

2. Care and maintenance

Installation important

Any screen should be installed so that it is readily accessible for changing screen surfaces and for conducting lubrication, maintenance or repair. A platform or walk away should be provided with sufficient space for overhaul. Associated with physical arrangement is the design of a vibrating screen's supporting structure. It should be strong enough to carry the load safety, and rigid enough to avoid resonance frequency. Resonant frequency will cause excessive building vibration. it is recommended that natural frequency of supporting structure should be at least 1½ times the operating speed of screen.

Table 54. VIBRATORY SCREEN DATA

Length of beam	Type of Support	No. of times frequeency of beam to be greater than frequency of screen
Not over 5 cm	Directly connected to column	1.5
Over 5 cm	,,	2.0
Not over 5 cm	Not directly connected to column	2.0
Over 5cm	,,	2.5

Checking Natural frequency of supporting structure

for any material $fn = (44.6/L^2) \times [(EI/W)^{\frac{1}{2}}]$

fn - natural frequency in vibration/min

E - Modules of Elasticity for steel

$= 2068965.5$ Kg/cm^2

I x 2.5 x 10^{-2} MI of beam

W x 0.453 beam wt in kg

l x 30 beam length in m

Vibrating mechanism

A vibrating screen undergoes some of the most severe mechanical service of any machinery in the plant. The bearings in the mechanism get more severe forces. They are selected on the basis of the fatigue life.

To get the expected life from the bearings, the dust seals must be kept in good condition and lubrication instruction carefully followed.

Bearings trouble can be detected by a change in sound of mechanism. It is recommended that when this occurs a convenient shut down is arranged and bearings changed. Continued operation will ruin seal plate and the spacing collar.

Spares

It is recommended that spares such as bearings seal plates, spacing collars screen surfaces tension plates for screens etc. be kept in hand at all times.

Conclusion

Vibration screen is a precision equipment and its maintenance and operation should be taken accordingly to ensure trouble free service. The preceding formula should be used where the structure supports screen only.

Investigation of formula reveals that long span on beams supporting a vibrating screen should be avoided, because, the longer the span the greater the deflection and lower is the neutral frequency Result is low screening.

Spring compression

When installing a screen it is important that the springs at the feed are compressed alike and also at discharge end are compressed alike.

Belt drive should be carefully aligned and tension springs installed to maintain proper belt tension. Tension spring helps to stabilize the screen horizontally.

To stabillize the screen in transverse direction friction checks are used. They also snub the motion in resonant period.

Screw conveyors

In the use of the screw conveyor we should first analyse certain design factors which have important effect on the maintenance problems. These factors are

1. Materials characteristics
2. Conveyor characteristics
3. Environment

Material characteristics include such things as bulk density, corrosiveness abrasiveness, moisture , size etc.

A spiral conveyor is a volumetric machine but its gravimetric capacity is dependent on the bulk density. So it is important that its volumetric capacity is selected on lowest density of the material to be handled, and its base horse power on the basis of highest density.

Corrosive proposels are important as the price of the material of construct vary highly as non corrosive material are expensive. S.S. Steel is 8 to 10 times costly than plain carbon steel. Economic selection must be based on the basis of corrosion rates, down time loss, Maintenance and repair costs.

Conveyor characteristics.

Important conveyor characteristics to be considered are size, speed, length power material of construction, style of hanger, drive machinery, erection etc.

Pre-caliberated data based on the above characteristics are often available with the manufacturer.

From Table 5.5 and Table 5.6 reasonable idea into the choice of material for conveyor to be used can be obtained.

Handling chips

The handling of materials involves two different problems.

a) Handling of raw chips

b) Handling of cooked chips from digestors or impregnators.

When moving chips from chipper it is necessary to screen out the oversize chips to prevent hang up to the hangers. Plain carbon steel of standard construction is satisfactory. No. 20B Hangers with hard iron bearings are recommended and a maximum loading of 30% is mandatory to avoid plugging.

Handling of cooked chips poses a multitude of problems.

Stainless steel type 304 is the recommended material. Thickness of 4.7 mm or 6.25 mm satisfactory. In view of electrolytic nature of the solution, caution is taken to the use of welding rods compatible with the base steel.

Where hangers are used 20B or 26B hangers prepared from 304SS steel is preferred.

Trough loading should be kept below 1/3rd of the cross section of hangers.

Once spiral conveyors is properly selected for application, maintenance is reduced to simple lubrication of rubbing parts periodic replacement of worn components, painting and periodic clean out as the process dictates.

Lubrication procedures for reducers and motors are usually described on the name plate or in the service manual of the individual unit. Hanger bearings and box ends are usually grease lubricated. Routine examination of all parts will dictate replacement procedures. Replacement of erroded parts before facture will save down time, and lower actual maintenance labour. Since work can be scheduled and replacement parts available well in advance.

Bleach plant maintenance

No where in the paper making scheme does machinery or instrumentation operate under more hazardous condition than at the bleach plant.

Maintenance costs will be lower in the mill where space requiremment to accommodate major overhauls have been given proper consideration. Sufficient room for good piping layout is essential. Floor latches and wall openings should be provided for lowering or raising equipment.

Exhausting process vapour

Proper exhausting of contaminated vapours has an important role on keeping maintenance costs down. Importance is on providing the washers with hoods designed for removing gases.

Fibreglass is proving to be the most effective material for hoods and duct works. Fibreglass is simple to assemble easy to repair or cut, easy to clean and support.

Ventilating system

Separate ventilation systems are recommended for each service ie. instrument air, chlorine unloading padoling of chlorine dioxide generator etc.

To assume the intake of purest air possible an important consideration is the designing of ventilation systems in the direction of prevailing winds.

Using Historical records

It is important to keep separate up-to-date history card on each piece of bleach-plant equipment.

To assist in equipment identification all items should bear a permanent mill reference code number. Maintenance personnel should use the number when making or repairing reports and operating personnel should use it when making request for repair.

A well organised system for recording routine physical examinations will provide a reporting history that can serve as a reference as well as a guide for future planning.

Materials and their case.

Because of the great number of chemicals and numerous concentration used in the bleaching process., There are usually more types of construction materials used in particular area than in any other department.

Piping materials may be 304, 316, 317 SS Steel, black iron, Steel lined and the likes.

Piping and vessels with Steel linings need to be clearly marked to avoid welding of the vessels.

Pyrex pipe subject to shock damage and it is advisable to be boxed for protection.

Pyrex pipe is finding wide acceptance as low maintenance material around ClO_2 generator and absorption tower.

Black iron is commonly used for caustic for caustic and chlorine service, provided moisture is kept out of lines.

It is common practice to leave the acid lines full to prevent corrosion by dampened air.

Chlorinated stock line of MS pipe with Hard rubber lining is growing in favour over 316 SS steel, used earlier. The life expectancy of former being longer.

To assist pipe line identification many nulls have favoured colour codings. This is valuable and desirable.

Maintenance costs will always be less if the pipe lay out in spacious and convenient.

Processing equipment

For Chlorine Dioxide handling, The problem of finding suitable material for mixing equipment is still a problem. Recent operating experiences tend to favour titanium.

A check list for inspection of pumps, heat, exchanges, blowers, assuring periodic coverage in the best mode of preventive maintenance.

The Washers

Since the brown stock washer is the biggest and the most expensive item in the bleach plant the case and maintenance of this warrants special emphasis.

At regular intervals the drain plug should be removed to check for any water that have got into the interior drum. If water is found the inspection personnel should report it and drum should be repaired for leak.

The maintenance department should keep in mind that whether exterior of washer is S.S. steel or rubber covered, the interior is made of cast iron or mild steel and are subject to corrosion.

At each wire change the interior of the drum should be inspected and areas of corrosion needs immediate attention. If the drum is rubber covered the concerns should be checked and all blistered areas should be patched.

Design for convenience

When surveying equipments the purchaser should see that proper facilities have been given for inspection convenience.

All vessels and chest should be designed with adeqaute drains leading directly to generous floor trenches and equipped with convenient manholes.

Lubrication

All equipments should be lubricated in strict accordance with manufacturers instructions.

A convenience in common use by many mills is the color coding of greate fittings and oil filler caps with corresponding colour for grease gum and oil cans to assure the use of proper lubricant. In accessible bearings should be equipped with extentions for service convenience.

The methods for getting longer life from conveyor belt.

The whole process of moving the raw materials from woodyard to digestor involves conveyor belts. Higher operating speed and capacity, Power savings of 60 to 80%. Maintenance saving of 40 to 60% have belt conveyarised the operation.

Pulp and paper mill use of the belts offers a rugged service. Operating condition are usually wet condition. Many transfers with barked logs present skid and impact problems.

An important consideration before maintenence is the use of a properly designed belt to do a job.

Some actions must resist scuffing; others must be resistant to organic solvents. Pulp mill requirements vary.

Next is the proper installation of belting. Often serious damage can result impairing belt life, if the belt is manhandle during installation.

Some typical belt operations are:

1. Yard belts - consisting of main hand.
2. Wood room feed belts - used to distribute wood to barking drums.
3. Log sorting belts: Used for sorting of wood
4. Chipper feed belts - carry logs to chipper.
5. Chips belt - carry screened chips to storage area usually silos.
6. Digestor feed belts - carry chips from silo to digestors.
7. Broke belts and used to carry broke to pulper.

Handling and storage

Conveyor belt rolls are packaged in cylindrical wooden crates which can be rolled. All crates are marked with an arrow showing the direction in which they should be rotated. They should be rolled placing on skids, or provision should be made for hoisting them.

New belting should be stored in factory crates. A cool dry room free from sunlight, steam pipes, oil or corrosive fume, is best.

Installing the belts.

Once the roll of belting has been brought for installations it should be mounted on a shaft for unrolling and threading. Belting may be pulled on to the conveyor by threading a rope or cable around idlers and pulleys, A leading end of the belt can be attached to a buck or tractor and slowly pulled forward.

Pulley lagging

Rubber covering of the pulleys is recommended for following reasons.

1. Improved coefficient of friction.
2. Elimination of slippage
3. Increased life for pulley and belt.

Training the bit

Correct alignment of idlers, pulleys and parallelism of shaft is essential.

Training the belt is a process of adjusting the idlers, pulleys and loading conditions to correct any tendency of belt to run other than centrally. Initially all idler stands may be positioned normal to the tune of belt travel. Training the belt can be done in two ways.

1. The feet of idler stands may be knocked or shifted to correct a condition where the entire belt run to one side along some portion of the conveyor

2. Tilting the troughing stands of the idlers forward not over 2° in the direction of belt travel produces a good aligning effect.

Loading

Receiving chips off center will cause the belt to move side-ways after loading as the centre of the load seeks the lowest points in the toughing idlers. The ideal condition is to have the material pass from chute to belt at the same speed and direction as the belt with a minimum impact.

Cleaning

Special care must be taken to keep the return rolls and snub pulleys clean. Build up of material of this equipment has a destructive effect upon training, with the result that the belt may run against the structure and damage itself.

Other maintenance factors.

Variable speed drives

Often a belt conveyor is used to regulate the feed to the chipper. Wth the use of the variabele speed drive the amount of wood handled by the conveyor can be kept in step with the capacity of chipper without frequent starting and stopping.

Lubrication

Since lubrication is also part of good preventive maintenance of any belt conveyor system, definite schedule should be worked up, after checking up with manufacturer.

PULP MILL - MAINTENANCE

Digestors

Cooking Liquors are highly corossive to mild steel and proper protection of the inner wall of steel and all fixtures exposed to liquor contact is a necessity. The inner lining consists of ceramic or carbon file or of stainess steel.

Carbon steel digestors are common with alkaline pulping process with an average life span of 20 years. But they also suffer from corrosion at a rate of 0.76 mm/yr. NaOH concentration is a critical factor. The corrosion rates for Inconel or stainless steel clad alkaline digestor is 10% of the above fig.

Liquor and Pulp processing equipment

Modern design usually provide stainless steel, higher alloy and non metallics at strategic locations in all equipments that came in direct contact with spent liquor usually including first washer.

Due to problems of stress ciloride cracking higher alloys like ASTM B 625. Hastelloy G, Incolloy 800, Carpenter LOC 63 are being used.

A specific composition of statistical (eg. 316 SS) can be specified for the surface of submerged are overlay. Submerged are overlays are much more uniform in composition and have fewer flaws for initiation of corrosion undercutting.

Stainless steel clad steel

Roll bonded or explosion bonded clad steel can be used for new construction to reduce the cost of solid stainless steel. Weld procedures for clad plate construction must be closely followed to prevent corrosion of welds.

Equipment failures.

Failures of stainless steel equipments are frequently due to either hus application (eg. incorrect alloy) or intergranular corrosion. Intergranuler corrosion of austenitic stainless steels are normally the result of sensitization which involves the continuous precipitation of chromium carbides when the metal is exposed to temperatures in the range of 425-815°C. Precipitation increases with increasing carbon content and exposure time.

While decay is an example of inter granular attach that occurs in bonds are exposed to initial temperature range adjacent to welds which for extremely erosive conditions as found in digestor cheap screw presses and refiner plates, corrosion and wear resistant alloys are used.

Corrosion prevention and repair

1) Thermal spray coatings

The life of plain carbon steel digestors have been extended by Thermal spray coatings. Thermal spraying is a process in which metallic and non metallic parts are deposited in a semimolten condition to form a corrosion resistant coating for the base metal. There are three major process.

- Flame spraying
- Electric arc
- Plasma spraying

Coating Thickness vary with processes and materials being sprayed but thickness in excess of 0.75 mm limits can be applied.

Disadvantage : Porosity may lead to corrosion under cutting.

2. Weld Overlay

A better method for refurnishing digestors is weld overlay. Both manual and automatic process are used. The automatic submerged arc process has been used extensively for extending the service life of Kraft digestor. Sensitization of stainless steel

Sensitization can be prevented or reduced significantly by reducing the carbon content to values such that the carbide formation is inconsequential less than 0.02 to 0.03% or by using carbide former alloy additions such as titanium or columbium Tantalum.

Stress corrosion.

Stress corrosion cracking is a form of corrosion that occurs when a metal is under combined inference of stress and corrosion.

One major drawback in the use of austenite S.S. steel is sudden and frequent failure due to chloride stress corrosion cracking.

Located corrosion

Of this type Pilling and crevice corrosion are the two forms.

Located corrosion is defined as the selective removal of metal by corrosion at small areas or zones, in a metal surface in contact with aqueous environment.

Only alloys such as S.S. Steel which depend on a passive film for corrosion prevention are susceptible to this type of corrosion.

Located corrosion can occur only in an environment which contain an oxidising agent, and aggressive anions eg. chlorides.

Corrosion-Erosion

Good design will avoid abrasion by suspended solids or impingement of liquor since this sources of the oxide layer that gives stainless steel is corrosion resistant properties.

In stationary digestors the vapor zone is especially susceptible beceause of condensation as is the side wall where liquor and chips wash the surface and tend to wipe off the protective coating.

TABLE 5.5
SOME BULK MATERIALS INDIGENOUS TO PULP AND PAPER MILLS HANDLED BY SCREW CONVEYORS [12]

Material	Avg. Wt. per Cu. Ft. Lbs.	Class (See Table I)	Wt. kg/m³
Coal, anthracite			
Coal, bituminous, mixed, 50 mesh and under	60	C27P	1078
Coal, bituminous, mixed, sized	50	B36P	898
Coal, bituminous, mixed, slack, ½" and under	50	D26PT	898
Fine Alum	50	C36P	898
Kaolin clay, 3" and under	45-50	B26*	808-898
Lime, ground, ¼" and under	163	D27	2928
Lime, hydrated, ¼" and under	60	B36Z	1078
Lime, hydrated, pulverized	40	B26YZ	718
Lime, pebble	32-40	A26YZ	575-718
Limestone, crushed	53-56	D36	952-1006
Limestone, dust	85-90	D27*	1527-1617
Bark, wood, refuse	75	A37Y*	1347.6
Pulp	10-20	H37X*	180-360
Salt cake, dry, coarse		*	
Salt cake, dry, pulverized	85	D27	1527
Sawdust	65-85	B27	1168-1527
Slag, furnace, granulated	10-13	*	180-234
Soda ash, heavy	60-65	C28	1078-1168
Soda ash, light	55-65	B27	988-1168
Starch	20-35	A27W	360-629
Sulphur, crushed, ½" and under	25-50	*	450-898
Sulphur, lumpy, 3" and under	50-60	C26S*	898-1078
Sulphur, powdered	80-85	D26S*	1438-1617
Trisodium phosphate	50-60	B26SY*	898-1078
Wood chips	60	B27	1078
Wood flour	10-30	H36WX*	180-540
*Consult the Manufacturer	16-36	*	287-647

TABLE 5.6—MATERIAL CLASS DESCRIPTION [12]

	Material characteristic	Class
Size	Very fine—100 mesh and under	A
	Fine—⅛-inch mesh and under	B
	Granular—½-inch and under	C
	Lumpy—containing lumps over ½-inch	D
	Irregular—being fibrous, stringy, or the like	H
Flowability	Very free flowing—angle of repose up to 30°	1
	Free flowing—angle of repose 30° to 45°	2
	Sluggish—angle of repose 45° and up	3
Abrasiveness	Nonabrasive	6
	Mildly abrasive	7
	Very abrasive	8
Other characteristics	Contaminable, affecting use or saleability	K
	Hygroscopic	L
	Highly corrosive	N
	Mildly corrosive	P
	Gives off dust or fumes harmful to life	R
	Contains explosive dust	S
	Degradable, affecting use or saleability	T
	Very light and fluffy	W
	Interlocks or mats to resist digging	X
	Aerates and becomes fluid	Y
	Packs under pressure	Z

CHAPTER 6

MAINTENANCE EFFECTIVENESS

A measure of how well a maintenance department is doing its job is called "maintenance effectiveness. This is not easily measured and defined as the efficiency of a piece of production machinery. These are however several yardsticks for monitoring and measuring a maintenance departmental effectiveness as it relates to the overall units productivity.

Availability performance and productivity

productivity

Availability performance can be defined as a measure of the performance of equipment in the terms of availability to operate without problems and their specified external condition. It depends partly on characteristics of the technical system and partly as the efficiency of maintenance.

Availability performance can be divided into three parts ie.

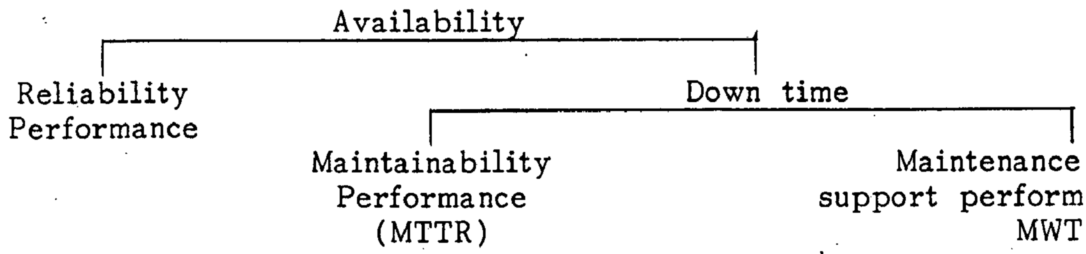
- Reliability performance.
- Maintenance support performance
- Maintainability performance

Reliability performance is measured by mean time to failure (MTTF). Reliability performance is the average time on equipment is able to operate between stops due to maintenance. Reliability performance can be influenced much in the project phase, when decisions are taken about the equipments that will be bought are influenced by performance of product and maintenance in the operation phase. Maintenance support performance is measured by mean waiting time (MWT). Maintenance support performance is the averag waiting time for maintenance resources when a stop occurs. Maintenance support performance is influenced by the organisation and strategy by both production and maintenance. Maintainability performance is measured by mean time to repair maintainability performance is the average repair time of the failure happened and is very much influenced by the design of the equipment ie. it is very much determined in the design stage.

To increase availability performance we must be able to increase reliability performance decrease maintenance support performance and maintainability performance.

Mean Down time is abbreviated MDT and it is MWT + MTTR.

If the maintenance department is managed the right way, the productvity can be increased. The production is of course department on the installed capacity. Seldom is it possible to achieve the same production as the installed capacity because difference factors such as maintenance losses, quality losses, idling etc. are influencing the production and the prductivity.



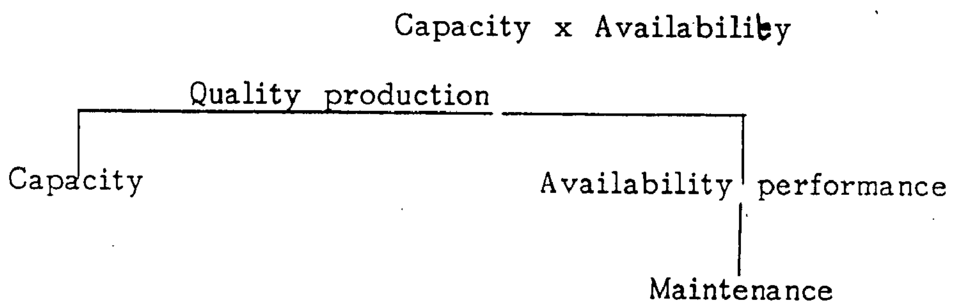
To get 100% utilisation of the capacity mean that the equipment must not be stopped any time when we want it in operation meaning that the availability performance must also be 100%. The lower the availability performance is the lower will be the production. Because maintenance influences the availability performance in a very high grade the productvity will also be influenced.

When an investment is done in maintenance, the pay back time in increased productivity must be calculated. Increased productivity can be increased production increased quality lower capital tie-up etc.

If we are planning to invest in maintenance, the payback time in increased productivity Must be calculated. Increased productivity can be increased production, better quality, lower capital tie up etc.

If we are planning to invest in maintenance, a calculation must be made in increased availability performance. Then we must evaluate how much the increased availability performance will influence the productivity.

Production = Availability performance x capacity



Availability performance can be calculated. The basis is maintenance management is to do availability performances calculations. Every economical calculation in maintenance must begins with an availability performance calculation to calculate the increase in availability performance due to planned change.

To calculate availability performance the following formulae must be used.

A = Availability performance

MTTF = (Mean time to failure) = Reliability performance

MWT = (Mean Waiting Time) = Maintenance support performance

MTTR = (Meantime to repair) = Maintainability performance

$$\text{Availability} = \frac{\text{MTTF}}{\text{MTTF} + \text{MWT} + \text{MTTR}} \times 100$$

or

$$A = \frac{\text{MTTF}}{\text{MTTF} + \text{MDT}} \times 100 \ \%$$

MDT = MWT + MTTR

(mean Down time)

$$A = \frac{\text{Tup}}{\text{Tup} + \text{Tdown}} \times 100 \ \%$$

Tup - Time for production

Tdn = Time down due to maintenance

MTTF = Tup Hrs/failure

a - Number of stoppage due to maintenance

Similarly MDT = Tdn/a

Calculation of availability performance of CMP plant.

As described earlier, Chemi-mechanical pulp plant is a continuous pulp mill hence the stoppage of any section will result in the stoppage of production, hence this plant is chosen for a maintenance availability study. Down time details for the year (1991 April to 1992 March) was taken from maintenance and plant log books and is tabulated in the data sheet 6.1. Different heads of stoppage are

a) Process

b) Maintenance

c) Planned shut (due to stoppages in paper machine or cloth changing or grinding sequent change in CMP plant.

d) Miscellaneous (Grid power facture, power restriction, high level in the storage tower, others such as recovery problem, effluent problem etc.

The stoppage percentage for years 1989-90 and 90-91 is shown for comparison. It can be seen that maintenance stoppages for the year 1990-91 is 7.3% and there is an improvement in the year 1991-92 as 5.7%. However taking into consideration 89-90, 5.3% there is room for further improvement.

Let us calculate the availability performance of the plant.

Tdn = Down time due to maintenance for the year 1991-92

= 500 hrs 20 mts

Tup = Time for production

= 6286 Hrs.

Availability performance due to maintenance

= [Tup/(Tup + Tdn)] x 100

= [(6286 x 100)/(6286 + 500.33)] = (6286/6786.33) x 100

= 92.6%

Even though 92.6% availabilility looks good there is a lot of room for improvement. This availability is obtained after getting a lot of maintenance windows and planned stoppages. Hence a survey was done to find out the equipment which caused the maximum breakdown hours thereby reducing the plant availability.

DATA SHEET 6.1. Failure of major equpement CMP plant year 1991-92

Sl. No.	Equipment	Hours
1.	No. 3 Raffinator	69 hrs 30 mts
2.	No. 3 High density pump	67 hrs 35 mts
3.	Unbleached washer	50 hrs 45 mts
4.	Double Conical press (DKP)	25 hrs 30 mts
5.	No. 2 Raffinator	23 hrs 30 mts
6.	No. 2 High Density pump	10 hrs 30 mts

Based on the theory explained here, a maintenance decision model as shown in figure evolved as given in chart 6-2. From the data collected three top tanking equipments which had contributed the maximum in breakdown were identified.

Namely
1. No. 3 High density pump
2. No. 3 Raffinator
3. Unbleach washer

Each case was studied and with the help of the maintenance decision model a suitable maintenance strategy is reached to reduce or eliminate breakdown in these equipments.

1. No. 3 H.D. Pump

As explained in CMP process, it can be seen that No. 3 Raffinator Pump is cleaned thickened and sent to the High Density tower for storage and further processing in paper machine. The high density pump No. 3 is used to pump thick pulp from thickner to the storage tower.

The breakdown analysis shows that most of the breakdowns are caused by the pump blades getting damaged by metallic parts coming to the system (thickner spray nozzles, conveyor fixing bolt etc) . Another reason is reduced pumping rate due to increase in clearence of the blades.

The maintenance decision model is applied to find a correct maintenance method. Condition monitoring is ruled out since there is a failure development time. Since the failrure are random, fixed time maintenance also is not very effective. Of course a certain percentage of stoppage due to low pumping can be avoided by fixed time maintenance. ie. checking the pump clearance due to adjusting it in every three month's time. The unexpected breakdown cannot be avoided. Since the breakdowns are random and without failure development time, a redundancy system is selected. To install another H.D. pump in parallel is not possible due to the following reasons.

1. H.D. Pump is very costly Rs. 1 crore cost prohibitive.
2. There is no space in the plant area. As shown in figure normally the pulp flow is from No. 3 stock chest ( ) to the centricleaners(4).

The pulp is pumped from stock chest to the centricleaner with the help of the stock pump . After cleaning, the pump go for thickening in the thickener . The thickened pulp is pumped to the storage tower (7) with the help of H.D. pump No. 3 ( )

The possible bypass system as shown is to use a low density pump (3A) to pump pulp directly to storage tower ( )

In that case there will be no cleaning of pulp which will mean that the pulp will be of the reduced quality. Secondly due to avoidance of the thickness, low consistency pulp is pumped to the tower and this will reduce storage at space. Since the pulp produced in Chemi-mechanical plant is of acceptable quality even without cleaning, the bypassing of cleaning system for short period will not affect. The high density tower is large enough and hence for short periods space management is possible. Moreover there will be a considerable gap between successive by-passing and will not cause much problem in the system. In short, the by-passing suggested is technically feasible.

Now let us look into the economic side of that. Cost of proposed modification.

		Rs.
1.	One Centrifugal stock pump of size 30cm x 25cm	300000.00
2.	One 130 kW motor for the pump	200000.00
3.	Cost of 100 mm of SS pipe of 350 mm dia.	650000.00
4.	Valves and other fittings	150000.00
5.	Erection charges including civil works	100000.00
		1400000.00
		Rs. 14 lakhs

Benefits

Plant stoppages reduced based on	
1991-92 No. 3 HP Pump stoppage	66 hrs 20 mts
Production saved in terms of pulp	524.87 Ton
Savings (calculated as difference in costs of imported mechanical pulp and indigenous pulp 4000 x 525)	Rs 2100000.00
Pay back period	= 8 months

It can be seen that the scheme is very much viable economically also. Moreover this bypass arrangement can take care of breakdown in centricleaner and thickners also.

No. 3 Raffinator

This is one of the most important equipments of the plant. Pulp is ground to the final freeness in this. The equipment is driven by 6.5 MW motor and is heavily loaded. There are built in protection equipments like vibration monitor, oil flow, bearings, temperature measurements etc. If anything goes beyond the threshold limit, the equipment stops, protecting from any further damage.

The plant stoppage due to this equipment for the study period (12 months) is 51 hrs 10 minutes. This was mainly due to the failure of the pressure cylinder 'O' ring.

During annual shut down 'O' rings do not have a falure development time and will not give any prior indication hence condition monitoring cannot be done. Look at the previous failure details, it can be seen that always the "O" rings give a regular failure pattern and it is more than 6 months. Hence it is recommended to have a fixed time maintenance ie. changing the "O" rings in every 6 months utilising a maintenance window. This will help in avoiding a breakdown and we can convert the unplanned maintenance into a planned one.

This will reduce the total time required for maintenance (since the work is planned) and because it is taken during a plant shut down. There is no production loss to count. The 'O' rings are not very costly, so the fixed time maintenance in all the more advisable.

The company had already started implementing the ideal successfully. This had helped them in reducing the down time of the equipment. This is an exa ple of the successful application of the maintenance decision model.

Unbleach washer.

The equipment is used to wash the pulp and the stoppage of it can cause the complete stoppage of production. It has got a drum of 33.75 cm dia and 55 cm long and is submerged half way in pulp causing a big upthrust.

This equipment has accounted for 50 hours 45 min. stoppage of the plant. Looking at the stoppages, it can be seen that a number of times this was caused due to drive failure. The bearing housing and gear box housing was not holding the drum down due to the upthrust and the drum gets lifted up. Because of this water enters the gear box, causing it to fall. On a number of occasions the motor has stalled one to increased torque.

One good method to avoid this failure is to use the design out technique. This washer drive head design should be changed to cast steel instead of cast iron and the drive gear box must be strengthened and a higher kW motor is to be used. This modification can be done by the maintenance department.

All these changes will improve the maintenance effectiveness. The plant availability will definitely improve resulting in better productivity.

Maintenance Effectiveness factor - UW factor [9]

A good factor on the effectiveness of a maintenance department is to use UW factor. UW factor is also a measure of the improvement potential. We are considering both the wasted time and the portion of unplanned activities in the maintenance department.

UW factor = U x W

U = Unplanned maintenance work

W = Wasted time related to unplanned work..

On consultations with the maintenance personnel and the process, it was observed that about 70% of the jobs done in the pulp null is of unplanned nature.

A few jobs were selected and a study was conducted to find out the actual time of work, the preparation time or wasted time also was calculated.

From this data it can be seen that nearly 50% of the time is wasted on preparation for unplanned work.

At the same time only about 30% time is wasted for a planned work for preparation.

If unplanned jobs can be brought down to 20% and the wasted time to 30% in the improvement potential will be 29% as shown by graph.

TABLE 6.2. PREPARATION TIME VS WASTED TIME

Sl. No.	Nature of work	Total Dn time	Preparation time	Actual work
1.	No. 1 knotter bearing change	4 hrs 20 mts	2 hrs 15 mts	2 hrs 05 mts
2.	Transfer pump rotor change	5 hrs 10 mts	2 hrs 30 mts	2 hrs 40 mts
3.	Conveyor drive belt change	2 hrs 40 mts	1 hr 10 mts	1 hr 30 mts.
4.	Agitator stand packing	3 hrs 25 mts	1 hr 25 mts	2 hr
5.	Screw drainer bearing change	4 hrs 50 mts	2 hrs 30 mts	2 hrs 20 mts

Preparation time is time wasted related to unplanned work such as finding out to do, find out right people, spares, technical documents, tools etc.

TABLE 6.5 DOWN TIME DETAILS OF CMP PLANT FROM 1989 - 92.

DESCRIPTION	1989-90		1990-91		1991-92	
	Hrs-Mts	%	Hrs-Mts	%	Hrs-Mts	%
ESS	4-30	0.1	13-20	0.2	23-20	0.3
TENANCE						
MECHANICAL	263-05		485-50		353-55	
ELECTRICAL	150-55	5.3	123-15	7.3	121-50	5.7
INSTRUMENT	51-40		29-50		24-35	
NED SHUT	453-40	5.2	941-15	10.7	640-77	7.3
ELLANEOUS						
GRID POWER FAILURE/RESTRICTION	116-05	1.3	125-05	1.4	266-00	3.0
HIGH LEVEL	826-20	9.4	415-18	4.8	636-00	7.3
ERS	644-00	7.4	280-45	3.2	407-25	4.6
TOTAL	2510-15	28.7%	2414-15	27.6 %	2474-00	28.2%

TABLE 6.4. Down time details of CMP Plant 1991-92

Details of Downtime for the complete equipments in following pages

April 91	Hrs.Mts.	Reasons
1/4/	4-30	DKP main motor replaced
	3-15	Unbleached washer patch up
5/4/	1-10	Bleached washer wire patch up
6/4/	1-15	No. 2 H.D. pump gear box oil change
13/4/	3-25	R2 Infeed couplings pad failure
18/4/	4-30	DKP gear box maintenance
19/4/	8-15	DKP gear box change
	26-20	

TABLE 6.1. CONTD.

May 1991 Date	Hrs. Mts	Reason
1/5/	Annual shut	Excluded from maintenance calculation
2/5/		
3/5/		
6/5/	6-15	Coupling pad failure on 521-25 pump
	1-25	Alignment work
7/5/	1-30	Trough welding work
9/5/	9-45	No. 3 H.D. Pump screw change work
13/5/	8	No. 3 Raffinator 'O' ring failure
15/5/	18	Unbleached washer and gear failure
25/5/	2-00	No. 2 H.D. Pump repair
26/5/	8-00	Screw drainer change
	10.00	
	31.05	Planned mainenance shut
	86.00	

TABLE 6.4 CONTINUED

June 1991 Date	Hrs.Mts	Remarks
1/6/	1-00	All raffinators tripped due to low pressure
15/6/	5-40	R1 infeed screw chain broken

	6-40	

TABLE 6.A. CONTINUED

July 1991 Date	Hrs.Mts	Remarks
4/7/	18-00	R3 rear side bearing change
10/7/	1-00	Planned shut for checking and modifying impregnation liquor system
11/7/	15-30	No. 3 H.D.pump failure
13/7/	16-00	No. 3 Raffinator 'O' ring failure
		Bearing repair
15/7/	7-00	Unbleached washer gear failure
18/7/	7.00	Screw drainer failure
21/7	2	No. 2 H.D. pumping not pumping properly

	66-30	

TABLE 6.A CONTINUED.

August '91 Date	Hrs.Mts.	Remarks
2/8/	4-30	No. 3 Raffinator 'O' ring change
4/8/	5	No. 5 H.D. Pump failure
6/8	6-30	Unbleached washer gear failure
9/8	2-55	Screw drainer repair work
15/8	8	No. 2 Raffinator bearing change
20/8/	2-15	No. 2 H.D. Pump not pumping

	29-10	

TABLE 6.4. CONTINUED.

September 1991-Dates	Hrs. Mts	Remarks
3/9/	1-30	Raffinator Discharge conveyor got jammed.
5/9	4	No. 3 Raffinator 'O' ring change . Lubrication problem
6/9	5	No. 3.H.D. pump not pumping
11/9/	6	Unbleached washer gear failure
15/9/	2	Screw drainer welding work
28/9/	2	No. 3 H.D. Pump failure

	20-30	

TABLE 6.4. CONTINUED.

October 1991-Date	Hrs.Mts.	Remarks
21/10	3-00	No. 3 H.D. Pump failure
25/10/	2-00	Bleached washer gear failure

	5-00	

TABLE 6.A CONTINUED.

November 1991-Date	Hrs. Mts	Remarks
31/11	8-00	No. 3 Raffinator 'O' rings failure
		No. 3 Raffinator bearing change
6/11/	3-00	Unbleached washer gear failure
8/11	4-45	DKP Gear box failure
13/11	3-00	No. 2 Raffinator 'O' ring failure
16/11	1-15	No. 2 Raffinator feed screw change
21/11	3-00	Bleached washer patch up
25/11	3-00	No. 3 H.D. Pump failure

	26-00	

TABLE 6.A CONTINUED.

December 1991-Date	Hrs.Mts	Remarks
3/12	8-00	No. 3 Raffinator screw change
		No. 1 Raffinator 'O' ring failure
5/12	8	No. 3 H.D. Pump failure, complete overhau
7/12	7	Unbleached washer gear failure
11/12	3	Conveyor coupling failure
21/12	8	D.K.P. Press pulley problem
27/12	3	No. 1 H.D. Pump gasket leak

	37-00	

TABLE 6.4. CONTINUED.

January 1992-Date	Hrs.Mts	Remarks
7/1/	3	No. 3 Raffinator Oil flow problem
		No. 3 Raffinator 'O' ring failure
9/1/	8	No. 3 H.D. Pump failure
13/1	6	No. 1 H.D. Pump failure
17/1/	3	No. 2 H.D. Pump contamination
21/1/	4	Screw drainer failure
25/1	2-30	Raffinator tripped due to water cooler cleaning
	26-30	

TABLE 6.A. CONTINUED

February 1992-Date	Hrs.Mts.	Remarks
10/2	2	Planned shut for checking impregnator liquor circulation
15/2	3-10	All raffinators tripped due to low pressure problem
	----------	
	5-10	

TABLE 6.A. CONTINUED.

March 1992-Date	Hrs.Mts	Remarks
8/3/	6-20	No. 3 H.D. pump failure impeller changed
16/3	4	Overhauling Hypo mixer failure
21/3	2-15	Bleached discharge conveyor failure
23/3/	8	No. 2 Raffinator rear side bearing change
26/3	5-30	Planned shut for thickness check and maintenance

	22-05	

TABLE 6.5 Down time details of CMP Plant 1991-92

Description	April	May	June	July	August	Sept.	October	Nov.	Dec.
A Process		6.00	5.00	3.15	--	--	2.15	2.00	2.30
B. Maintenance									
1. Mechanical	19.20	86.00	6.40	66.30	29.10	20.30	5.00	26.00	37.00
2. Electrical	0.30		20.30	23.15	4.30	10.40	0.30	9.05	2.25
3. Instrument	0.35	14.20	6.30	--	5.40	4.40	1.00	--	0.65
C. Planned shut	449.15	39.30	16.15	--	12.15	21.10	35.10	19.35	--
D. Miscellaneous									
1. Grid failure		7.15	4.00	2.05	18.00	27.25	54.55	11.20	61.50
2. High level failure		27.15	7.40	30.30	35.40	47.00	5.00	197.45	156.10
3. Others		68.00	45.20	60.50	2.00	7.40	109.30	7.25	5.55
Total	458.30	246.55	111.50	186.25	107.15	141.45	213.20	273.10	265.05

TABLE 6.5. CONTINUED.

	Jan.	Feb.	March	Total	%
A Process	1.05	0.30	0.45	23.20	0.3%
B. Maintenance					
1. Mechanical	26.30	5.10	29.45	353.55	
2. Electrical	12.40	2.35	33.45	121.50	5.7%
3. Instrument	--	--	7.40	41.05	
C. Planned shed	12.00	36.05	--	640.55	7.3%
D. Miscellaneous					
1. Grid failure	33.20	26.40	19.10	266.00	3.0%
2. High level failure	45.30	39.55	43.35	636.00	7.3%
3. Others	26.15	14.50	59.40	407.25	4.6%
Total	125.45	125.45	186.40	2774	28.3%

TABLE 6-6

List of six equipments in CMP plants which causes maximum down time

1991-92

No.	Equipment	Hrs.Mts
1.	No. 3 Raffinator	69 Hrs 30 mts
2.	No. 3 H.D. pump	67 hrs 35 Mts.
3.	Unbleached washer	50 hrs 45 mts
4.	Double conical press	25 hrs 30 mts
5.	No. 2 Raffinator	23 hrs 30 mts
5.	No. 2 High density pump	10 hrs 30 mts

CHAPTER 7

MAINTENANCE PROBLEMS IN PAPER MACHINE SECTION

HNL paper machine down time analysis for year from 1991 April-1992 March is shown on Page 101. During the years there is a marked reduction in maintenance problem. It should be commended that the machine down time has reduced in spite of the aging problems of paper machine.

The Detailed down time chart for 1991-92 is shown below. We see that the maintenance is slightly greater than that of the previous year 90-91.

Based on the data obtained from this chart down time for maintenance problems can be classified under the following titles.

1.	Breakdowns	=	690 minutes
2.	planned shut for maintenance reasons	=	7750 minutes
3.	Improper functioning of machine parts	=	261 + 435 + 340 + 935 = 1971 mts
4.	All other jobs combined	=	2326 mts

A pie diagram indicating the time consumed as shown below:

Total 12737 minutes

1. BREAKDOWNS

Paper machine is an assembly of different rotating elements with independent drives. In such a combination mechanical breakdown in inevitable. The duty of the maintenance department is to keep the time consumed to minimum levels. Most of the breakdowns in the rotating elements like drives, gears, pumps can be detected by the unusual vibrations these machines make. This is why all major paper mills consider vibration analysis as an essential tool to their maintenance philosophy. If the vibration change is detectable machine component is detected for investigation a future date during a planned shut. This way the minor breakdowns can be avoided by a prompt vibration analysis. Besides the change of machinism if needed can be done during a planned shut instead of causing a breakdown.

In any case breakdowns should be kept a minimum because in a large integrated paper mill, Each minute of production loss means a loss of Rs. 3600/- to the company.

PLANNED SHUT

Major part of the planned shut of 7750 minutes is taken up by individual component replacement.

The roll replacement which has consumed much of the time of the planned shut has often taken place on subsequent weeks causing unnecessary production delays. Often this has been attributed to the lack of trained technicians. Compared to the production loss of 3 to 4 hours for a roll change, added personal cost for the same purpose is often low.

3. IMPROPER FUNCTIONING OF MACHINE PARTS

This is an area worth doing detailed study.

A break of 1970 minutes consumed shows 260 minutes of calender blade problems. This has been found out to be due to substandard doctor blades used for the purpose.

Here a new type of doctor blade called "maxi flex" doctor blades have been found successful.

After the frequent complaints on the doctor blade passing HNL has introduced the superior grade of doctor blades which have been found to be working satisfactorily. However the doctor blade problems (on) stone roll doctor which has taken place less frequently but has taken more time (435 minutes) still remain. This area needs urgent attention.

Other maintenance problems include oil flow problems in the press section (340 m) and shower problems in duo-formers and press section (935 minutes)

4. <u>All other maintenance</u> jobs combined has taken up the rest of 2326 minutes.

This means machine availability

for the year 1991-92 has been	=	Tup/Tup + Tdn
	=	(330 x 24 x 60)/12736
	=	475200/487936
	=	97.39%

Time taken up by maintenance

department is	=	2.61%

which has been good.

This performance has however been possible after the 15 day annual shut down and the increasing operational problem like paper breaks, felt change etc. that has taken place during the year.

TABLE 7.1. PAPER MACHINE PLANT

Down time Analysis for the month of April 1991

Head	Dn. time [Hrs. Mts]	Remarks	Hrs. Mts (Date)
Maintenance			
Mechanical	7.35	1. Calender doctor passing	.20 (1/4)
		2. Paper breaks due to oil leakage at press	.20 (1/4)
		3. Stoppage for arresting oil leakage at press	.45 (1/4)
		4. Oil leakage from Dryer No.27	.10 (7/4)
		5. Condensate leakage from dryer No.10	.10 (3/4)
		6. Vacuum flume pump failure	1.25 (5/4)
		7. Work on LP shower Duo-former pump	4.00(17/4)
		8. Delay for bypassing save all shower pump	.10 (18/4)
		9. Bottom wire return roll shower hose failure	.15 (19/4)
Electrical	0.45	Tripping of Vacuum pump	11/4
Instruments	1.40	Steam and moisture control malfunctioning	.15 15/4 .15 on 17/4 1.00 on18/4 & .10 on 20/4
Planned shut down	216.45	Annual shut down	22 (30/4)

May 1991 TABLE 7.1 CONTINUED.

Head	Dn. Time Hrs. Mts.	Reasons	Hrs/mts	(Date)
Mechanical	21.35	1. Work on presspit agitator	8.05	4/5
		2. Work on calender rope pulley	0.35	5/5
		3. Calender doctor passing doctor blade changing etc.	1.10	19/5
		4. Stone roll doctor passing 4.50	0.30	9/5
			0.10	11/5
			0.30	26/5
			1.55	27/5
			1.45	29/5
			-4.50	
		5. Sweat dryer doctor passing doctor blade changing		
		6. Problem one to wrong portion of pick up vacuum box	0.30	8/5
		7. Water splashing from cooling water connection causing breaks at sweat dryer	0.35	
		8. Bursting of top felt HP shower hose	0.15	30/5
		9. Work on press hydraulic system for press load failure	1.50	31/5
Electrical	11.20	1. Duoformer & Save all HP shower pump motor burning	2.00	
		2. Secondary fan pump tripping, starting problem	3.45	
		3. Reeler tension controller malfunction-ining	0.15	2/5

TABLE 7.1 CONTINUED

		4. Vacuum pump No. 1 tripping		0.35	12/5
		5. Save all by-passing	1.40	0.35	13/5
				1.05	14/5
		6. Crane failure	2.05	1.30	15/5
				0.25	19/5
				0.10	29/5
		7. Stone roll drive failure		1.00	19/5
				2.05	
Instruments	16.05	Plant shut 12.65			
		1. Start up after annual shut			
		2. Work on BM gauge and changing top felt			

June 1991

TABLE 7.1 CONTINUED.

Head	Dn. Time (Hrs. Mts.)	Reasons	Hrs/Mts	(Date)
Maintenance				
Mechanical	11.50	1. Stone dryer tail feeding pipe problems	0.10	4/6
		2. Stoppage due to hindrance to crane movement for problem in the rail	0.15	7/6
		3. Checking suction press rolls	0.15	9/6
		4. Bypassing No. 2 pressure screen	0.20	16/6
		5. Work on pressure screens	4.35	16/6
		6. Bypassing No. 1 pressure screen for gland leakage	0.15	13/6
		7. Work on press pit agitator gland	0.30	19/6
		8. Tripping of vibrating screen	0.30	19/6
		9. Changing the gear box of piper roll before pope reel	0.45	23/6
		10. Stone roll doctor blade passing and doctor blade changing	0.10	27/6
		11. Wire return roll doctor blade changing	0.10	27/6
		12. Calender doctor blade changing	0.10	27/6
		13. Pope reel break down	3.15	29-30/6
Electrical	6.35	1. Crane facture	3.55	
		2. Pick up roll getting lifted on its own	0.50	17/6.
		3. Secondary fan pump starting problems	0.20	22/6

TABLE 7.1 CONTINUED

		4. Tipping of the condensate pump of A2 tank	0.15	20/6
		5. Work on refiner No. 3	0.20	22/6
		6. Tripping of No. 5 Vacuum pump	0.10	22/6
		7. Tripping of No. 2	0.45	27/6
Instruments	10.15			
Planned shut	16.55	For changing top press felt 3rd group top screen and for other works on 30--6--1991		

July 1991

TABLE 7.1 CONTINUED

Head Maintenance	Dn. time	Reasons	Hrs/Mts	Date
Mechanical	6-45	1. Calender doctor blade change	0.20	12/7
		2. Adjusting the F/S edge stabilizer as it was touching screen	0.20	24/7
		3. Work on press Hydraulic line, checking press part of vibrations	1.00	29/7
		4. Work on 4th group bottom screen stretcher	3.25	30/7
		5. Press shower pump/coupling change	1.40	31/7
Electrical	7.55	1. Crane failure	0.50	3,10/7
		2. IV group ·ippings	0.10	15/7
		3. Primary fan pump failure	6.55	23/7
Instrument	4.05	1. Work on m/c chest	0.10	4/7
		2. HDCP +cy. controller malfunction	0.30	11/7
		3. Stream controller malfunction	1.45	15,24,29 30,31/7
		4. Caliper control failure	0.15	19/7
		5. Breaks and stoppage due to II and III Group thermo-compressors	1.00	25/7
		6. Bursting of top felt HP shower oil hose	0.25	27/7
Planned shut	21.10	11.00 on 9/7 for work on the bearing of dryer No.31 and press pit agitator 10.00 on 23/7 for pick up felt change		

+Cy. - Consistency

August 1991

TABLE 7.1 CONTINUED.

Head	Dn. Time	Reasons		Hrs/Mts	Date
Mecchanical	3.10	1. Reeler Dr. Blade changing		0.50	3/8
		2. Stone roll doctor blade changing		0.25	4/8
		3. Stone roll doctor passing		0.15	6/8
				0.15	1/8
		4. Reeler rope pully position		0.15	9/8
		5. Work on No. 2 refiner intel plate		1.00	1/8
				2.20	
Electrical	9.15	1. Trim Squirt pump tripping		1.00	1,2/8
		2. M/c Drive tripping	1.35	0.35	2/8
		3. Secondary fan pump tripper	1.20	1.00	9/8
				.20	18/8
		4. Cy. Dilution pump trippng		0.15	8/8
		5. No. 3 vacuum pump tripping		0.10	14/8
		6. No. 5 Vacuum pump trippng		0.15	14/8
		7. Work on Duoformer, LP shower pump		2.10	20/8
		8. Work on top wire over rum L.S.		2.35	23/8
Instruments	4.05	1. Steam controller	2.25	0.35	10/8
				0.10	11/8
				0.10	19/8
		2. 3rd dryer group tripping		0.15	15/8
		3 PH controller malfunction		0.30	
		4. Head variation in computer mode		0.25	20/8
		5. Calender F/S air green below way		0.20	20/8
		6. Primary fan pump valve HIC-3 mal-functioning		0.10	26/8

TABLE 7.1. CONTINUED

Planned shut	21.40	1.	12.35	On 1/8 for ash control system incorporation and bottom felt changing
		2.	9.05	on 18/8 for top wire top felt changing

SEPTEMBER 1991

TABLE 7.1 CONTINUED

Head	Dn. time	Reasons		Hrs/Mts	Date
Mechanical	4.05	1. Stone roll doctor blade changing	0.30	0.10	1/9
				0.20	18/9
		2. Pick up suction box Vac strips positioning		0.30	2/9
		3. Trim squirt pump factors		0.45	8/9
		4. Calender doctor passing	0.35	0.10	10/9
				0.25	17/0
		5. Top felt HP shower hose failure		0.15	13/9
		6. Calender air blow pipe position		0.10	16/9
		7. Press LP shower coupling failure		1.20	24/9
Planned shut	38.40	30-25 on 6, 7/9 for changing pick up and cough rolls and pick up felt and for other works			
		7.15 on 19/9 to top felt changing			

OCTOBER 1991 TABLE 7.1 CONTINUED

Head	Dn.Time	Reasons	Hrs/Mts	Date
Maintenance				
Mechanical	10.25	1. LDCP pump failure	0.15	4/10
		2. Bursting of HP shower	0.10	9/10
		3. Calender doctor blade adjusting	0.10	9/10
		4. Work on press shower pipe	0.35	21/10
		5. Press pit agitator coupling failure	4.55	26/10
		6. Wire shower drain hose bursting	0.50	26/10
		7. Wire shower line bushing	3.30	27/10
Planned shut	35.35	For changing calender stack stone roll and pick up felt and and other works		14,15/10

November 1991

TABLE 7.1 CONTINUED

Head	Dn. Time Hrs mts	Reasons		Hrs/Mts	Date
Maintenance	3-40	1. Blending chest pump problem		1.00	6/11
		2. Press swimming roll oil failure		0.20	1/11
		3. Press swimming roll oil flow failure		0.10	26/11
		4. Break wheel fixing air hose of sweat dryer		0.10	14/10
		5. Calender doctor blade changing		0.15	19/11
		6. No. 2 Paper roll drive belt slipping			
			0.45	0.30	26/11
				0.15	28/11
		7. HP shower pump tripping		0.30	30/11
		8. L.P shower pump failure		0.30	29/11
Electrical	0-50	Calender loading failure			15/11
Instrument	9.20				
Planned shut	10.20				

Note:

1. Service efficiency = $\frac{\text{Hrs made available for paper making}}{\text{Hrs available excluding planned shut}}$

2. Operating efficiency = $\frac{\text{Actual m/c effective hours worked with paper}}{\text{Hrs made available for paper making}}$

3. Conversion efficiency = $\frac{\text{Finished production}}{\text{M/c effective hour}}$

Overall efficiency = 1 x 2 x 3

December 91

TABLE 7.1 CONTINUED

Head	Dn Time	Reasons		Hrs/Mts	Date
Mechanical	5-40	1. Failure to pump of condensate tank A5		0.30	1/12
		2. Bottom press Hydraulic flow failure		0.20	2/12
		3. Vibrating screen failure		0.20	2/12
		4. Work on duo-former LP shower pump		3	3/12
		5. Calender doctor passing	0.15	0.05	4/12
				0.10	7/12
		6. Breakes due to grease from press part		0.15	6/12
		7. Checking calender vibration		0.20	18/12
		8. Duo-former HP shower pump problems		0.25	23/12
		9. Calender doctor blade change		0.15	27/12
Electrical	9.25	1. Crane failure	7.55	7.00	4/12
				0.50	5/12
				0.05	11/12
		2. IV group tripping		0.20	5/12
		3. No. 2 vacuum pump motor failure		0.40	14/12
		4. 2nd group dryer tripping		0.30	18/12
Instruments	4.25	1. Measurex problems		4.00	
		0.20 (3/12 Steam control mal function)			
		0.10 (3/12) Speed variations			
		2.45 (7/12) work on caliper carbol			
		0.25 (9.12) BM gange malfunction			
		0.10 (10/12) clay pump speed control failure			
		0.10 (30/12) steam control mal function.			
		2. PH control mal function		0.25	12/12
Planned shut down	21.25	1. 14.35 on 2/12 for changing pick up fettle & other works			
		2. 6.50 on 4/17 for top process felt change			

January 92

TABLE 7.1 CONTINUED

Head	Dn. time	Reasons	Hrs/Mts	Date
Paper Breaks	25-35			
Rope change	1.00	1. IV group rope positioning	0.25	
		2. IV group rope positioning	0.20	
		3. Reel role position	0.15	
Others	16-16			
Maintenance				
Mechanical	4-45	1. Calender roll passing	0.20	2/1
		2. Tramp squirt pump coupling failure	0.15	8/1
		3. Ist press swimming roll oil flow failure	0.10	10/1
		4. Doctor passing on 3rd dryer	0.25	13/1
		5. Work on Ist group doctors and top wire F/s knock off shower	1.00	14/1
		6. Stoppage due to vibration in dryer No.31 and pick up lowering	2.15	14/1
		7. Disturbance due to tertiary cleaner leg leakage	0.20	17/1
Electrical	Nil			
Instrument	0.35	1. PH control malfunction	0.20	5/1
		2. Bottom press felt guide roll problem	0.15	10/1
Planned Shut	37.45	1. 17 hrs 35 mts 9/1 for changing Bottom and top press felts and other works.		
		2. 20 Hrs 10 Mts on 14, 15/1 for chaing pick up felt pick up roll and F/s b roll and F/s bearing of dryer No. 31		

February 92

TABLE 7.1. CONTINUED

Head	Dn. Time	Reasons	Hrs/Mts	Date
<u>Maintenance</u>				
Mechanical	1-20	1. Ist dryer doctor passing and doctor blade changing	0.5	4,9/12
		2. Oil flow factor in III Press causing press tripping	0.30	9/3
Electrical	8.25	1. Paper breaks due to draw vibration and calender problems.	1.20	13/2
		2. Stoppage for electric work	4.00	13/2
		3. IVth group drive tripping	0.30	14/2
		4. Stoppage due to electrical failure in winder	2.35	15/2
Instruments	1.45	Measurex	1.35	
		1. Steam corbol valve failure	0.20	1/2
		2. Steam carbol failure in remote mode causing paper break	0.35	18/2
		mode causing paper break		
		3. Ash carbol malfunction	0.25	28/2
		4. -do-	0.15	29/2
		Ph variation	0.10	22/2
Planned shut	Nil			

March 1992

TABLE 7.1. CONTINUED.

Maintenance

1. Mechanical 4.00 hrs

1. Calender doctor passing, doctor blade changing	1.05(0.35 on 2/3 0.10 on 21/3 0.20 on 23/3/92
2. Stone roll doctor passing and doctor balde changing	0.50 (0.20 on 8/3 and 0.10 on 26/3 0.15 on 29/3
3. Sweat dryer doctor blade changing	0.15 on 29/3
4. Sec. cleaning system functioning	0.45 on 11/3
5. Blow roll drive belt changing	0.25 on 23/3
6. Bypassing No. 1 pr. screen for abnormal sounds	0.10 (24/3)
7. Save all disturbances due to shower header leaking	0.30 on 29/3

Electrical 14.55 hrs

1. Stoppage disturbances due to speed variations	0.55	3/3
	2.15	4/3
	1.50	5/3
	0.15	6/3
	4.45	7/3
	1.20	8.3
	2.35	9/3

Instrumentation 0.55 Hrs

1. Stone roll doctor loading problem	0.20	14, 16/3
2. CP flow system malfunctions	0.35	31/3

Planned shut 25.509 hrs

1. 7.15 (1, 2/3) for top press felt change
2. 18.35 (13/3) for changing couch roll bottom wire and pick up and bottom felt

- AVAILABILITY CALCULATIONS 1991-92.

APRIL 1991

Maintenance time lost = 7.35/60 + 0.45/60 + 0.40/60

= 9 hours

Total time = 30 x 24 = 720

% time lost = 1.25%

Therefore availability = 98.75%

MAY 1991

Time lost by maintenance = $21\frac{35}{60} + 11\frac{20}{60} + 16\frac{5}{60}$

= 49

Total time = 31 x 24 = 744

% time lost = 6.59%

Therefore Availability = 100 - 6.59 = 93.41%

JUNE 91

Time lost by maintenance = $11\frac{50}{60} + 6\ \frac{35}{60} + 10\ \frac{15}{60}$ = 28.66

Total time = 30 x 24

% time lost = 3.98%

Therefore Availability = 100 - 3.98 = 96.02%

JULY 91

% Time lost by maintenance = 2.6%

Therefore Availability = 100 - 2.6 = 97.4%

AUGUST 1991

% Time lost by maintenance = 2.2%

Therefore Availability = 100 - 2.2 = 97.8%

SEPTEMBER 1991

% Time lost by maintenance = 2%

Availability = 100 - 2 = 98%

OCTOBER 1991

% Time lost by maintenance = 4%

Availability = 100 - 4 = 96%

NOVEMBER 1991

% Time lost by maintenance = 1.9%

Therefore Availability = 100 - 19 = 98.1%

JANUARY 1992

Availability

% Time lost by maintenance = 0.7%

Availability = 1-00 - 0.7 = 99.3%

FEBRUARY 1992

Availability $= \frac{MTTF}{MTTF + MRT}$

Repair time = 1.20 + 8.25 + 1.45 = 10.75

Total running time = 29 x 24

Availability $= \frac{696 - 10.75}{696}$

= 98.46%

= 100 - 1.7 = 98.3%

MARCH 1992

Availability of the paper paper m/c section $= \frac{MTTF}{MTTF + MRT}$

MTTF = Mean Time To Failure

MRT = Mean Repair Time

MTTF = Total running - Repair time

Availablity $= \frac{744 - 19.5}{744} = 97.32$

TABLE 7.2 Down time Analysis of paper m/c 1992-92

1.	Calender doctor blade problems		261 mts
2.	Stone roll doctor blade problems		435 mts
3.	Oil flow problem in press		340 mts
4.	Shower problem in Duoformer and press		935 mts
I.	Down time due to improer functioning of m/c parts	=	1 + 2 + 3 + 4 261 + 435 + 340 + 935
		=	1971 mts
II.	M/c parts failure causing breakdown of the paper plant (Most of these can be minimised by proper condition monitoring)	=	691 mts
III.	Planned shut for paper plant due to a number of maintenance reason	=	7750 mts
IV.	All other jobs combined	=	23.26 mts
	Total maintenance down time	=	1971 + 690 + 7750 + 2326
		=	12737 minutes

CHAPTER 8

VIBRATION ANALYSIS

ITS IMPORTANCE IN PREVENTIVE MAINTENANCE

Analysing vibration signals transmitted from rotating equipment is the cornerstone of many predictive maintenance programs. Studying these signals can be of great assistance in determining the operating condition of equipment and the nature of problem if one exists.

Mechanical equipment will oscillate in reaction to excitation or forces. The amount of vibration present depends on the amount of excitation present, the equipement's mass, stiffness and how much damping is present.

For vibration to be interpreted, it must be transformed into a signal that can be analyzed. Mechanical motion from a piece of mechanism can be sensed by a vibration transducer and converted to an electrical signal which can be amplified, displayed and analysed.

Analysis format[3]

Some mills obtain overall vibration reading for the equipment that they survey. The overall vibration level is a measurement of the total energy associated with all of the vibration frequencies coming from a given measurement point. With these readings, they [illegible] the numbers to determine if there is an increase and if any overall vibration readings are above a predescribed alarm limit. This process has the advantage of being very easy to understand and of being able to analyse a considerable amount of equipments in a short period of time. In addition some mills will use a real time analyzer to further analyze equipment with high vibration levels.

Other mills take dedicated real time analyizer to the field. This allows direct readings to be analysed, with the greatest flexibility at the equipment location they are portable and more difficult to use, few readings can be taken per unit time.

During the past several years mills have begun to use computer based data collection systems.

The computer software creates the database which defines each point to be checked and fits into a survey format. These surveys are loaded on the electronic data collectors so that vibration readings can be taken to the field. After the route is complete, the readings are downloaded back into the computer for analysis.

A fast computer is required because it can easily be overwhehmed with data. Most importantly, is the need of a software system that is fast and easy to use.

The data collectors are improving and some are beginning to rival the dedicated real-time analysers. They offer several advantages over real time analyzer and tape recorders.

* Just about any survey can be performed by one person
* They are easier and faster to use due to their portability
* They organize the equipment to be surveyed into a route format.
* They can lesser the reponse time to a request to spot check a piece of equipment.

<u>Resonance</u> [13]

The natural frequency of any object is the frequency that it would vibrate at if it was struck a blow. The natural frequency increases with increased stiffness and decreases with increased system mass.

When an excitation to an object is vibrating at the same frequency as the object's natural frequency then a state of resonance occurs. At this point the object will have much higher amount of vibration. This is also called the object's first critical. An object also has higher frequencies at which it will resonate. They are called second critical, third critical etc.

Beating

Beating occurs when two pieces of equipment operate in close proximity to each other at similar operating speeds. Their vibration go in and out of phase with each other, in a sinusoidal manner. Beating can be significant when vibration signals align with each other.

Imbalance problems

Imbalance in rotating equipment is characterised by being sinusoidal at a frequency of once per revolution and an amplitude that will increase with speed. Imbalance forces increase with square of the rotating equipment's speed.

When balancing corrections are made a key phaser is utilised as a means to reference shaft rotation with respect to phase and vibration amplitude.

Rotating machinery parts that are repaired or manufactured should be balanced before leaving the machine shop. Nower balancing equipment with built in software make balancing more accurate and faster.

Misalignment

two times running-speed frequency component and high axial readings. Often harmonies of two times the running speed will be present. Relative phase readings can help determine if misalignment is a problem. Axial vibration at each end will be approximately 180° from each other.

Mechanical Looseness

This is characterized by a large number of running-speed harmonies in the frequency spectrum. Looseness tends to produce vibration that is directional, and therefore the time-domain signal will probably be truncated. Readings can be taken at various positions on the machinery to help detect this problem.

Fluid-film bearings [12]

A fluid film bearings that is damaged will experience a great deal of inability. This is due to a pressure differential in the direction of rotation causing an oil whisle to occur. This vibration will be present at slightly less than one half times the running speed. This oil whisle may be constantly changing speed and amplitude.

Pump vane pass [12]

A pump that is not operating on its designed pump curve will cut a vane pass frequency equal to the number of vanes times the running speed. Usually several harmonics of the frequency will be present.

Gear reducers [12]

Gear problems are characterised by vibration spectrums that typically are easy to recognise but difficult to interpret. Comparisons but difficult to interpret. Comparison of vibration spectrums to baseline vibration spectrums is helpful because high-amplitude frequency components are common even in some new gear boxes. Identifying new components in the vibration spectrum or components whose levels have changed significantly, is important. A gearmesh frequency will be emitted by almost all gear sets. It will be equal to the number of teeth in the gear mesh times its rotational speed. The amplitude can vary with load.

Electrical Motors[12]

When the motor is not aligned properly within the stator an uneven air gap occurs. This can produce a vibration at 120 Hz.

Motors under load that have damaged roter bars will experience a high vibration at one revolution frequency close examination of this frequency may reveal that it is constantly changing speed and amplitude.

Another indication of electrical problems is when then slip frequency's amplitude is within at least 40 db of the time frequency's amplitude. This can be checked with a clamp type amp probe around the electrical lead.

Synchronous averaging

Different sections of a paper machine, especially the press section can be analyzed by synchronous averaging. This is a process of determining the effects of one rotating piece of equipment on another. It is the averaging together of different time-domain waveforms and developing a resultant frequency domain spectrum.

An example of this is to place vibration probes on two separate press rolls and connecting them to a two channel analyzer. The analyzer can then be triggered from one of the rolls by a . This synchronous averaging takes away the contributions of the roll being used as a trigger.

By placing probes on various rolls in press section and moving a trigger from place to place, the cause or causes of vibration can be isolated. If a large number of averages are taken, any vibration that is not in synchronization with a particular roll will appear as noise and average out. Problems such as an out-of-balanced roll, a non concentric roll, roll support looseness, drive train problems, or a worn felt may be diagnosed.

Antifriction bearings [12]

A real time analyzer is very effective at identifying defects in antifriction bearings. If the geometry and speed of the bearings are known, distinct frequencies can be calculated that will be emitted from the bearing for each part of the bearings that is defective. The geometry of parameters that need to be known are the number of rollers the diameter of the rollers, the pitch diameter and the contact angle.

From dynamics, the following equations can be derived for calculating the frequencies that will result from bearing defects.

$$C = [rpm/2\ (1 - (d/D)\ \mathrm{Cos}\ \phi)]$$

$$R = [D/2d]\ rpm\ [1 - (d/D)\ \mathrm{Cos}\ \phi]$$

$$O = N/2\ rpm\ [1 - (d/D)\ \cos\ \phi]$$

$$1 = N/2\ rpm\ [1 + (d/D)\ \mathrm{Cos}\ \phi]$$

C = Cage frequency cycle/min

R = Roller frequency, cycles/min

O = Outer race frequency, cycles/min

I = Inner race frequency, cycles/min

d = Ball or roller diameter in

D = Pitch diameter, in

N = Number of balls or rollers

ϕ = Contact angle

The results of these equations can be visually understood by taking a bearing and placing a mark on the outer race, the case and the inner race and then lining them all up. While holding the outer race stationery, rotate the inner race one complete rotation. The cage will have rotated only about 40% of the revolution. The exact amount can be calculated from one of the previous equations. The cage speed is equal to the percentage of revolution times the speed of inner race. The outer race frequency is equal to the cage speed times the number of rollers. The inner race frequency is equal to one minus the cage speed times the number of rollers.

If a defect was present in the outer race of the bearing, there would be an impact each time a roller passed over it. Therefore the outer race defect frequency is equal to one minus the cage speed times the number of rollers.

If a defect was present in the outer race of the bearing, there would be an impact each time a roller passed over it. Therefore the outer race defect frequency would be the number of rollers multiplied by the cage speed.

As an example, assume that the bearing has 20 rollers and that the cage rotates 40% of the revolution per revolution of the inner race. This would mean that 20 x 0.4 = 8, or eight rollers would pass over a defect in outer race per revolution of inner race.

Inner race problems

If an inner race defect frequency appears first, the situation must be looked closely. A cracked inner race may be determined by looking at time - Domain signal. If a strong once per revoltution peak is present in time domain then a crack may be present.

Corrosion

If a defect frequency harmonies seem to form a bell shaped curve past experience has revealed that corrosion may be present in the bearing at roller spacing.

Locked up bearings

When a bearing locks up it slides instead of rolls. It may produce a high base-level random noise with few distant peaks. This situation may also produce a high amount of vibration at once per revoluion frequency.

If a bearing is loose on its shaft it will look much the same. But it might display more harmonics of running speed.

Priority of critical equipments

Developing a list of critical equipment to be surveyed should be done with the people that are responsible for each maintenance area of the mill. Try to keep these people involved because they can determine the success. On finding a problem, tell them immediately. When they call in to check a problem, react quickly, in making up a priority list.

* The equipment without spares that can shut down or slow production.
* The equipment with spares that can shut down or slow production.
* Secondary equipment that is an inconvenience to production if shut down

Let the people in each area know that engineers really need their support to help collect information on equipment to notify it when a correction is made to a problem already diagonised, and to help in examining the replaced equipment.

Paper machine surveys

The first place to start surveys is on the paper machines Their down time is the most costly. Also their analysis is easier than other equipment in the mill. In most cases, the element is a roll with a bearing on each end. In addition a large number of possible problems can be surveyed in a relatively short period of time.

One way of breaking up the survey is as follows:

* Fourdrinier section
* Press section
* Dryer bearings
* Dryer felt rolls
* Dry land
* Pinions

* Gearboxes
* Drive motors

Usually these individual surveys can be performed in ½ hour to 3 hours. To perform the analysis of a survey can taken from 10 minutes to 4 hours depending on complexity of survey.

Monitoring intervals depend on how rapid failures in these situation can develop. Experience is a vital guide. Once a problem is detected it should be monitored more frequently.

There are three common positions for placing the vibration probes, vertial horizontal and axial.

Such as leaking pipelines, loose support feet, damaged guard and safety hazards.

To perform the analysis on the auxiliary equipment efficiently and correctly, a considerable amount of time is required. Complete and detailed information about each piece of equipment and organizing it. To be efficient and effective, Engineers need to have available the following type of information.

* Equipment number
* Equipment name
* Manufacturer
* Size or model
* Bearing portions, size, manufacturers and defect multiplier frequencies.
* Gear position and number of teeth on each
* Number of vane of blades.

History collection

One of the best ways to improve the accuracy of a vibration analysis program is to develop good history files on the equipment. It helps for future analysis. It is beneficial to keep the following information.

* Information data sheets describing equipment.
* Instrument set ups and any necessary maps
* Dates of when equipment was monitored
* Point outs of vibration spectrum when problems are found. This should be continued until the problem is corrected and then filed for further reference. Include photographs of any problems that were found and a short write-up of these problems.

CHAPTER 9

FERROGRAPHY AND ITS USE IN MAINTENANCE

Ferrography is a means of microscopic examination used to analyze particles separated from fluids. Developed in 1971, it was initially used to magnetically precipitate ferrous wear from lubricating oils.

Ferrographic instruments and techniques[1]

Advances in ferrographic instrumentation have paid the way for broader study and for classifying wear particles produced by many different metals and substances, both magnetic and non-magnetic. A ferrographic analysis of wear particles start with magnetic separation of machine wear debris from lubricating or hydraulic media in which the particles become suspended.

To establish accurate baselines the running condition of a machine, samples are taken at regular intervals from carefully selected location within the machine system preferably during normal operation. If possible, samples should be taken during normal operation. If possible samples should be taken ahead of in-line filters to ensure representative concentration of wear particles.

Two basic types of ferrographs are used to evaluate the wear particles. These are the direct reading ferrographs and the analytical ferrographic system.

The direct reading ferrograph is used to obtain numerical baseline values for normal wear. When sudden increases in direct readings occur. The analytical ferrograph allows to virlually analyse the wear particles to identify the rite and nature of the wear in time to prevent estrophic damage.

Direct reading ferrograph

The direct reading ferrograph measures the concentration of wear particles in a lubrication oil or hydraulic fluid. The particles are subjected to a powerful magnetic gradient field and are separated by order of decreasing size. Particles of 5 µm and larger are confined to the entry and of the deposition field. The particle sizes became progressively smaller along the deposition path.

Particle concentration are sensed at two locations - at the entry deposit and at a point approximately 4 mm further down the tube. A value based on the amount of light measured at two location is then determined. Based on the measurement of the density of large particles and density of small particles. We can derive values for wear particles concentration and the percentage of large particles.

With these measurements, machine wear baseline can be established, and trends in wear condition can be monitored. In this way, direct ferrograph reading serve to alert maintenance personnel to an abnormal trend in wear.

Analytical ferrographic system

When Direct ferrographic readings indicate abnormal wear, analytical ferrographic techniques can be used to study the wear pattern. The purpose is to pin point the difficulty and identify the nature is potential machine problems.

The analytical ferrograph system includes I.A. ferroscope for measurement and Analysis.

2. The ferrograph, which accurately prepares ferrograms, or slides on which wear particles have been deposited.

3. The FAST system of data management and reporting (Ferrographic analysis software technology).

Ferroscope

Ferroscope is a three power bi-chromatic microscope for instant and 35 mm cameras. Under magnifications of 100X, 500X and 800X the ferroscope utilises both transmitted and reflected high sources with red screen and polarizing filters to distinguish size, composition, shape and texture of both metallic and non metallic particles.

Ferrogram maker

The ferrogram maker is designed with two independent station to permit two samples to be prepared at the same. Each station includes a holder that accurately positions a slide at a slight incline over the machine assembly.

A sample of used fluid which can be a lubricant preparation, a hydraulic fluid or an aqueous solution is prepared by diluting with tetrachloride ethylene as a fixer to improve plastic precipitation. The prepared sample is allowed to flow down the inclined slide, passing across the magnetic field. Wear particles arrange themselves along the slide, with largest particles deposited first. Ferrous particles line up in string that follow the magnetic lines of the instrument.

This long deposition pattern spreads the wear particles out, providing good resolution of large and small particle. Good resolution is important

The FAST system

The automated mode features the FAST analytical system for enhanced data management. Comparative analysis and reporting. The system features a video camera that projects the image through a personal computer to a high resolution video monitor. The system also incorporates an optical video monitor for data stage and retrieval.

TYPES OF WEAR PARTICLES - IDENTIFYING PARTICLE TYPES

Rubbing wear

This particle type consists of flat platelets, generally no more than 5 µm in major dimension. They may range upto 15 µm before being considered to be severe wear particles. There should be little or no visible textures to the surfaces, and the thickness should be 1 µm or less. A special case of normal rubbing wear is break in wear which is characterised by flat, long particles generated as machining marks are rubbed off by sliding surfaces.

Sliding wear

These particles are identified by parallel stiration on the surface. They are generally greater than 15 µm in major diameter, with the length to thickness ratio falling between 5:1 and 30:1 severe sliding wear particles sometimes show evidence of temper colours, which may change the appearance of the particles after heat treatment.

Cutting wear

Cutting wear particles may resemble drill turnings, whittling chips, or gourged out metal.

Spalls and Chunks.

Chunks are generally greater than 5 µm in major dimension, with the length 5:1. There is generally same surface texture, and the particles do not appear flat. Instead they are rough and shaped like chunks, but they are thinner, Small spalls are distinguished from normal rubbing wear by slightly great thickness and surface texture. It is often necessary to examine very small particles at 800 x magnification to resolve these characteristics.

Laminar particles

When a plastic of any severe wear type passes between surfaces of rolling elements, the effect is similar to that of a rolling pin on pie dough. The particle is flattened out, the edges may split and there are often holes in the centre. There are called laminator particles.

The length to thickness ratio is generally greater than 30:1. Although laminar particle can be very small, in a practical sense only the larger particles will be rolled out. Laminator particles greater than 15-20 µm in major dimension indicate the formation of other severe wear particles.

Spheres

Spheres may be present either as symptom of wear, as a symptom of fatigue or from contamination. The formation of sphere as a wear phenomenon is generally associated with rolling elements. Spheres formed by wear mechanism are generally less than 5 µm in diameter, with very smooth surfaces. if the diameters range beyond 5µm or if the surfaces appear rough or oxidised, the source of spheres is probably cavitation or contamination. Sources of contamination include grinding or welding.

Red-oxides

These particles represent severe sliding wear particles, except that they are usually grey whether viewed in white transmitted light only. They will appear translucent and reddish brown. They are formed in condition of inadequate lubrication and they are in effect oxidation of severe sliding wear particles. Particles of this type that are thick and rounded with a thickness ratio similar to that of chunks may organise from fretting mechanisms.

Dark metallic oxides

These particles resemble red oxides sliding wear, except that they contain a core of free metal and thus are not translucent. They will also often show freeks of free metal on the surfaces. These particles are caused by heat and by lubricant starvation they indicate more severe wear than red-oxide sliding because the free metal is thicker than the red-oxide.

Black oxides.

Black oxides are grey to black, and they resemble pebbles. The oxide in this case is Fe_3O_4. Black oxide indicate a more severe condition than do red-oxide particles. More iron is being consumed in the oxidation process, as a result of inadequate lubrication.

Friction Polymers

Friction polymer is a material that forms when a lubricant is under stress and this polymeric material is insoluble in solvents used in ferrography. Depending on wear mechanism in the equipment, they may or may not be metal particles trapped with polymers.

Red Iron Oxides (Fe_2O_3)

There are characterized by an orange to brown poly-crystalline agglomerate that does not align with the magnetic field on the ferrogram. The colour of the particles may best be evaluated under reflected polarised light. Particles that change from yellowish orange to a more reddish-brown after heat treatment are hydrated iron-oxides probably organising from rust. Particles that are reddish-brown before heat-treatment could be just that has been exposed to heat already, or they may originate from fretting or other corrosion oxidation mechanisms.

Corrosive wear

When acids and other corrosive agents attack the surfaces of the machine and its accessories, sub-micron-sized free metal particles, oxides, and other metal compounds are yielded. These are so small that they generally do not form a deposit along the ferrogram. However in eddy currents at the exit from ferrogram and under the influence of magnetic flux at the end of the magnet a deposit of this material will form the size of this deposit can warn of chemical attack on the equipment.

Inorganic crystalline

Certain minerals that often are associated with dirt and construction materials will depolarize light that has passed through a polarizer.

This phenomenon is called 'hirefrigence'. Materials that are hirefringent usually show same degree of internal order or crystallinity.

The hirefringence of inorganic material usually is not influenced by heating to the temperatures used for analyzing a ferrogram. Same minerals are hot hirefringent and must therefore be classified under the "other" category.

Organic crystalline

Organic materials that are hirefringent may include wood, certain plastics, Teflon, insect parts or cotton. These materials will generally char or lose hirefringence at around 340°C.

Identifying alloy type

To identify alloys in ferrography, the particles on the ferrogram slide are subjected to heat treatment. When the slide is heated in the presence of air, oxide films grow as the particles. The rate of film formation is a function if the alloy composition, temperature and other factors such as the rate of differences of oxygen through the film as it continues to form.

Heating the particles at 340°C for 90 secs. yields. Oxide film thickness that are in the range the wavelengths of visible light. When light reflectsof the metal surfaces underlying the oxide layer, it produces interference effects with the result that the particles appear to be coloured different elasses of alloy will show different colours and can be so identified. The prior heat history of a practices may sometimes show up as temper colours or variation in the colour of the heat treated surface.

re we present a brief guide in alloy identification based on heat-treat-nt at 320°C for 90 secs.

rrous alloys

So called low alloy steel is generally less than 1% carbon and other .oying elements. These alloys turn blue under heat treatment. The degree saturation of the colour has been observed to vary, which may be manifestation of residual oil on the particles or it could represent riation between alloys within classification.

"Medium alloy steel is generally cast iron or case-hardened low-.oy steel. These alloys are generally about 3.5% carbon with little else the way of alloying elements. This type of alloys turn to a straw lour in heat treatment. "High alloy steel covers all stainless steels. der heat treatment, no significant change in color is observed. Such .oys are generally only weakly affected by the magnetic field of the ·rograph. Therefore they will show a more random distribution across ɜ ferrogram.

CHAPTER 10

RECOMMENDATIONS

In this project a detailed study of the maintenance practices in HNL Mill is done. The maintenance availability in chemi-Mechanical plant and paper machine section is calculated. Methods of improvement are discussed. More and more companies are now in the process of computerising their maintenance systems. This will help in stream lining the maintenance operation and for maintenance planning.

A case study in the utilisation of process personnel in repetitive types of jobs is done. This will ensure uniform workload for employees and better participation.

A maintenance decision model is evolved and is recommended for use in HNL. A down timelist is made and three cases selected for study. Depending on the decision model maintenance method is recommended. The model can be applied for other equipments as well.

Records are base for future planning. Without proper records maintenance planning is impossible. It is suggested to keep records. Life cycle cost is a new concept in the maintenance field. It is suggested to use LCC in ordering new equipments and in ordering spare parts.

Quality circle.[9]

Quality circle is a small group of people who do similar work meeting voluntarily on a regular basis under the leadership of their supervisors to identify and discuss and analyse their problems and identiify solutions.

APPENDIX: NOTES ON REFINER MAINTENANCE

REFINER MAINTENANCE [14]

Responsibility for the maintenance of a refiner must be the concern of everyone who is involved in its operation. One very big step towards adequate maintenance (and very substantial savings) is a training program to inform all operating and maintenance personnel of the correct maintenance procedures.

To minimize downtime, it is advisable to have a recommended number of repair parts in stock. For some parts, such as bearings, this is not always necessary, in case of a reliable local supplier with an adequate stock. Regardless of the source of supply, repair parts must be readily available.

Record keeping is an important phase of any maintenance program. these records should include daily observations and comments from the individuals directly responsible for the refiner operation. A log book kept handy near the refiner, is the simplest way of making sure no one overlooks reporting any abnormality about the operation.

The contents of the log book can be reviewed, condensed, and discussed at regular meetings. Often, gradual quality changes and malfunctions can be detected that might otherwise continue, and progress to a place where emergency repairs are necessary.

Installation and Alignment

Proper installation of equipment plays a very important role in reducing maintenance costs, by providing maximum accessibility for maintenance and by eliminating stresses which might cause malfunctioning or breakdown later on.

The best possible location should be chosen for the refiner, and should provide for ample head room, sufficient working space for maintenance personnel, and space for proper routing of piping and wiring.

Equipment should be located immediately in the best possible spot, because temporary installation quite often restricts maintaining accessibility, and can even be hazardous. Furthermore, "temporary" installations have a way of becoming permanent.

When installing the refiner, remember that remote control equipment can be easily and economically provided at any time. This factor should give much more flexibility in choice of locations.

The foundation is very important, and should have enough rigidity and mass to prevent misalignment for the motor and refiner, and to absorb damaging extraneous vibrations from adjacent machinery.

The pump-through pressure refiner is driven by an externally mounted motor which is separate from the refiner base. A 450-550 r.p.m motor or other recommended speed should be direct-driven through a jordan gear-type coupling with approximately 1.6cms extended travel. If such a motor is not available, then one of the different speed can be employed, using a jack shaft arrangement to develop the same speed.

When aligning the coupling, 1.6cms should be left between the ends of the refiner shaft and the motor shaft and the coupling hubs should bet set .32cm apart (See Figure 11.2). The maximum allowable run out is .076mm for both parallel and angular alignment. The alignment check must be made with therefiner shaft in the extreme open position, to allow maximum coupling travel.

The best possible location should be chosen for the refiner, and should provide for ample head room, sufficient working space for maintenance personnel, and space for proper routing of piping and wiring.

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On the refiner and motor have been properly aligned and secured to a suitable foundation, very little if any maintenance can be expected. Periodic lubrication every three months should be sufficient. Use an extreme pressure (E.P) type grease. Alignment and wear should be checked annually. Since a coupling replacement could be considered a major item, any misalignment should be corrected to eliminate further wear. If the condition is such that replacement would soon be required, a new coupling should be obtained, machined to the proper shaft size and placed in stock ready for immediate installation. Unnecessary down time can certainly be reduced in the event of coupling failure.

The time required to change plates is generally around two hours. To install refining plates, the heads must be in the wide-open position. The case can be opened quickly for easy access to the disk. The face of the disk should always be cleaned, to insure proper seating of the new plate.

Although the disk is constructed of stainless steel, it is still important that it be thoroughly cleaned, since deposits of stock and material on the disk might cause the new plate segments to break when they are installed and might also cause the refiner to run roughly, perhaps resulting in an inferior product.

Since each set of plate segments is machined and balanced as a unit, the segments are, therefore, not interchangeable between sets. Ring numbers and individual segment numbers are painted on the back side to identify each. When installing a new set of segments, be sure that they are in the proper sequence (0-0, 1-1, 2-2 etc) (See Fig.).

Each plate segment is attached to the disk by stainless steel socket head bolts. The heads of these bolts are counter-sunk in the plate to prevent wear and erosion. Check to make certain that each socket, or recess, is in good condition to facilitate removal at the next plate change.

The choice of the alloy composition of a plate is determined by pulp characteristics (whether it is abrassive or corrosive, etc) and here again the refiner manufacturer's experience is usually relied upon. Plates are usually best suited to run in only one direction of rotation, this direction being determined by through-put and pulp quality.

Tramp Metal Hazards

Every precaution should be taken to keep tramp iron out of the system. However, should a piece enter the refiner with the stock, power to the refiner motor should be shut off before opening disks. Plates should be inspected to determine if any segments have been damaged. If any segment is damaged, replace entire circle of plates.

If the remaining segments are in good condition in that circle, they can be returned to the factory for replacement of the damaged segment and regrinding.

Tramming

Each new refiner has been accurately trammed and doweled at the factory. However, the tram should be checked before start-up, to be sure no damage has occurred in shipment.

The proper tramming method is to remove the refining plates and fasten a dial indicator to a bolt on the rotating head. The indicator point should contact the plate seat on the stationery head, near the outer edge. A second indicator should be placed at the motor end of the shaft or coupling, to indicate any drift of the head and shaft assembly.

Rotating the head will indicate if the plate seat is out of perpendicular with the axis of the shaft. (See fig 11.4). Indicator readings should be checked at the top, bottom, and both sides of the head. Readings should be within 0.004-.01mm , when the head is rotated. If it is necessary to correct alignment, shims should be placed where the stationery head is bolted to the bearing housing.

It is most an impossibility for any machine stresses caused by case pressures or temperatures to affect the tram once it has been installed and set properly. The only time that the tram might change is if the refiner has been torn down for a major overhaul.

If care is taken in marking the shims during dissembly, and they are put back in the same location during reassembly, the tram should not change. It is always recommended that it be checked afterward, regardless of care given in reinstalling the shims. The small amount of time required to do this is certainly justified.

Bearing Lubrication [13]

Before any new machine is put into operation, special consideration should be given in selecting proper type of lubricant. The equipment manufacturer specifies a type that best fits and conditions under which the machines operate most satisfactorily. Lubricants for each refiner can be shown on a lubrication specification plate permmanently attached to the machine base. This plate generally names only one type and grade; however, any equivalent could be obtained from any reputable supplier, provided it meets the same specifications.

The refiners are equipped with a dual purpose oil system in which the same pump supplies circulating oil to lubricate the bearings and also operates the hydraulic controls for positioning the refining disk.

An adequate flow of oil should be maintained to the bearings at all times. An insufficient amount can cause abnormal bearing wear and shorten the expected life. Excessive oil can cause heat by bearing flooding and create oil seal leaking problems.

Because of high pressures common in any hydraulic system, a certain amount of heat is generated. A water-cooled heat exchanger is used to lower the oil tank temperature to a recommended range of (60 - 70°C). If oil temperatures consistently run above this, the cooler should be checked to be sure some of the tubes are not plugged. When unusually warm supply water is used here, it is often advisable to replace the heat exchanger with a larger one with more heat dissipating capacity.

The oil change frequency will depend on varying mill conditions such as bearing thrust load, water condensation, accumulation and the ability of the oil to withstand its intended purpose without breaking down or emulsifying. It is recommended that the oil be changed at least every six months. The tank should be drained and thoroughly cleaned at each oil change. The pump stainer should be removed and flushed before installing the new oil. The filter should be checked perodically to insure a free flow of oil for lubrication without too much restriction to flow. The condition of the filter and an oil sample from the tank will serve as the best indications in determining the time for oil change.

When periodic inspection of the oil is made most hydraulic, lubrication and down time problems can be completely eliminated. If the oil is contaminated and can be changed at a scheduled shut down, it definitely is the most economical way of doing it.

Hydraulic system Maintenance

There are several points of possible malfunctioning in any hydraulic system. A few of the more common difficulties and possible causes are listed with suggested remedies, illustrations and parts list of hydraulic components are shown in the service manual supplied with the machine. It should be referred to during the trouble shooting.

Failure to build up pressure

1. Check pump drive. Make certain coupling is not loose on pump drive shaft.
2. Check pump rotation
3. Check fluid level in reservoir. Make certain sight gauge is not plugged, providing faulty reading.
4. Check for contaminants in relief valve causing it to stick open.
5. Check springs in relief valve to be sure one is not broken.
6. Check strainer on pump suction line for dirt.
7. Check for air leaks in intake line
8. Disconnect pressure line and see if pump is delivering fluid.
9. If pump delivers fluid, connect to a proven relief valve and direct the flow from the relief valve to the reservoir and see if the pump will generate sufficient pressure with this test valve.

Noisy Pump

1. Check for vacuum leaks in suction line
2. Check for vacuum leak in pump shaft seal.

3. Check alignment of coupling

4. Check for worn vane or ring if pump delivery is not adequate.

Noisy Relief valve

1. Oil temperature too high. Check operation of oil cooler to be sure it is cooling properly.

2. Piston scored, allowing too much control oil to pass to pilor mechanism.

3. Worn pump with pulsating delivery can become sufficiently erratic to prevent relief valve from levelling out pulsations.

Stuffing Boxes

Stuffing boxes must be adequately water-purged with clear filtered water at all times. The supply pump pressure should be set to 7 to 8.5 kg/cm^2 minimum. The purpose of the purge water is to lubricate the packing and create a seal to prevent stock from getting under the packing. If the packing becomes worn and is not kept reasonably tight, stock leakage will occur and accelerate sleeve wear.

When the packing has worn beyond the practicable take up point, it should be replaced with a type approved by the refiner manufacturer. The packing glands should be removed and cleaned before every installing new packing. After the new packing is installed the clearance should be checked to be sure the gland does not rub the shaft sleeve. Recommended minimum clearance at any point around the shaft is .025 cms.

Safety in operation

The stock preparation refiner is simple to operate, and is easily adjustable to perform the desired task. When starting the refiner, the oil pump and water pump must be started first. After adjusting the lubricating oil flow to the bearing and the purge water flow to the packing, the main drive motor can be started. Operation of the refiner then requires only three simple steps.

1. Start the stock through the refiner and adjust the stock valve on the dischargeon the outlet side, to regulate the desired flow of stock through the refiner.

2. Close a directional control valve in the hydraulic system to bring the heads together into refining position.

3. Adjust the hydraulic loading pressure to the desired motor load.

The hydraulic system, with its control valves, enables the operator to adjust quickly for the type of stock desired and to maintain uniform quality. Briefly, this is the way it functions:

The rotating head is positioned by balancing the four forces shown in Figure 11.2 to obtain the desired refining. F1 is the force developed by the pressure of the stock between the refinding plates which tends to open or force the plates apart. F2 is the force developed by the pressure of the stock in the case acting on the back. The force (F2) developed in the case, with some types of plates, may be greater than F1, in which case a force (F2) on the opening side the hydraulic cylinder is necessary to achieve good control. The force F, is controlled by the operator to accomplish the desired degree of refining.

A stock pressure switch installed in the inlet stock line which supplies the refiner is interlocked with the hydraulic loading pressure controls.

In the event of stock pump failure or unusually low line pressure, the refiningdisk will open, preventing damage to the plates or machine. The pressure switch should always be in operating condition to insure safety. The adjustable micro-limit switch located inside the stock pressure gauge or safety switch, should be set to open and close the electrical circuit at short notice.

Electrical and hydraulic controls should be checked regularly ensure safety and trouble free operation. The water pump and oil pump starters should always be interlocked with the starting circuit of the main drive motor. This reduces the possibility of ruining the bearings or plugging the packing purge water lines in the event of motors fail. It also prevents the operators from starting the refiners without starting the lubrication and water pumps.

Indication of Malfunction

Usually, the refiner operator is the first to detect trouble. His findings should be reported directly to the repairman doing the job, since relaying the information through channels will open result in conflicting reports, which might only prolong down time.

Regular checking of stock quality records is also very important, since such records indicate gradual changes in product quality which might otherwise go unnoticed.

Field service men are available from the refiner manufacturer for the start up of new equipment, and for assistance in repairs or maintenance and production problems. The instruction manuals furnished with the refiner will also prove quite helpful in answering most common questions.

Should any unusual problem arise in the servicing of equipment, it pays to talk it over thoroughly and right away with the manufacturer's servcie department. The cost of the long distance phone call for such a purpose looks mighty small when compared the pulling a refiner out of production for any length of time.

FOURDRINIER MAINTENANCE

Fourdrinier maintenance is easy to neglect as long as the machine is running smoothly and wires are holding up. To keep the machine operating efficiently, and to prevent unscheduled shut down, requires a regular surveillance for symptoms of malfunction.

Good fourdrinier maintenance requires minute attention to many small and varied details. Some of the major items are:

- Mechanical condition of parts
- Roll coverings
- Surfaces of wireboxes, forming boards, deflectors
- Alignment of machine components
- Corrosion prevention
- Cleanliness.

No one needs to be persuaded that an improvement in machine efficiency or longer wire life is desirable. In the following paragraphs, we will show how these objectives are affected by the condition of fourdrinier components. To make our presentation more graphic, we will discuss the fourdrinier components in the order in which the wire contacts them.

Breast Roll

The alignment of the breast roll is of first importance to a true running wire. Because of its heavy wire wrap, the breast roll, along with the couch roll or wire turning roll, is more potent in guiding the wire than the other components on which the wire rides.

If the breast roll is not raised properly, a strain can be placed on the rising arm and the resulting distortion of this arm can change the alignment of the forming board. Fig. 11.5. shows the type of breast roll raising arrangement in which the breast roll is raised by a gear unit driving a cross shaft on which are mounted pinions which engage gear segments on the raising arm stub-shaft. With this type of raising arrangement, the breast roll arm should be raised until there is approximately a .16cm gap between the raising arm and the stop on the wet end support stand. The arm should be raised the rest of the way by tightening the swing bolts on the support stand. If the arm is raised by the gear unit until the arm comes up against the arm on the support stand, a strain is placed on the arm. Because the gear unit (in many cases) is a double worm self-locking unit, the resulting distortion in the arm and alignmment of the forming board remains until the next time the breast roll is lowered. This may explain why the flow looks good at the forming board when the fourdrinier is in operation, and, on the next wire change, the flow looks entirely different. To keep the flow characteristics over the forming board consistent, the breast roll should be raised in the same manner after each wire change.

Shacking breast rolls require checking to be certain that the breast roll bearing arms have been pulled all the way up into the breast roll saddles. From figure 11.3., it can be seen that the breast roll must be raised by the breast roll saddle arm until the bearing housing is lifted off of the support on the raising and lowering arm. The necessary clearances are set up in the initial installation of the breast roll, but, to obtain these, both the breast roll raising arm and the arm on the breast roll saddle must be raised against the stops.

Forming Board

The primary purpose of the forming board is to support to wire between the breast roll and the first table roll. The wire sags following the breast roll because of the pumping action of the breast roll. On some grades of paper or board, this pumping action is necessary to assist the water removal in the forming section. If this is the case, the forming board should be tilted as shown in Fig 11.6 so that the wire does not break sharply over the forming board tip. On other grades where the optimum in fibre retention is desired, the forming board tip should be set as close to the breast roll as is possible without jamming up the water removed at this point.

In any event, some of the discharge from the slice splits off at the forming board. In order to divide the flow cleanly, the forming board tip must be sharp, and free from nicks. Damage to the tip comes either from handling or from walking on it. If the forming board tip has been damaged or worn uneavenly, the forming board should be removed and ground while supported on its own journals so that the normal deflection is taken into account. Fig 11.7 illustrates the disturbance to the flow on the wire caused by a damaged forming board tip.

Table rolls

Table roll surfaces should be kept clean. This is particularly true of grooved rolls where stock accumulation can throw the rolls out of balance, or defeat the purpose of the grooved table roll which is the break the sunction at the off-going wire nip. Table roll surfaces, therefore, should be cleaned off thoroughly before a new wire is mounted.

Micarta covers on table rolls may wear unevenly leaving high spots which wear on wires. Rubber covers may blister from corrosion at the surface of the metal core. Rolls should be covered when necessary.

Misalignment of table rolls is indicated when the wire runs to front or back side when the stock is put on the wire and runs to the opposite side when the stock is removed.

When bringing the table rolls into vertical alignment, the check should be made by "gap" rather than by contact as shown in fig. 11.8. If the table roll is brought up into contact with the piano wire, there is a tendency for each successive table roll to raise the piano wire a little higher as shown in fig. 11.8.

In squaring the table rolls, the important thing is to set each roll in relation to the centerline of breast roll rather than the adjacent roll. This can best be done by clamping a tape to the apron lip at the slice. Pull the tape with a tension scale, and set each roll to the desired spacing, using a scale and centerhead on the journal. To square the rolls, use the same procedure and tape on the back side of the machine.

Deflectors

On high speed paper machines, the wire requires support after table rolls where the pumping action is heavy. The flat top deflector shown in figure supports the wire and performs the same function as the forming board. It follows that the same precautions against damage to deflector tips should be followed. Also, grind the surface of the deflector when required to prevent damage to edges of the wire.

Wire Suction Boxes

The friction between the wire and the surface of the flat boxes constitutes the major load on the fourdrinier drive. It follows that it is the major source of wire wear. Our aim should therefore, be to keep the flat box covers as smooth as possible, first, by keeping the covers moist during shut down to prevent wrappage, and second, to keep the wire from grooving the covers by either oscillating the boxes or the wire.

Wire friction can also be reduced by the choice of appropriate materials for flat box covers. There are many new materials on the market which have a lower coefficient of friction than the conventional cover materials for example: Teflon, nylon, PVC silicon carbide, polyurethane, etc. Some mills are reporting considerable improvement in wire life by the use of these materials. However, these materials must be properly selected to suit mill conditions.

Embedded grit in wire box covers has been a cause of short wire life. Flat box covers should be examined for embedded grit or sand, and if found, performance of stock cleaners should be checked.

Couch Roll

The friction between the couch roll shell and its suction box packing strips can consume a considerable amount of horsepower. This friction can also cause difficulty in starting upt the fourdrinier. Tokeep the friction load at a minimum, the packing strips should be free from binding and the friction surface lubricated with water. The packing should be checked for freeness when the sunction box is removed from the shell by depressing the packing to see that there is no binding and that there is resiliency in the reponse. A fog shower helps to reduce the friction between the suction box pawcking and the couch shell.

Water is used to lubricate between the packing surface and the side seals. To keep the packing from seizing due to excessive water pressure, the supply pressure to lubricating lines should not exceed 5 kg/cm^2

When the suction box is removed from the shell (which should be at least once a year), the couch roll bearings should be checked and the back internal bearing lubricated. This bearing can be lubricated while the couch is running, but technician cannot tell how much grease is getting to the bearing. Furthermore, there is a danger of over-greasing and the excess getting onto the sheet. If the back internal bearing is checked and repacked annually with a good grade of water-resistant grease, greasing in the interim is not necessary.

To keep the holes open in the cough roll shell, the flushing shower should be turned on when the sheet is off the machine and before the machine is shut down. Flushing periodically with detergents is helpful in many cases. When the suction box is removed from the shell, the shell holes should be cleaned out, drilled if necessary. High pressure showers (56 – 70 kg/cm^2) are used periodically by some mills. Sometimes this shower is permanently installed adjacent to the outer surface of the roll on the nside of the wire run, and is turned on periodically during operation of the machine.

The couch roll and wire turning roll can get out of alignment because of play between the keys and keyways in the remover blocks. These should be examined on every wire change.

Turning and return rolls

The surfaces of the wire turning roll and wire return rolls must be in good condition to prevent damage to the wire. Metallic surfaces should be free of nicks and grooves. Rubber covers should be replaced if blistered.

The alignment and levelness of these rolls is important because of the grinding potentialities of these rolls.

The structural rigidity of these rolls should be sufficient to withstand all probable wire tension forces. Otherwise, high wire tensions mmay cause excessive deflection of the rolls. This results in wrinkled wires.

Showers

An efficient shower system is essential to wire life because there is always present the danger of stock getting between the wire and the wire return rolls and causing ridges.

The showers which knock the trim or sheet off the wire must be in good working order, and the pressure supply, dependable. Trip and sheet wetting showers should be used before the knock off showers.

A wire cleaning shower is frequently located above the first outside wire return roll. This shower should be of the high pressure jet type, and should be oscillated.

On the inside wire return rolls, the showers move on the axial centerline with a doctor following the shower as shown in fig. 11.10. The doctor must have a saveall for collecting the doctored material, and downspouts which drain outside the wire. The doctor should have a protective guard to protect the wire from any throw-off from the doctor blade.

On the outside wire return rolls, the showers wash the wire as well as the roll, (See fig. 11.10). These showers are generally interchangeable with the inside roll showers, and operate at the same pressure. They should be spaced closer to the wire for effective cleaning.

The shower pipes should be cleaned out frequently to prevent any encrustation fro m interferring with aw uniform spray pattern.

At the breast roll, a shower should always play on the underside of the apron cloth to keep strings from forming and to lubricate the end of the cloth. A worn apron cloth should be replaced before its effect can be observed in the sheet.

Showers can become a menance to wire life if the shower water is not filtered. A piece of grit between the wire and a roll can cause a dimple in the wire which will wear into a hole. Indications are that considerably more wires have to be changed because of holes than have to be changed because of ridges.

The spray from the showers should be directed away from roll bearing seals as far as possible to prevent water contamination of the bearing lubrication.

Doctors

The purpose of the doctors, like the showers, is to protect the life of a wire.

An efficient breast roll doctor is very vital to wire longevity. Any stock falling onto the wire will be carried into the nip between the wire and the breast roll, and very likely cause a ridge. The doctor back or save all behind the doctor blade should allow the unimpeded passage of the water removed at the breast roll so that the water will Not jam up. If this happens, the doctor balance may be affected so that the doctor lifts up off the roll (See Figure 11.11).

Doctors should be oscillated to prevent scoring the surfaces of the rolls. If the doctor is not oscillating, it can be due to two reasons-the setting of the valves regulating the air supply to the diaphragms, or binding between the bearing housing and the outer race on the doctor journal. If opening the regulating valves to full open does not oscillate the doctor, there is binding between the outer race and the bearing housing.

We find that the most efficient angle for doctoring the fourdrinier is 25 degrees. As the blade wears, this angle increase, and the blade should be replaced when the angle reaches 30 degrees to prevent damage to rolls surfaces. A spare set of doctor blades should be on hand at all times.

Automatic wire guide

Guarding against failures of the automatic wire guide is a must. On air-operated guides, the air diaphragm should be checked for cuts, cracks, and wrinkles. On mechanically operated guides, the surfaces of the dog blades which actuate the ratchet wheel should be true and sharp. Also, the surfaces of the pins connecting arms and forks should be in good mechanical condition.

The movement of the roll should be checked for freeness, there should be no binding in any part of the mechanism.

Wire Tension controller

One of the greatest aids to wire life and consitency in the quality of the sheet is the wire tension controller. The device shown in Fig. 11.12 is a stretcher and wire tension controller combination. As shown there is an air spring between the stretch roll arm and the raising arm. The raising arm floats on the stretch roll air cross shaft and raises the stretch roll arm by compressing the air spring against the force of the air pressure.

One of the important things to remember about this device is that the air spring is kept within its working range by the lift arm. When the length of the fourdrinier wire changes, the stretch roll establishes a new position which is determined by the balance between wire tension force and the air spring force. If this new position is outside of the working range of the spring, the first thing to do is to raise or lower the lift arm to set the spring at the operating position, then adjust the air pressure in the air spring for the new angle of the stretch poll.

Mawintenance of this wire tension controller consists of checking the air spring for bulging, and that the extension of each air spring, front and bawck, is the same.

Roll bearing Lubrication

The following are important points to keep in mind.

1. Use the type of grease recommended for wet end bearings.

2. Do not over-grease because housing cavities may become grease packed and interfere with free running of lightly wrapped rolls such as table rolls.

3. The condition of grease in bearing housings can be determined by inserting a loop, made of soft copper wire, through the vent plug hole into the housing cavity and removing a sample.

4. Once a year, clean out bearing with solvent, such as kerosene, and repack.

Fourdrinier shake.

The bolts securing the clamping devices at each end of the micarta springs should be checked for tightness. This is important because, if the bolts are loose, the strain from the bending of the spring will come on the notch in which one end of the clamp grips the spring.

The proper alignment of the fourdrinier shake is necessary to keep blending stresses on the shake springs at a minimum, and to insure long spring life. It should be determined that, when the shake units are at the center of the stroke, the table rolls and the breast roll are centered on the centerline of the machine.

The springs should be checked for permanent set and replaced if this has occurred.

Wire Changing gear

Wire changing equipment should be in good condition so that the wire can be put on safely and without damage to the wire. The surface of wire poles should be smooth.

Required tools, slings, brackets, and pins should be readily available because makeshift devices can be hazardous. The above equipment should be cataloged, and also locked up between wire changes.

Condition of fourdrinier remover rails and gear wheels should be checked periodically, and surfaces cleaned.

Wire History

The prevention of damage and wear to the wire is an essential part of fourdrinier maintenance. A wire history or log is a valuable tool in maintaining the fourdrinier because it may point to the causes of wear or damage originating in the machine or to the stock system ahead of the machine. However, the wire log by itself is of little value. The find contributory causes, the comp limentary records listed below should be available.

A wire log should include the following information:

a. Name of manufacturer

b. Mesh

c. Caliper, new

d. Date installed

e. Date removed

f. Reasons for removal

g. Caliper, used - readings from several points across the wire.

h. Description of condition of wire when removed - i.e. ridges and indentations, holes and cracked edges, etc.

Complementing the wire log should be the following records.

1. Operating logs which show
   a. speed
   b. Basis weight
   c. Machine settings
2. Record for machine maintenance
3. Record of machine modifications
4. Record of changes in other parts of the plant which might affect machine operation.

By working with records such as these, it is sometimes possible to find changes which resulted in loss of wire life.

Corrosion

One of the most troublesome problems of fourdrinier components is corrosion. Corrosion may be caused by moisture-laden air, chemical attack or galvanic action.

The simplest means of combating corrosion on iron and steel is paint. There are many excellent paints and coatings available which resist chemical attack.

The use of corrosion resistant materials does not insure corrosion protection. A corrosion-resistant material may corrode due to galvanic action if it is in contact with another material to which it is anodic. For instance, certain aluminium alloys, when in contact with asustentic stainless steels, will corrode if an elelectrolyte such as fourdrinier white water is present. If such combinations are unavoidable, the anodic material should either be painted or the joint should be insulated. Also stainless steel welds should be cleaned with a stainless steel brush to prevent galvanic corrosion.

In Summary

The maintenance requirement of one fourdrinier in one location may be different in several respects from a similar fourdrinier in another location. It is different, if not impossible, therefore, to set up a maintenance schedule which would apply generally. We have, instead, categorized the items discussed previously into running maintenance and down maintenance.

SIZE PRESS MAINTENANCE

The maintenance required by size presses is as relatively simple a procedure as is the size press itself. Reduced to their basics, size presses consist of rolls and bearings, frames, the roll loading system, a drive, a save all arrangement, showers and (in the more modern installations) a rope system. In this discussion, it is necessary to differentiate between vertical and horizontal units because the maintenance requirements of the horizontal size press are considerably less complicated (because of basically simpler construction and design) than that required by its vertical counterpart. Aside from a few special considerations, effective maintenance of size presses can be summarized into two areas: constant attention to cleanliness and roll care.

Main press Rolls

One thing to watch for at all times is roll surface etching which in metallic rolls is usually caused by a mechanical reaction to certain size press formulawtions. Today there appears to be a trend towards composition rolls. And one of the reasons for this is that little or no etching is encoutntered with composition rolls compared with metal rolls. However, certain size press operations demand metallic surfaces and the maintenance thereof has to be a compromise between good mettallurgical composition and chemical size formulation.

The maintenance of soft rolls is a much more delicate problem on the other hand. It is extremely important to inspect for cracks in the rubber cover which will eventually lead to cracked ends. And if dry size gets into these cracks, the condition can be expected to worsen. Surface cracks start as hairlines and if they are caught early in that state, they can be ground out easily.

The next most obvious maintenance consideration is roll grinding. Generally roll grinding is necessary when cracks appear on the surface or (much worse) on the roll face, when crown adjustments are necessary, when crown requirements change, and, finally, when the crown wears down as a result of usage.

Crown wear and roll condition generally are considerably affected by the abrasiveness of the sizing material and the nip pressure. We have found remarkable examples of this in competitive mills, running nearly identical grades where pressures will vary from one extreme to the other between 12 and 25kg / per linear cm And, as could be expected, the running mill with [illegible]0kg/cm of nip pressure experienced considerably higher maintenance costs with its size press.

One more word about the soft roll and nip pressure; a general rule of thumb is that the softer the roll, the higher will be the nip pressure required. This often leads to corrugation problems, which in turn, lead to more frequent roll grinding.

An important and recurring source of necessary roll maintenance work is, indeed, the roll wrap. However, this is a rather infrequent occurrence with the horizontal size press because of the inherent design of this unit. Roll wrap may cause nicks and grooves on the soft roll surface. When this occurs, they must be ground out immediately. Higher than usual grinding expense may very well mean excessive instances of roll wrap.

Auxiliary Rolls

While the auxiliary rolls ahead of the size press-the paper carrying rolls and spring rolls-require little special maintenance, the rolls found immediately past the press do require special attention. Such afterpress rolls ofter become subject to size contamination.

Herein lies an important aspect of size press maintenance - cleanliness. This inturn depends greatly on the roll covering material. Every mill has its own feelings and preferences with regard to the covering material of these rolls. The expander roll is normally rubber-covered. Some mills have wound them in Teflon, is an effort to reduce adhesion of size particles, while other mills have installed a steam shower immediately below the expander roll. This, it is claimed, helps to prevent size pick-up to an appreciable extent. Paper carrying rolls are sometimes stainless steel, sometimes, bome-hard rubber-covered, Teflon and sometimes even chrome-plated. All these efforts have one basic objective: to reduce cleaning maintenance.

Keeping such rolls clean is vitally necessary because any build up creates the danger of size flaking off and adhering to the sheet as it comes into contact with the rolls.

Roll Bearings

Roll bearings may be either thge plain type or the antifriction type, usually depending on whether the size press is of vertical or horizontal design.

In the vertical press, equipped with anti-friction or plain bearings, it is symptomatic that the size will run off the edge of the sheet almost directly onto the journal of the bottom roll. This will of course cause size to be directed at the bearing housing. Attempts have been made to shield the journal and thus the bearing housing, but this is an almost futile gesture

In the horizontal size press this problem is of course not the case because the size pond fills through the familiar V formation, created by the nip. This, in turn, means that the size will not come into contact with the bearings under normal conditions.

Plain bearings are found predominantly in vertical presses because the relatively new horizontal size press utilizes, anti-friction bearings. In the case of the plain bearing, it is generally accepted that the only thing that can be done once wear and tear have progressed to the critical point is to re-line the bearings. This is one reason bearing inspection should be periodic and why a written report is often helpful.

Finally, it can be said that trying to keep grease in while attempting to keep size out of such bearings is an almost paradoxical job. Often, when you succeed with one, you accomplish the exact opposite with the other. However, it is doubly important at the size press from the standpoint of size and sheet contamination.

Some mills often add pillow blocks to replace conventional plain bearings. Pillow blocks are of course, not designed to exclude any liquid directly running towards the bearing. Therefore if these are used on vertical presses, one should make sure to provide auxiliary flanges and/or seals and to check these regularly.

Anti-friction bearings necessitate only the simplest of preventive maintenance procedures. This consists simply of occasional visual inspection in the case of the horizontal size press and occasional disassembly inspection in the case of the vertical unit. The reason for recommending disassembly inspection in the case of the vertical model is related to the aforementioned tendency for the size to find its way into a bearings. A practice recommended in this regard is regularly "sounding out the bearings".

Oilers should inspect the bearings at weekly intervals, with constant attention to keeping out the size. Checks should be made regularly (weekly at least) for vibration and roll thumps. And bearings should be checked almost daily by the simple expedient of feeling whether they are running at Normal temperature or whether they are running hot. The importance of correct lubrication cannot be overemphasized. This, of course, applies to both inadequate and over lubrication. During an annual or semi-annual shutdown, bearings should be completely disassembled and cleaned.

One highly helpful schemme is the use of lucite or other similar transaprent material which, when it replaces the conventional metal casting, will permit constant visual inspection of the bearings.

Size Savealls

Savealls of size presses can be defined as either the saveall pan below the bottom roll of the vertical size press or the downspout saveall on the horizontal size press.

Downspout saveall maintenance consists primarily of cleanliness and this centers around the important effort of keeping bits of paper from building up and individually clogging the drain line return to the size storage tanks. The main cause by far of paper getting into the downspout occurs when the sheet tail is being sent through the press and a piece falls off into the spout.

Saveall maintenance in the case of vertical size presses deals with a regular tub which automawtically requires periodic attention. This too, however, is principally a matter of cleanliness, with the exception of periodic checks for leaks so that size loss does not occur. Thorough scrubbing of the saveall pan is highly recommended to prevent dried size film build up and also to check corrosion.

Showers

Here again the maintenance requirements of horizontal and vertical presses differ. In the case of the horizontal size press, an open pipe delivers the size from a single spout at each side of the sheet, while a vertical press is equipped with conventional orifice-type showers. Plugging is virtually impossiblke in the horizontal type press shower. However, cleanliness is here also the main concern. The inside and the outside of the delivery pipe should be cleaned periodically and the best recommendation is thorough flushing with hot water during every machine shut down. In fact, many mills make it a practice to flush the pipe with hot water each time an order-change is made. Cleaning the outside of the shower is also very important and sometimes overlooked. Neglect in this case an affect roll maintenance because dried size and starch particles adhering to the outside of the shower, will break off and may easily mar and nick the rolls as the particles pass through the nip.

Shower maintenance for vertical size presses requires even more attention to cleanliness. Manual cleaning of the orifices is recommended and this is a task which is best assigned to specific individuals to assure periodic action. A simple, rounded scraping tool inserted into each orifice and twisted to free the opening from any dried size is recommended.

Rope systems

Rope system maintenance on the size press is quite identical with the rope system on other parts of the paper machine. The important difference lies in the fact that the rope system should not be contaminated with size. Rope system maintenance on the horizontal size press is concerned primarily with attention to cleanliness. If serious size contamination occurs it is a relatively simple matter to correct it by the rope run.

Rope inspection is extremely important. A large percentage of roll grinding is necessitated by broken rope ends going through the nip.

Each time the machine is shut down, the dryer section should be turned over slowly (it should be ldoged) and the rope condition should be inspected, inch by inch. Ropes should be checked for fraying and for all kinds of wear. Special attention should be paid to the splices. Where a buckle is used, the rope-wearing pont is usually found immediately where the rope enters the buckle.

With vertical units size run off is such that rope contamination is a mrore serious problem then rope breakage. Anyway, rope contamination should be avoided because such a condition will accelerate rope breakage. In the hrorizontal press the rope misses the size run off entirely. Finally, it should be said about rope in general that buckles should be avoided where possible and that long slim splices are more preferable.

Loading Systems

Maintenance of loading systems (whether pneumatic or hydraulic) should consist first and foremost of inspection. If the design includes steel pivot pins, lubrication is essential. Fretting corrosion is a result of inadequate lubrication of steel pivot pins and can easily be avoided. Stainless steel pins in brass bushings are the solution and for all intense purposes eliminate, the necessity of lubricative maintenance. Accumulation of hardened size around the pivot arm to a point when the arms are not free to move should obviously be avoided.

Keeping exposed cylinders cleaned of size, particularly the cylinder rods, is the single most important consideration. The installation of a protective shield is recommended where presses may have exposed cylinder cases.

<u>Frame work</u>

Cleanliness scrubbing and painting are important considerations pertaaining to the maintenance of size press frames. Unfortunately, we have found many mills do very little about this. As the result, frames frequently rust out much earlier than expected. In some cases, extreme degrees of corrosion of various brackets and frames above the unit can cause flake-off that may contaminate the size. For this reason, it is recommended that equipment immediately above the size press be inspected carefully at frequent intervals and that cleaning and paining of such equipment be made a definite part of the size press maintenance program.

In summarizing the maintenance requirements of size presses, whether they be the horizontal or the vertical design, it can be said that the most basic concepts of maintenance anywhere apply most specifically to these units (1) checking for wear and tear on a regular preventive maintenance schedule and (2) Keeping the suit and all its parts clean. A regular inspection schedule for this equipment and common sense care are not difficult to manage. They will pay off every time - in the long run and in the short run too!

<u>CALENDER ROLL MAINTENANCE</u>

In the manufacture of paper, calendering is a critical process. It is the operation that must impart the practically perfect uniformity required high-quality production. Particularly in the making of light gauge papers, unvarying thickness across the entire sheet is essential.

Because the calender carries this heavy responsibility for the quality of the finished product, it should be kept in mind that it should be operated with care and good attention given to its maintenance. When the rolls of a stack have been ground to proper shape and satisfactorily aligned, the calender should not be subject to unnecessary manipulation. This, however, is not always the case because calender men frequently resort to practices of heating or cooling bearings, or jacking arnd padding in an effort to make a better reel. Certainly all possible sources of trouble ahead of the calender should be investimated because such expedients can abuse this highly precise machine and should be avoided. Moreover, they are non standard arrangements which provide no guarantee of stisfaction under slightly altered circumstances, or with a change of operating personnel.

Roll Doctors

Proper calender maintenance importantly includes the preservation of fine roll finish. This directs attention to doctors which, although improved in their designs, still, under certain conditions, mark and rolls. The weight of the doctor assembly, as it affects the pressure of the blade against the roll, is very important, and this pressure should be as light as possible. The angle of the blade against the roll is also important for satisfactory performance and to make it, as far as possible, self-cleaning. There are various types of blades available, but, regardless of choice, the blade must be shaped correctly to the roll and ground frequently enough to maintain the shape. Doctors should be kept clean to vaoid foreign material lodging between the lade and the roll which could cause scoring. The use of oscillating doctors helps to prevent scoring of the rolls; also avoiding excessive pressure on doctors lessens this hazard.

Importance of Proper Crowns

If a hard centre or hard edges develop on the reel, or if hard and soft spots occur across the reel, attention should be given to correcting amount of crown or shape of crown and also to checking conditions which might affect uniformity of temperature.

When the product being made is always the same and the operating conditons remain essentially the same, a single set of crowns, properly calculated and checked, should produce satisfactory operating conditions. For the mill running a variety of papers, that is with respect to caliper and finish necessitating operating a calender with varying nips, the crown applied to a set of rolls is, of necessary, a compromise and, therefore, will not be truly correct for all conditions.

Fully as important as proper amount of crown and its proper distribution in the calender is correct crown shape. This also holds for any other rolls of the paper-machine, press rolls and draw rolls for example. All rolls should be ground within accuracies suitable for the particular type of product being proceed. To illustrate, it is certainly most important to have a very accurately ground set of rolls when producing sheets in a thickness range from .005 cm to .01 cm compared to the production of a sheet of board which may be .025 cm or more in thickness. In any event, it is desirable to keep the roll shape as accurate as possible, that is, with a minimum deviation from target curve.

The correct crown shape for most paper mill applications of chilled iron rolls is a 70 degree curve, illustrated in fig. 11.13

When a roll is measured for proper shape, a roll caliper such as is illustrated in figure 11.13 should be used. The roll should be divided and marked off into twenty divisions starting 4 cms from the end of the face on each end and caliper readings taken at each of the twenty positions. These readings should then be graphed and plotted against a standard target curve based on the actual measured crown. As pointed out above, the deviation from target should be held to a minimum.

The machine used for roll grinding should be periodically checked for proper alignment and levelling. When a roll is set in the grinder, a check should be made to make sure that the bearing areas are running concentric. It is important that the grinder be isolated from external vibration with a suitable foundation to insure accurately ground rolls. The two wheel roll grinder illustrated in Fig. 11.13. has proved to be the best type of machine for grinding rolls in the paper industry.

Roll Grinding Tips.

As with the calender, roll grinders also require intelligent and careful operation and proper maintenance. The following suggestions come from men of log experience in the operation of various roll grinding machines used in paper mills.

1. If results are not satisfactory, don't be hasty about blaming the grinder. Check first on conditions that may need correction:

a) Are the roll necks round and in good shape?

b) Are the roll neck rests in good condition and is the work properly set?

c) Is the wheel in good condition?

d) Is there any unusual activity in the vicinity causing vibration of your machine?

2. Don't try to hurry roll grinding. If too much stock is hogged off at first, it is probable that more time will be lost than saved in trying to get a satisfactory surface when finish grading. It is wise whenever possible to scheduele fine work so that the job can be completed within one work period. Conditions overnight can vary slightly; even strong sunlight on a roll can cause sufficient metal expansion to affect a fine adjustment.

3. Unless a wheel is ideally suited to the work, occasional dressing may be required to obtain the best results.

4. It is good practice to cover the roll journals when grinding the roll body to keep the compound from contaminating the journal lubricant and to keep grit out of the gib area.

5. Make sure that the grinder in use is properly lubricated. A check up by chart should be made at regular intervals.

Roll handling and storage

It is well to remember that proper roll maintenance starts the moment a roll arrives at the mill. If it is opened for inspection, the roll should be recoated to prevent corrosion and wrapped in paper which is coated on the inside with rust-resistant compound. How substantial the wrapping should be depends on how soon the roll will be used. For longer storage there should be several layers of wrapping paper and the rolls should be periodically inspected. Also, when storing rolls for long periods, they should be rotated at regular intervals to minimize permanent set. Storage for any period of time should be in a dry and heated area.

When lifting and transporting a roll a protective canvass wrap should be used. Rolls with small diameter steel journals should be liefted with a sling around the body, not supported by the journals. Other types of rolls may be lifted from the journals, using well protected wire rope. Do not use chains.

Problems and Causes

Following is a list of problems which may be encountered in connection with the use of chilled iron rolls or calenders and the probable causes based on very considerable trouble shooting experience.

BURNED SPOTS, SPALLING

Pads - running metal-to-metal - violent bouncing of the stack - high ends - bearing heat - misalignment - stalling.

DENTING

Foreign material in furnish or possibility of roll diameter being reduced to a point where proper hardness no longer exists - improper roll selection - wads and plugs.

PITTING

Chemical action (which might be improved by the use of higher alloy rolls, the addition of an inhibitor to the solution or grounding the water box) - poor grinding and finish - improper roll selection - pitted water doctor rolls.

EXCESSIVE WEAR

Improper crown or excessive pressure on doctor blades - misalignment - bearing wear - running metal-to-metal.

SCORING

Poorly ground doctor blades - excessive doctor pressure - dirty doctors.

EXCESSIVE VARIATION IN BULK OR CALIPER LENGTHWISE OF THE SHEET

Eccentric rolls

EXCESSIVE VARIATION ACROSS THE SHEET IN BULK OR CALIPER

Improperly crowned rolls - non uniform temperature conditions.

FINISH NOT UPTO QUALITY

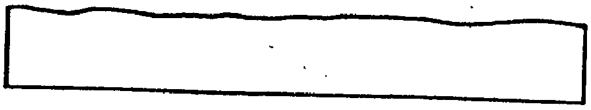
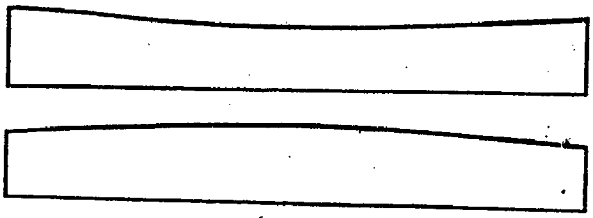
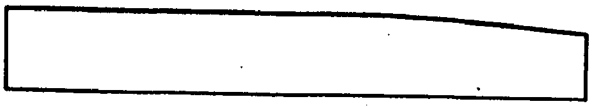
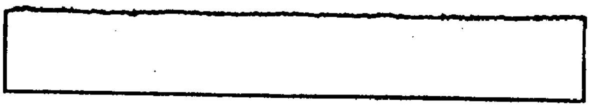
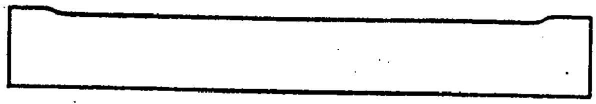
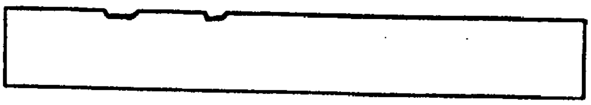
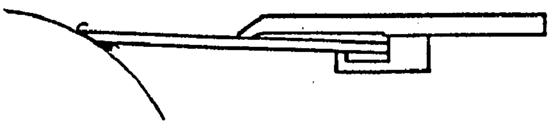
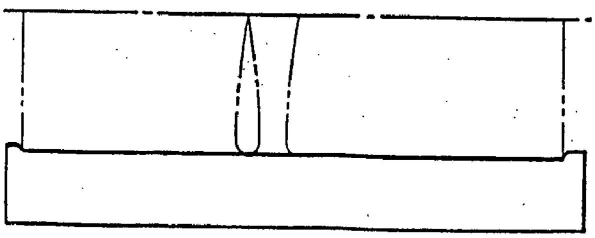
Insufficient number of roll nips - poorly ground rolls (on the assumption that there is no trouple at the wet end).

BROKEN ROLL JOURNALS

Excessive loading - jacking - lifting several rolls with one inermediate roll.

BARRING

Poorly ground rolls - improper bearing assembly - burns - excessive speed (operating the rolls too close to a critical speed) - rolls not ground cocentrically - rolls not properly aligned.

MPTOMS	BLADE APPEARANCE	PROBABLE CAUSE(S)	REMEDY
ven Wear . quent Blade nge		a. Poor Roll Surface b. Damaged or Dirty Blade Holder c. Deposits	a. Use more flexible blade. b. Clean, repair or replace holder c. Use abrasive blade
ssive wear in er of blade t ends		a. Doctor not machined to match roll crown b. Old doctor sagging into (or away from) roll	a. Refit and shim holder to doctor back as necessary (Return new doctor for re-planing if mismatch is excessive b. Replace old, sagging doctor
ssive wear ne end		a. Doctor Misaligned — Not parallel to roll axis	a. Shim, or move bearings and brackets as necessary to align doctor parallel to axis
wear but rough		a. Deposits on roll b. Excessive pressure on blade c. Blade material too hard	a. Use abrasive blade as required b. Reduce pressure c. Use softer blade
ssive wear eet run		a. Deposits left on roll by sheet	a. Use abrasive blade as required b. Trim blade edges frequently c. Use end slotted blades to prevent build-up of excessive pressure on roll ends
ssive wear de sheet run		a. Sheet lubricates roll	a. Slot blade ends to relieve pressure
ized Pitting		a. Blade attacked by 1. Electrostatic discharge 2. Electrolysis 3. Heat	a. Insulate doctor from machine frame; or use non-metallic blade
develops red edge		a. Blade material too soft b. Excessive pressure c. Blade angle too flat	a. Use harder blade b. Reduce pressure c. Move bearings or brackets to increase angle. Check for correct angle with gauge
s on blade le roll surface		Blade overhangs roll a. Not centered b. Too long c. Not oscillating properly	a. Center blade b. Trim length c. Adjust oscillation stroke
in blade edge		a. Blade caught scab on roll at start-up. (Most common on old dryers.)	a. Change blade and remove scab

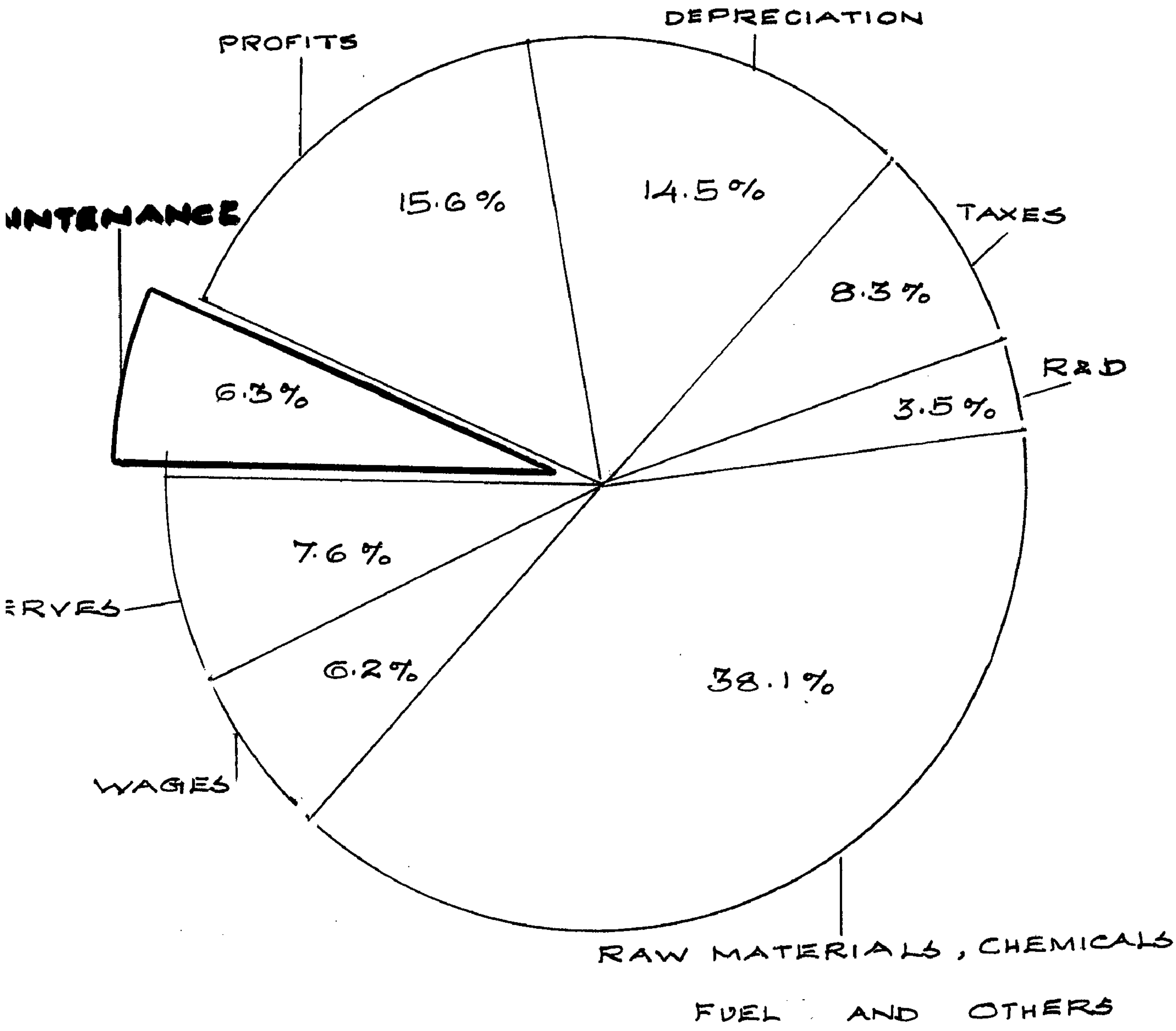


FIGURE 1.1. SHOWING ALLOCATION OF REVENUE

IN HINDUSTAN NEWSPRINT LTD 1990-91.

FIG 3.1. MAN HOURS OF PREVENTIVE MAINTENANCE VS COSTS

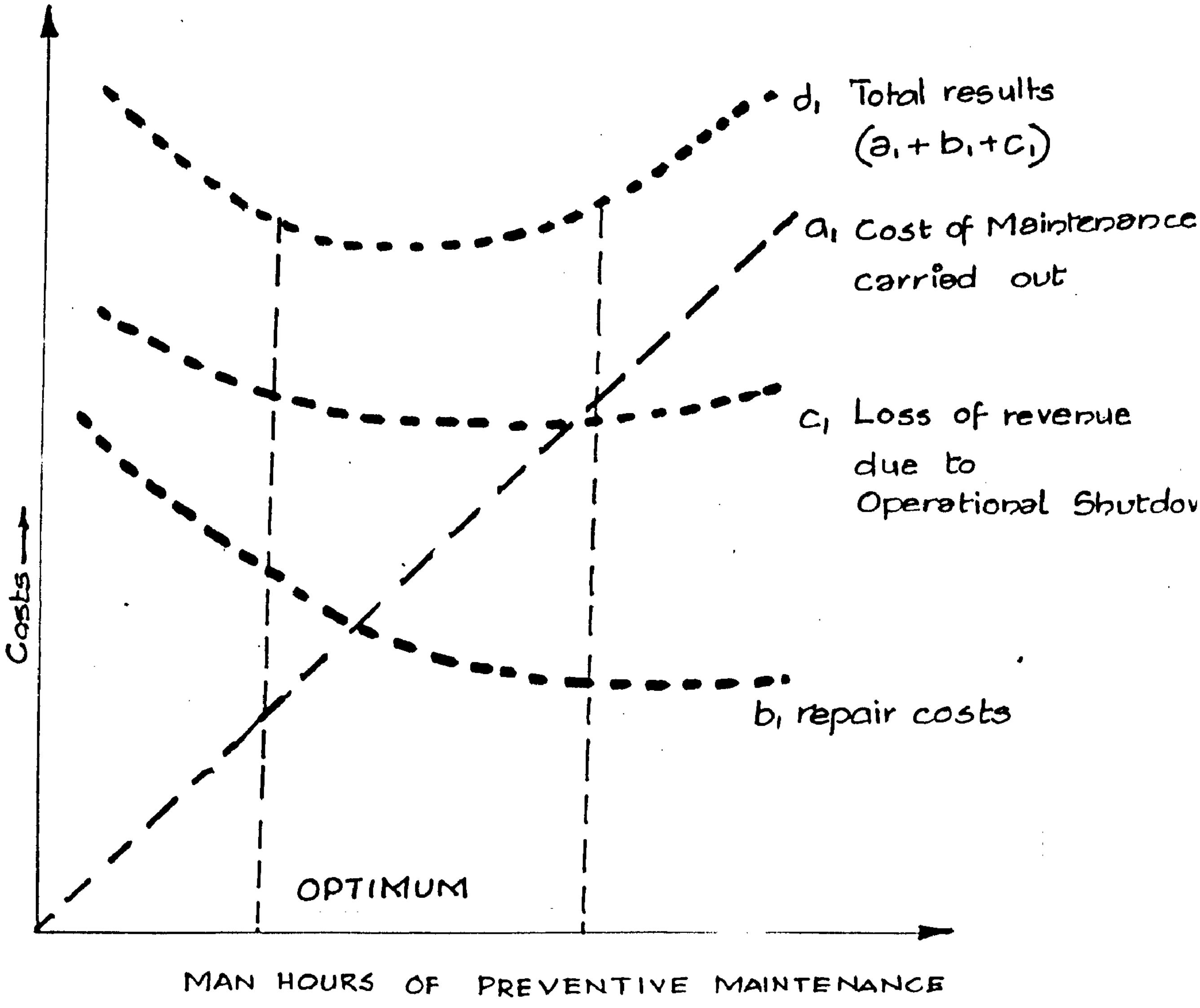
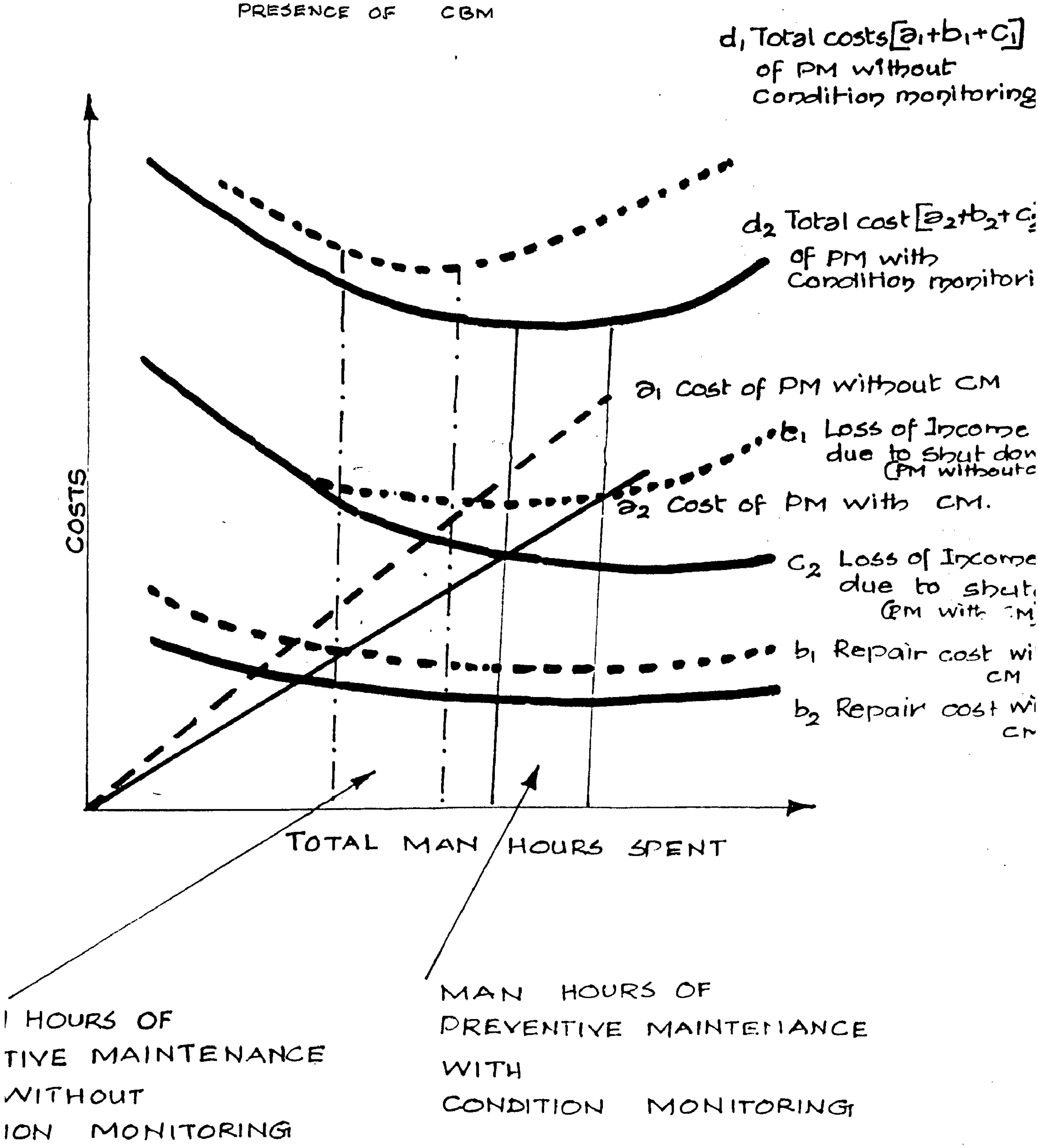
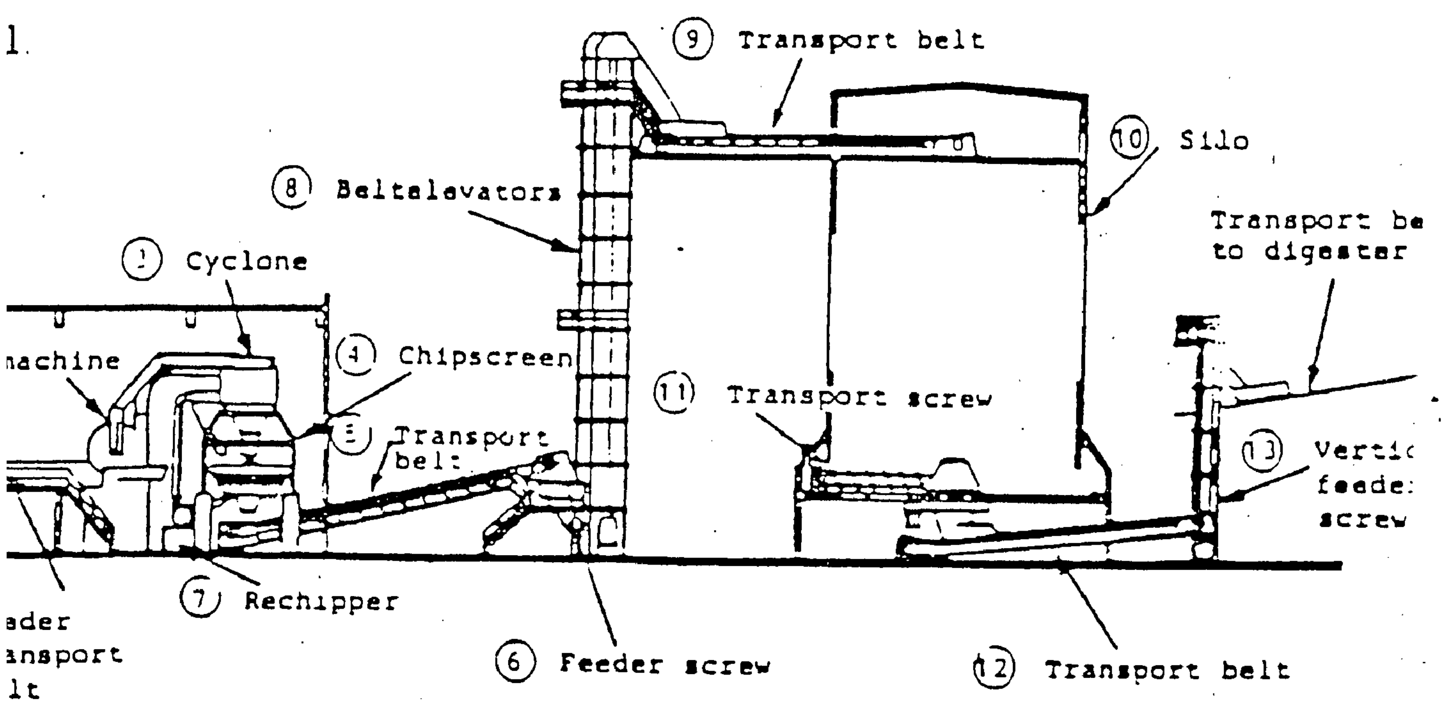


FIG 3.2. MAINTENANCE MAN HOURS VS COST IN PRESENCE OF CBM





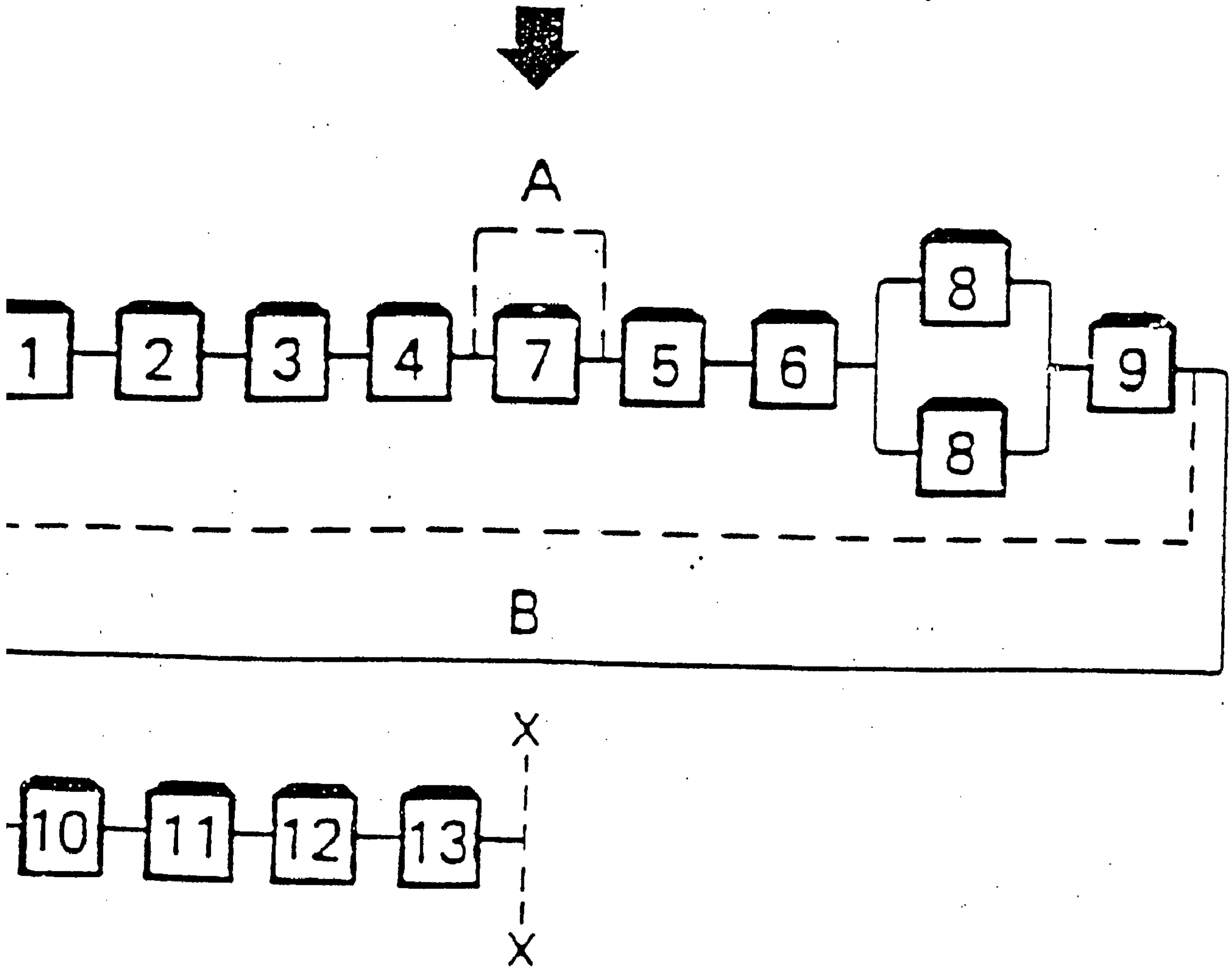


Figure 3.3 CHIP MILL FLOW DIAGRAM
ALTERNATIVE I

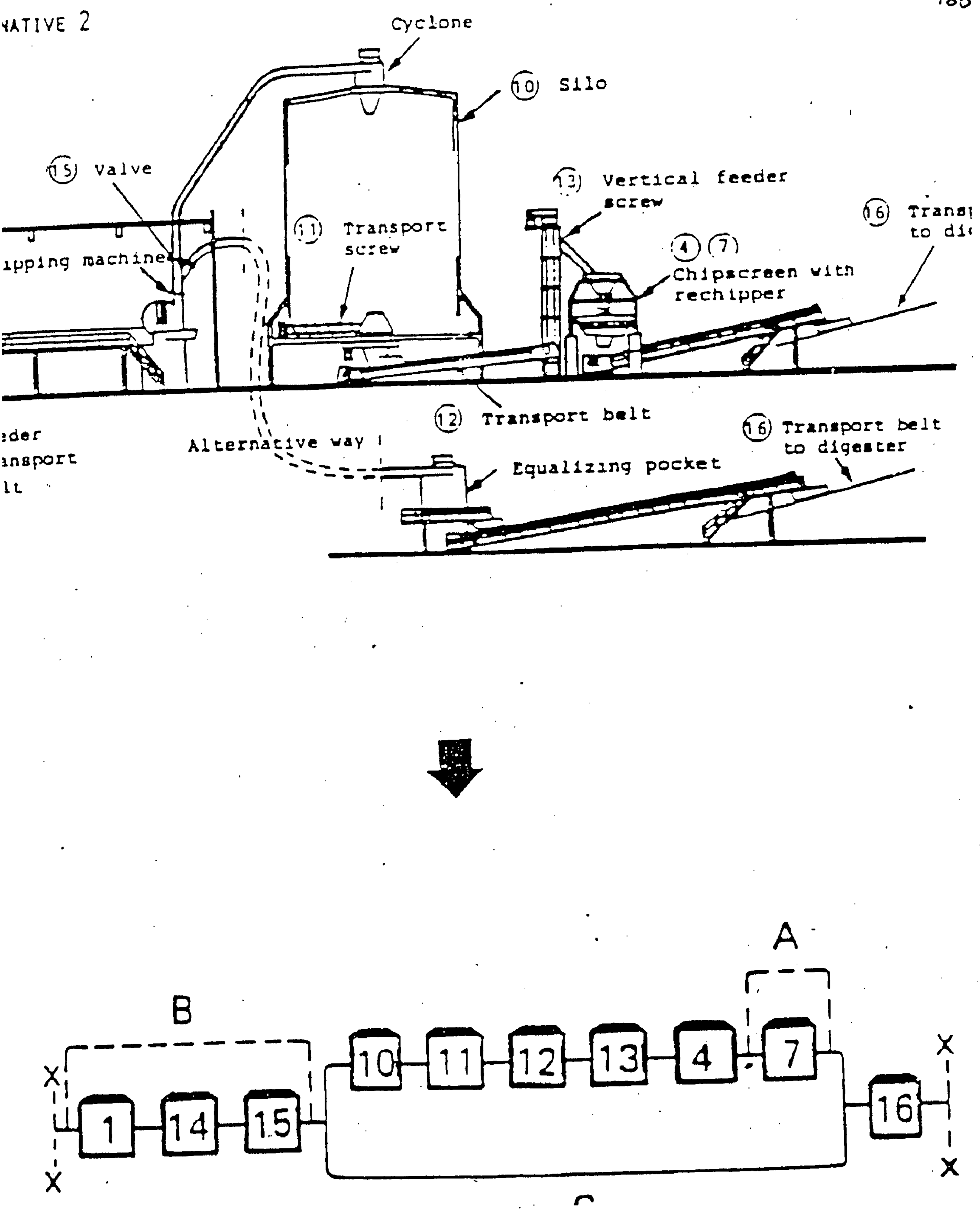
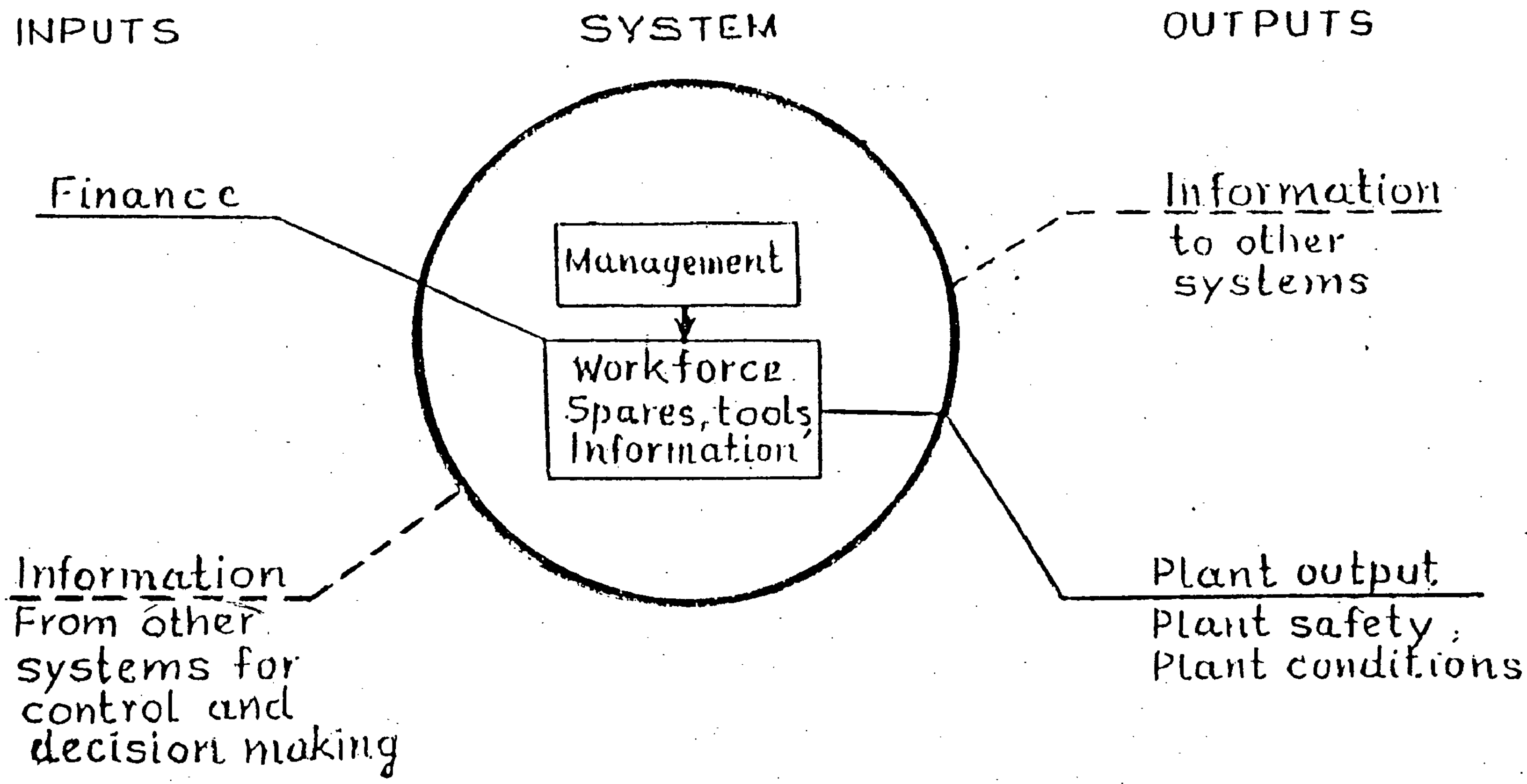
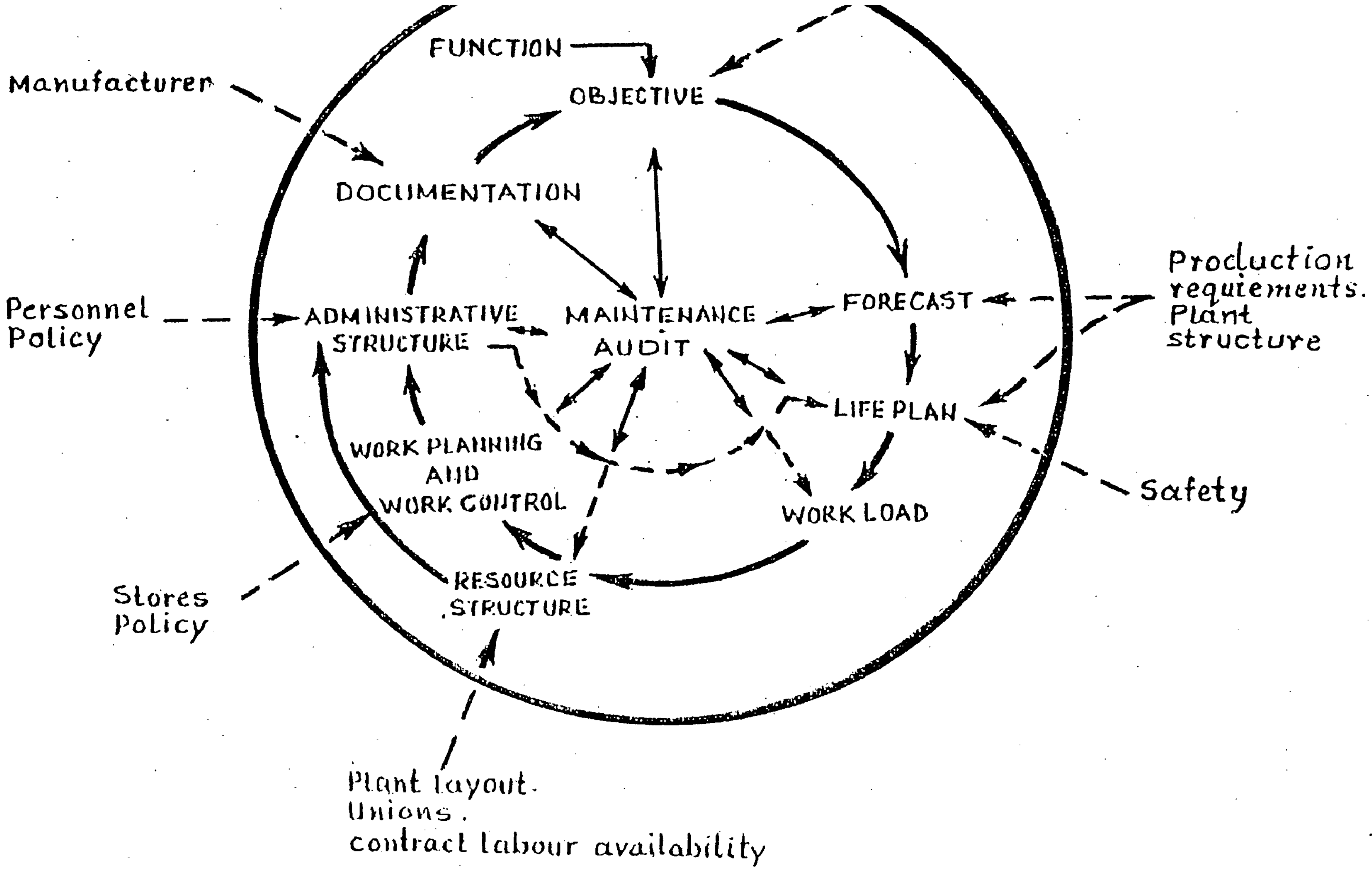


Figure 3.4. CHIP MILL FLOW DIAGRAM ALTERNATIVE 2



FUNCTION OF A MAINTENANCE SYSTEM

Figure 4.1.



A METHODOLOGY FOR THE MANAGEMENT OF A MAINTENANCE SYSTEM.

Figure 4.2

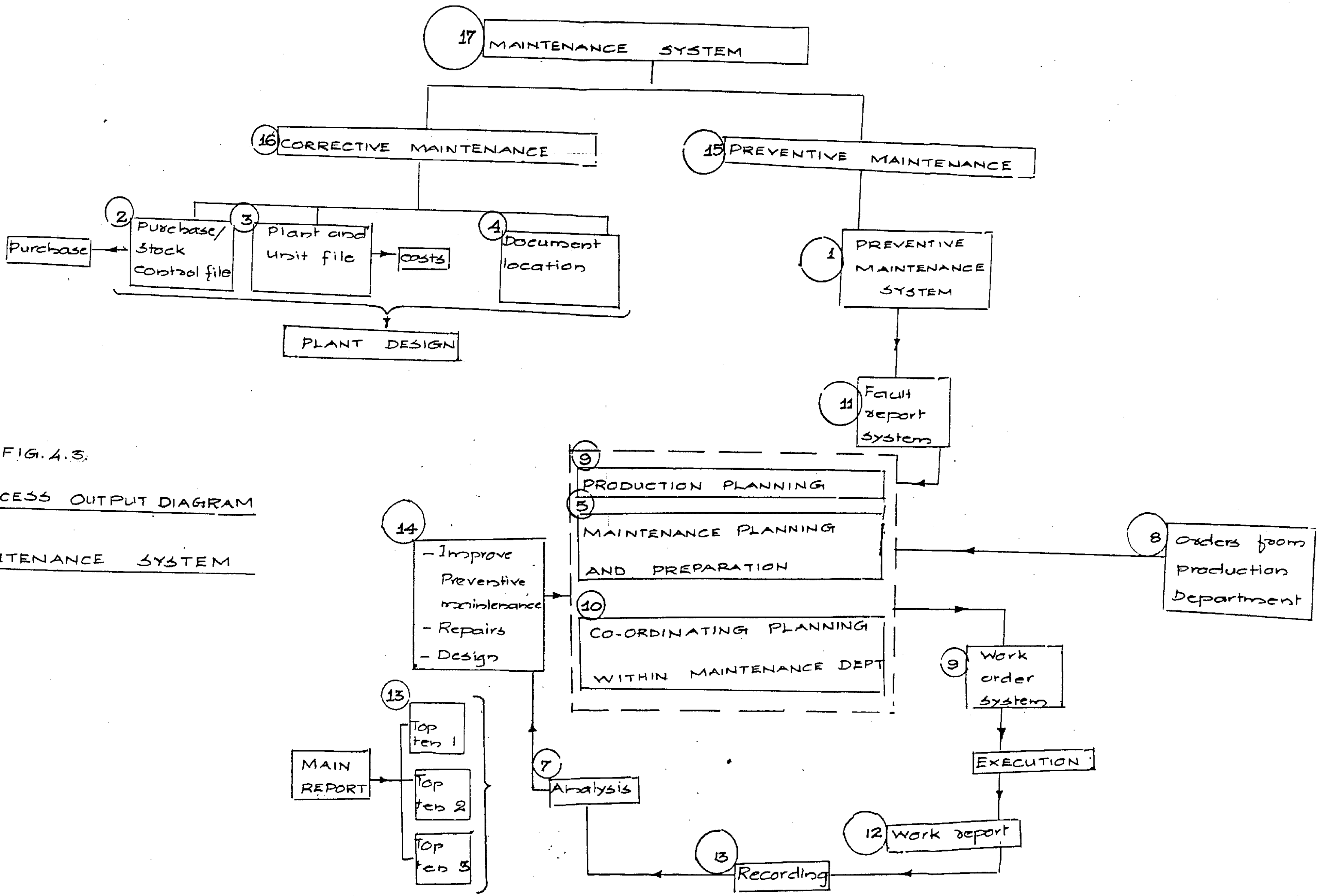


FIG. 4.3.

INPUT PROCESS OUTPUT DIAGRAM

OF MAINTENANCE SYSTEM

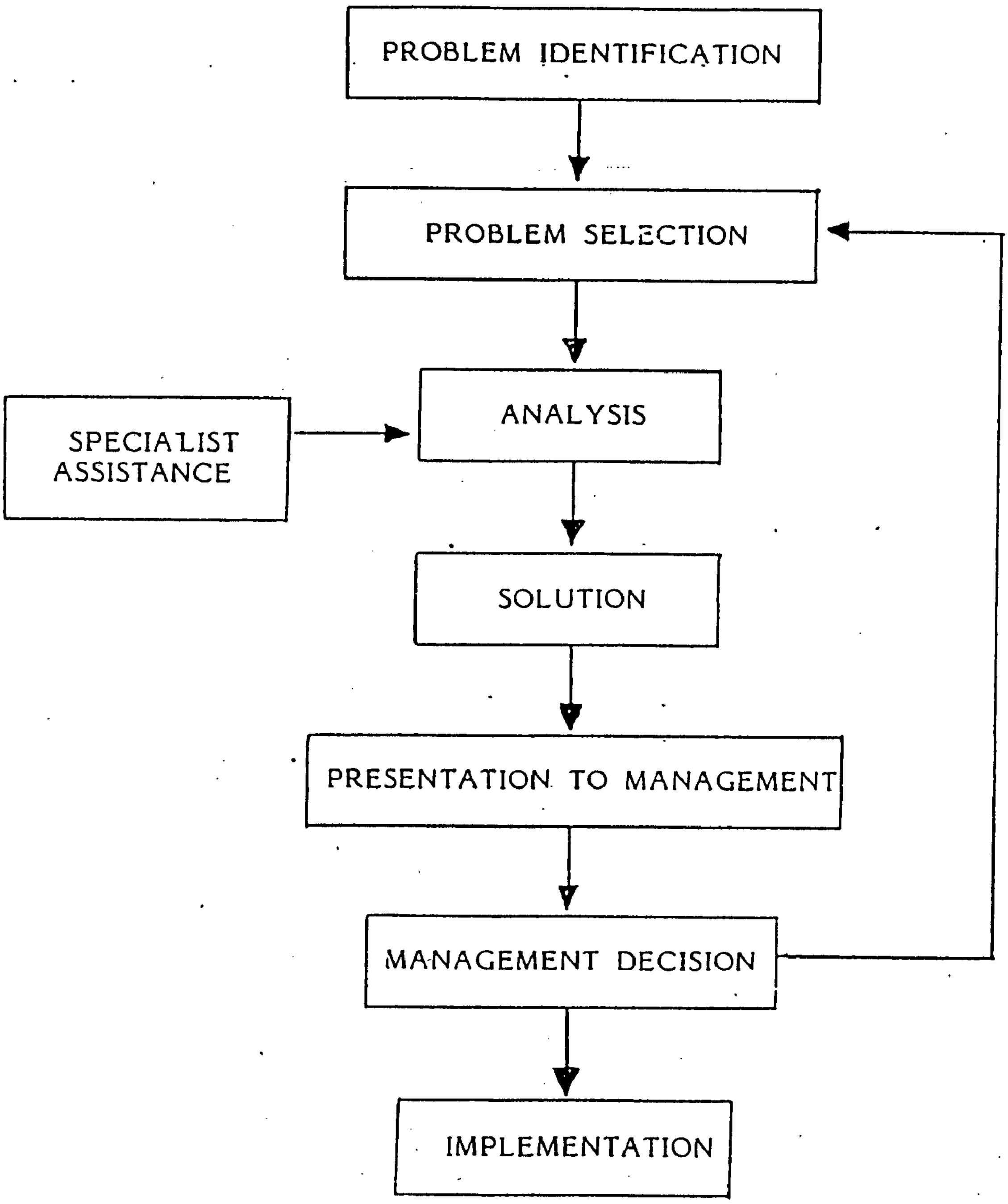


FIG 4.4 MAINTENANCE PROCEDURE FLOW DIAGRAM

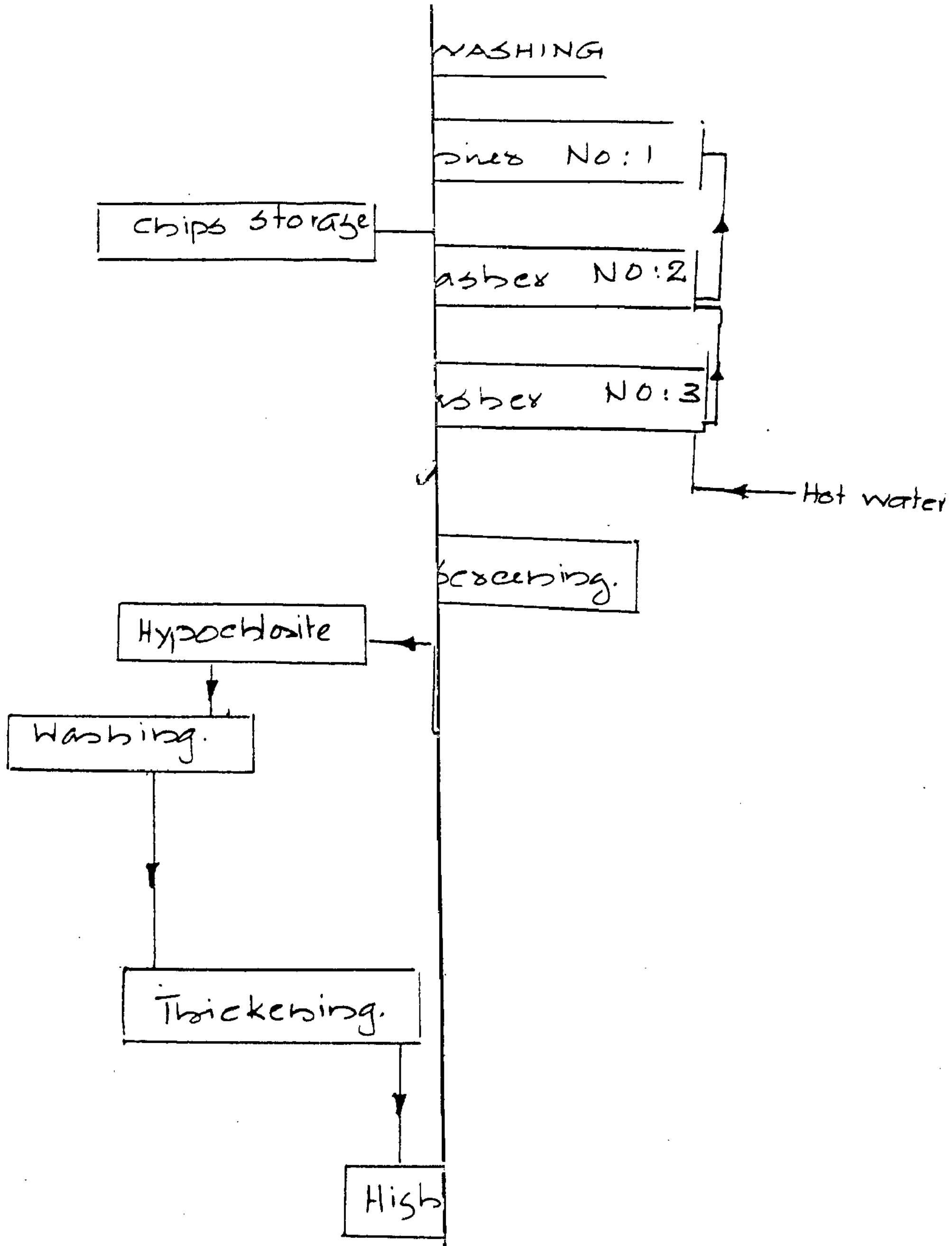


FIG 5.1.

FLOW CHART OF

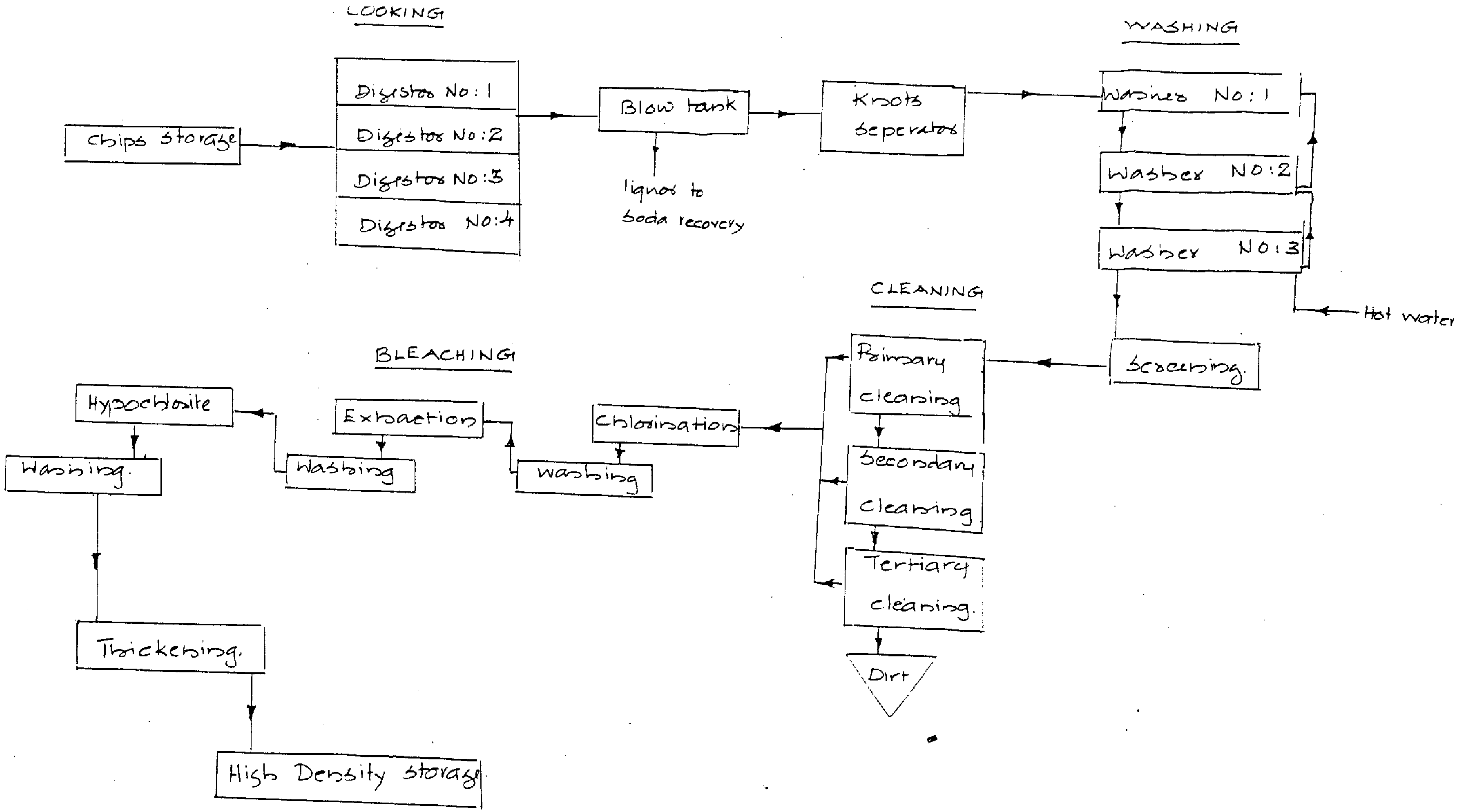


FIG 5.1.

FLOW CHART OF CHEMICAL PULPING

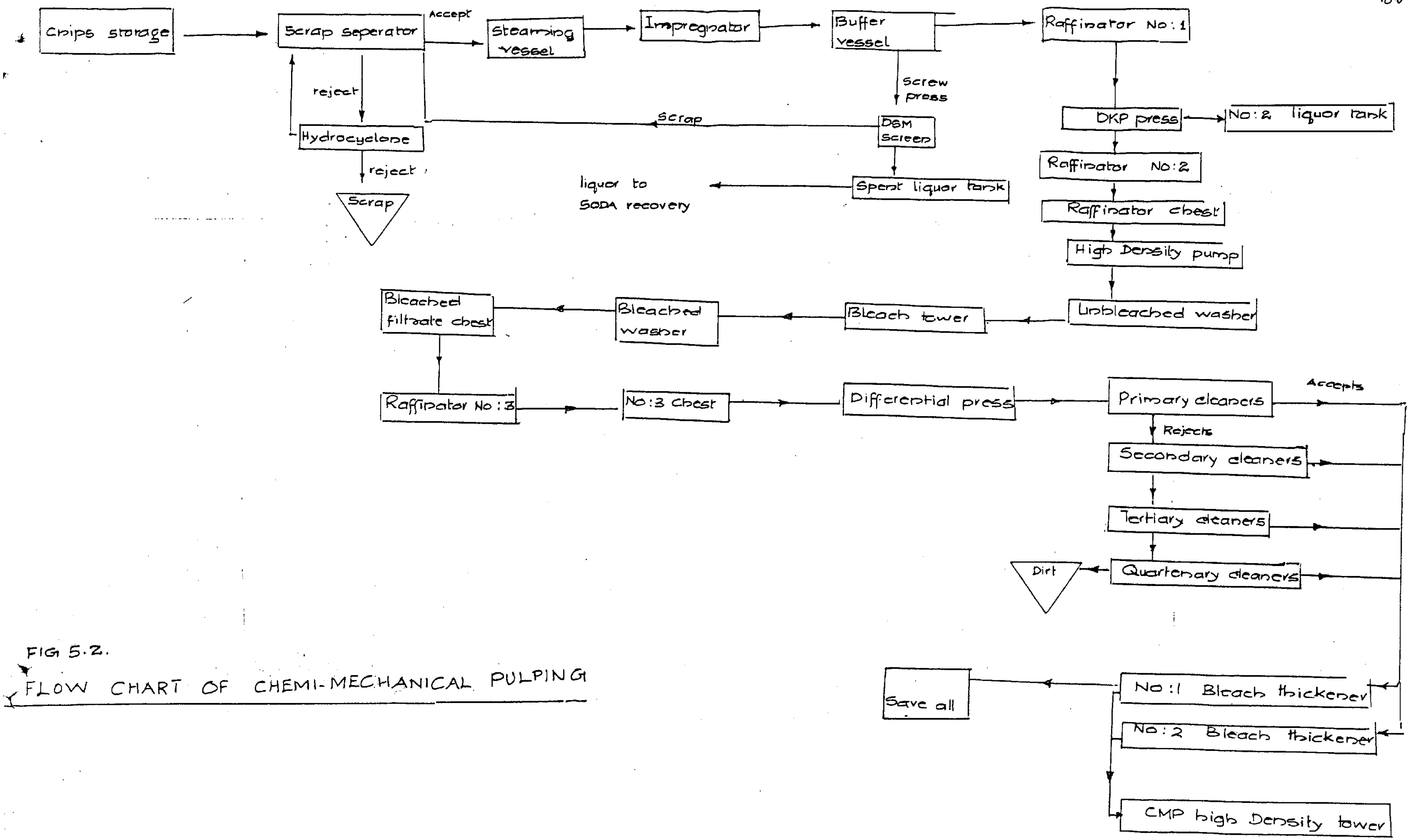


FIG 5.2.

FLOW CHART OF CHEMI-MECHANICAL PULPING

Figure 5.4. HISTORY CARD.

HISTORY CARD

FORM - "C"

EQUIPMENT Pump- primary Cleaner feed No. 531-18

LOCATION CMP

SCHEDULE OF MAINTENANCE

DATE START	DATE COMPLE	MAN POWER	TROUBLE	MAINTENANCE WORK DETAIL	SPARES USED	MAN HOURS SPENT	MACHINE DOWN TIME HOURS	SIGN OF ENG.
14/4/84	14/4/84		Bearing change	Rotor replaced by new one & Brgs. N4316 & 22316)	~~Rotor~~ Rotor	32	8	[illegible]
3/2/86	3/2/86		Shaft broken	Rotor changed				
27/6/86				Body coated with Belzona R metal (top half only)	Rotor	25 hrs	7 hrs	[illegible]
12/12/86	12/12/86							
11/5/87	11/8/87		Shaft broken	Rotor unit changed.	Rotor	36 hrs	7 hrs	[illegible]
			Shaft broken	Rotor changed	Rotor	24 hrs	7 hrs	[illegible]
14/1/88	14/1/88	[illegible]	DE Brg lost	Rotor changed	Rotor	25 hrs	[illegible]	[illegible]
23/1/88	23/1/88	[illegible]	Rotor fixing damage	Rotor changed	—	[illegible]	[illegible]	Planned
8/12/89	8/12/89	[illegible]	[illegible]	Rotor changed	—	390	Nil	Planned

Pump - Primary Cleaner feed

CMP

Figure 5.5. SPARE PARTS RECORD

EQUIPMENT No.

SPARE PARTS RECORD

NAME D. A. P. Parts

S. L. No.	DRG No./ PART No.	STORE CODE No.	DESCRIPTION	INST. QTY.	UP DATE QTY.	UP DATE QTY.	UP DATE QTY.	UP DATE QTY.	UP DATE QTY.	UP DATE QTY.	LOCATION
		5436102249	Gear ring item No. 151 3700		2 10.10.91						C/S B-C
		5436102261	Rollers tracks item No. 151 3500		2 10.10.91						C/S B C
	[illegible] /521/ B_3 - 001	5411C2 3C	Support Rollers collars item No. 1		2 14.10.91						C/S 493 C
	[illegible] /521/ B_2 001	543610 23	Support Rollers [illegible] item No. 2		2 8.10.91						[illegible]
		5436102536	Drive pinion code No. 12 2-23 item No. 151 3200		2 8-10.91						C/S [illegible]
		543610345	Bearing cover inner code 335-12-178 No 30116 2-001		1 8.10.91						C/S [illegible]
		543610350	Bearing cover outer code 335-12-179 No. 30116 1-001								
		5436103566	Sealing band bottom		4 8.10.91						C/S B_3 26-C
		543610360	Sealing band top		2 8.10.91						C/S B_3 26-C
		545710100 1	Screw cylinder item 17/7500		2 7.10.91						C/S B C
		542732005	Parts for Lubricator 135M 4/3 S. Part No. 150		2 8.10.91						495 C
		542730050	[illegible] glass (for [illegible]) 10.12 & 001 5mm length 45.5		10 14.10.91						BL-HC 57.B

Possible Supplieres

Re-order Qty.

AREA ..431..

PREVENTIVE MAINTENANCE SCHEDULE ____ FOR THE MONTH OF..........

page 2

EQP:NO	EQUIPMENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	3
431-30	Repulper - Hypo Washer	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	BG R	B R
431-32	Pump - Hypotower dilution	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	B
431-33	Belt Conveyor - Bl. H.D. stock Chest	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	B
431-35	Agitator No1 - Bl. H.D. Chest	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BC T
431-36	Gas Scrubber																															
431-39	Pump - Washer cleaning shower warm water	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	
431-40	Agitator No.1 - Chlorination tower	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG
431-41	Agitator No.2 - Chlorination tower	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG
431-44	Pump - Warm Water booster	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG
431-46	Condensate pump	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG	BG
431-47	Agitator No.2 - Bl. H.D. Chest	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	BG T	
431-29	Hypo Washer	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	
	Hypo Washer Main drive	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR	
	Hypo Washer Reci. Shower	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	

B — BEARING TEMP.
G — GLAND SEALING/COOLING
T — BELT/CHAIN TENSION
R — GEAR BOX

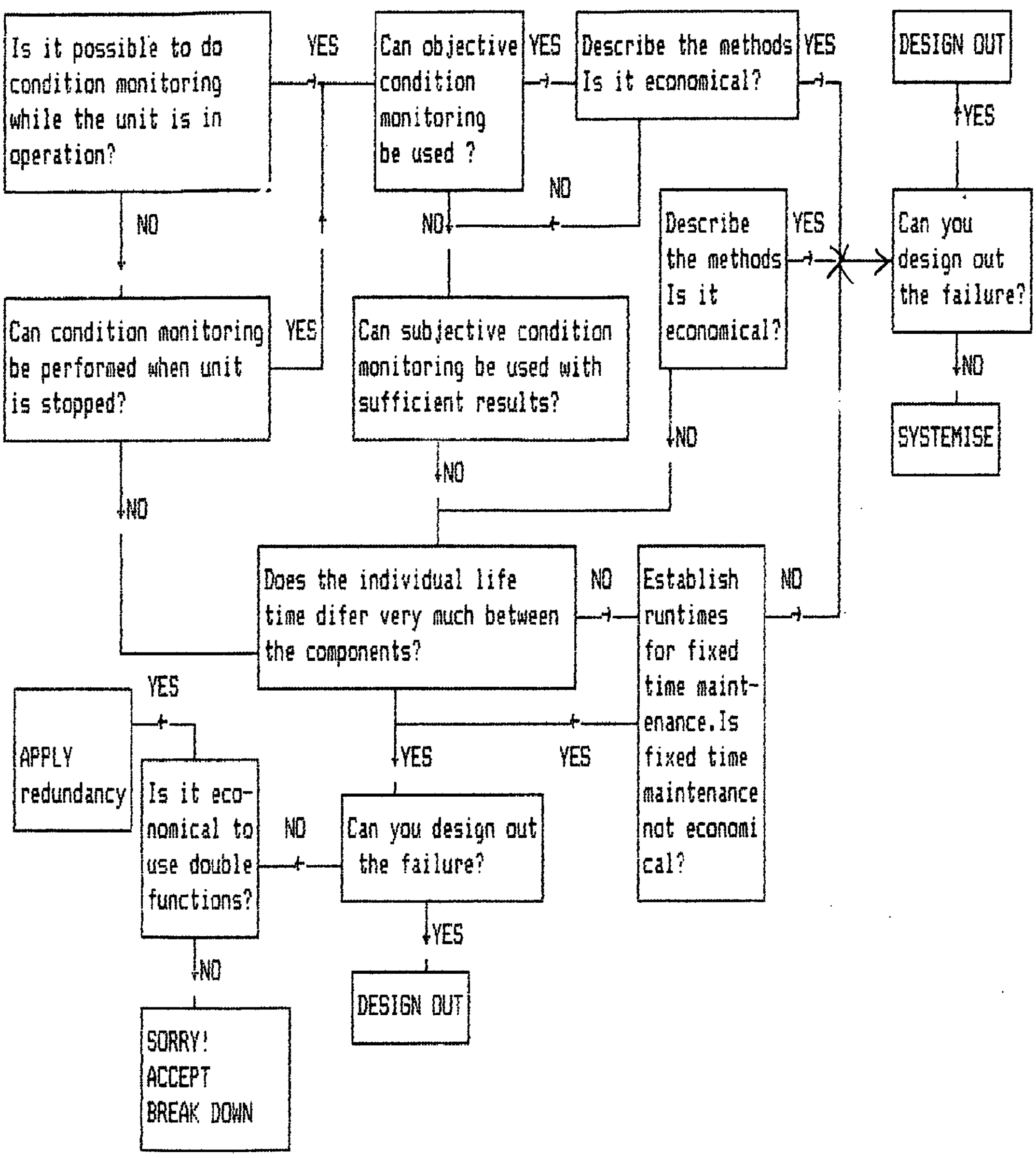
C — COUPLING/BUSH/PAD — CONDITION
P — PRESSURE READINGS — GAUGES
V — VIBRATION

SIGNATURE

Figure 5.6. PREVENTIVE MAINTENANCE SCHEDULE

FIG 6.2.

MAINTENANCE PROCEDURE DECISION MODEL



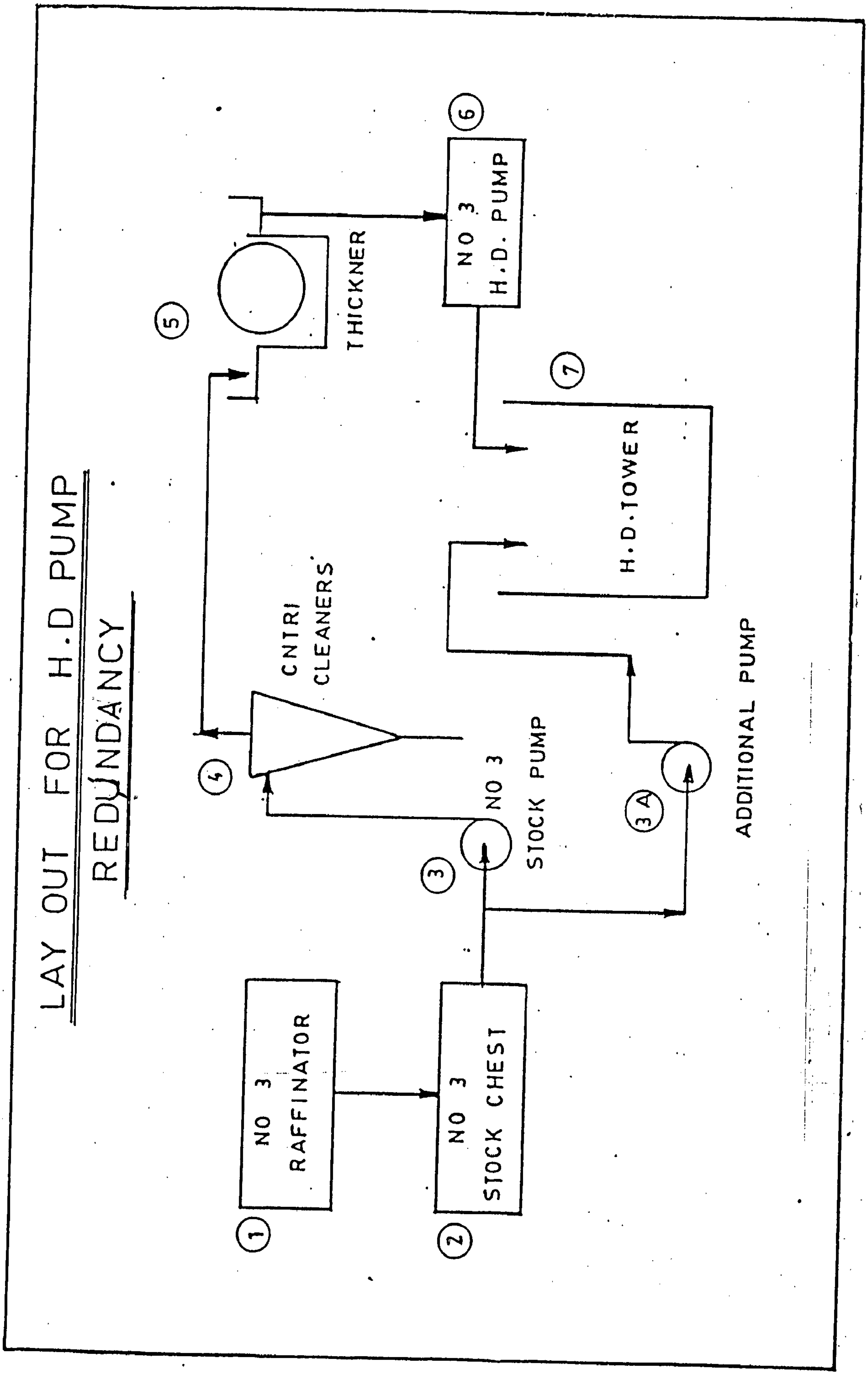


FIGURE 6.3. LAY OUT OF H.D. PUMP REDUNDANCY

FIG. 6.4. JOB REPORT, WORK ORDER, JOB CARD.

JOB REPORT

Description of performed job

Spare parts and material used

Start date	Finished dt	Time	Opinions	Approved Sd

WORK ORDER

Initiator/Requester

Machine/Unit	Section	Account No	Unit No

Description of job or failure

Contractor	Priority/Date	Date	Signature

JOB CARD.

Preparation and planning					
No.	Operation description	Section	Estimate Time	Planned Dt.	No.of wkrs
1. 2. 3. 4.					

Attached drawings and instructions	Requisitions

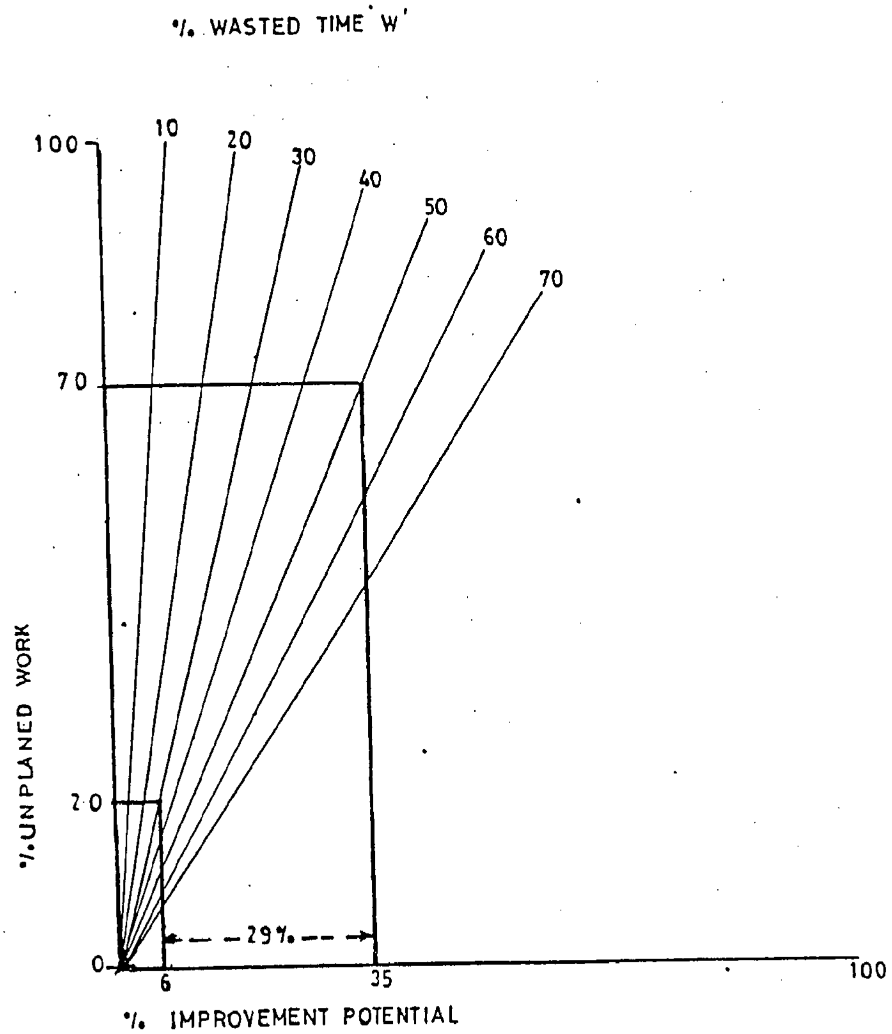


FIG 6.5. UNPLANNED WORK VS WASTED TIME [5] GRAPH.

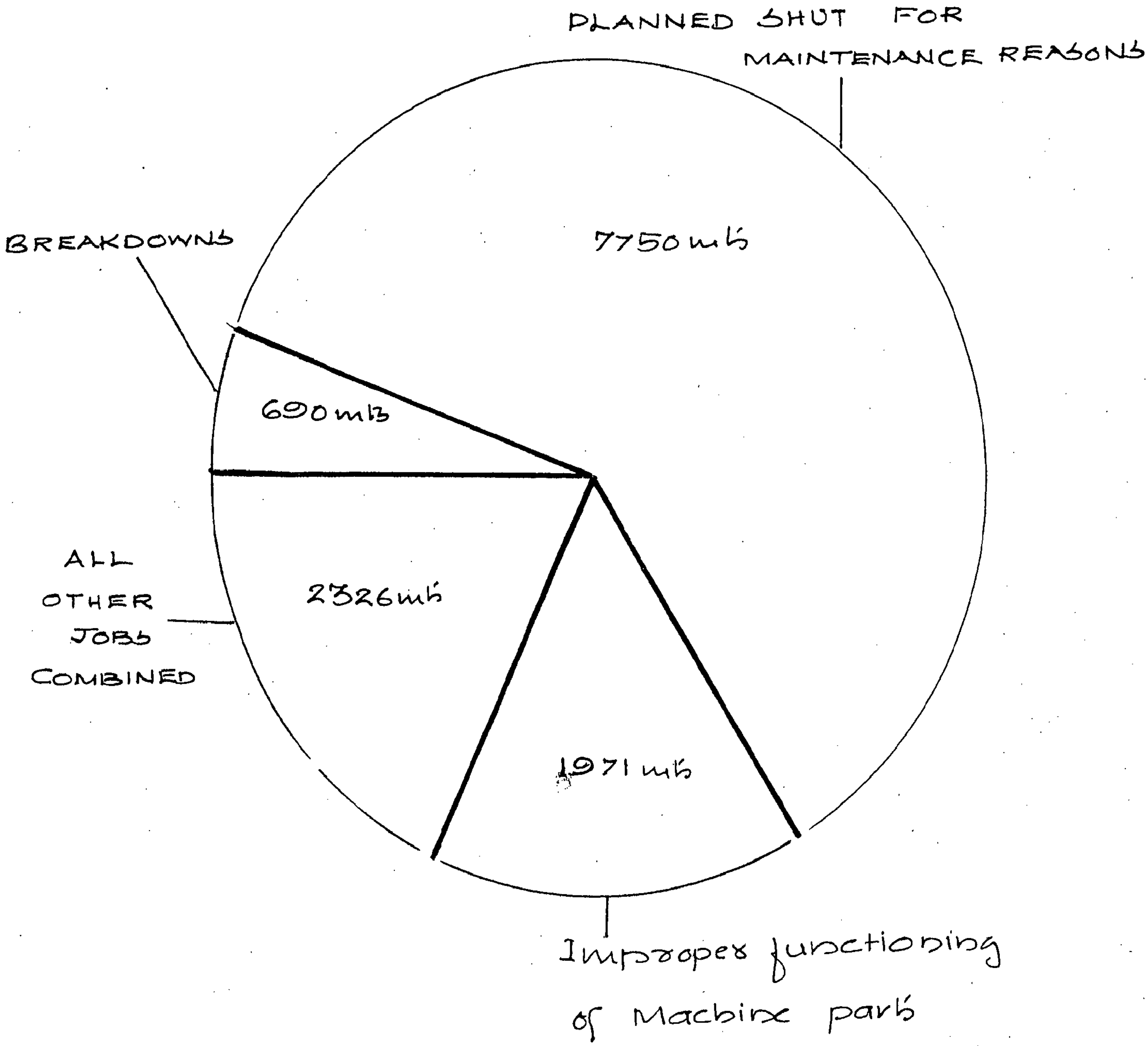


FIG: 7.1.
MAINTENANCE PROBLEMS ON PAPER MACHINE SECTION

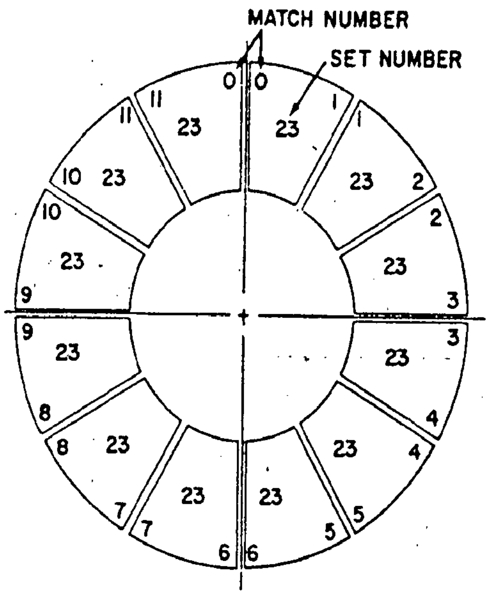
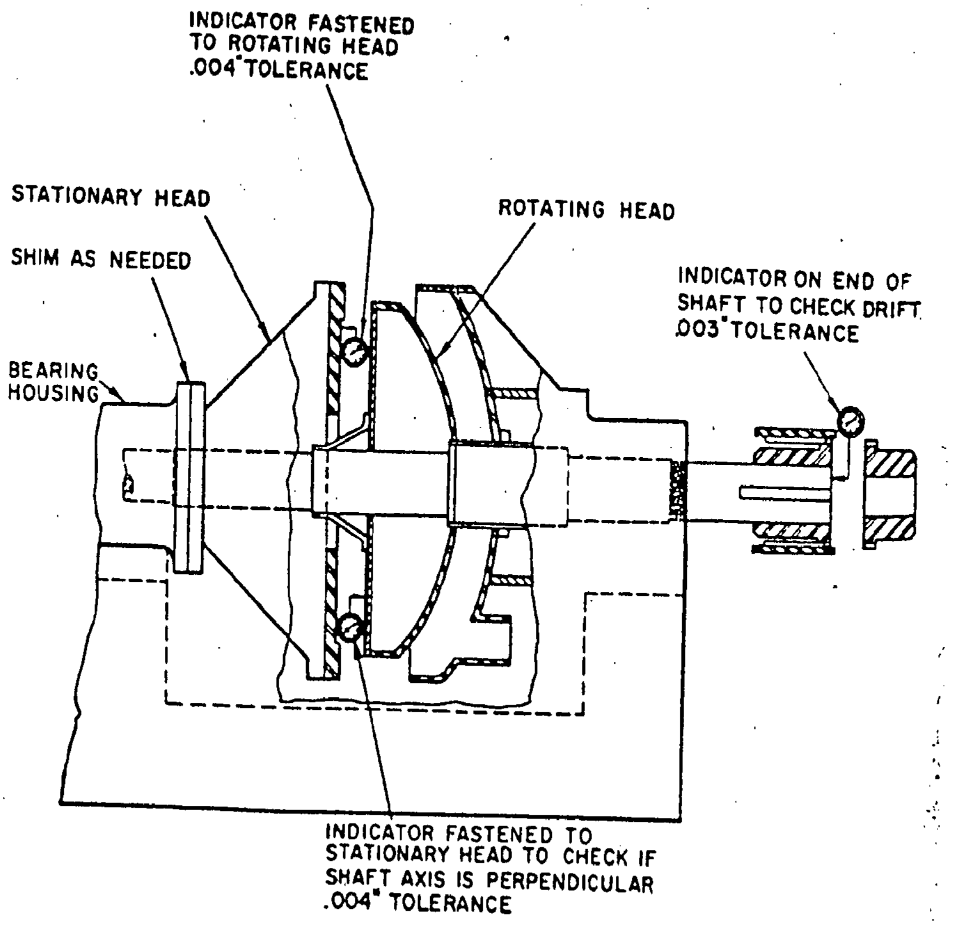


FIGURE 11.1 Half a set of refiner plates, showing numbering scheme on back.

FIG 11.2. ALIGNMENT OF COUPLES.



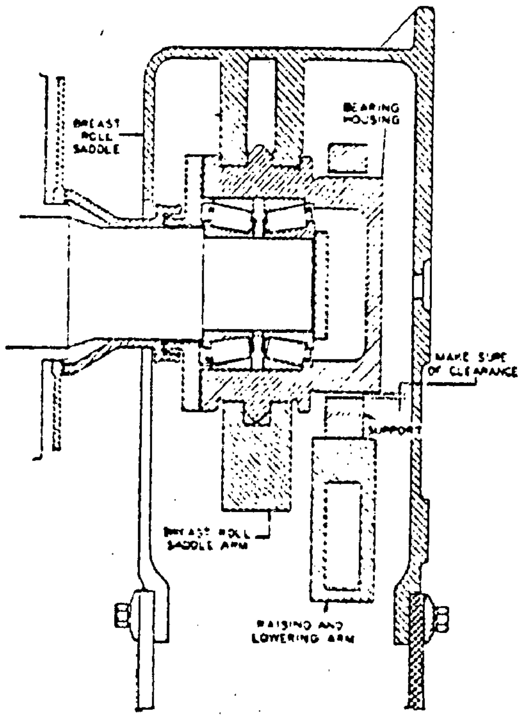


FIGURE 11-3 PROPER RAISING OF SHAKING BREAST ROLL

FORCES IN REFINER

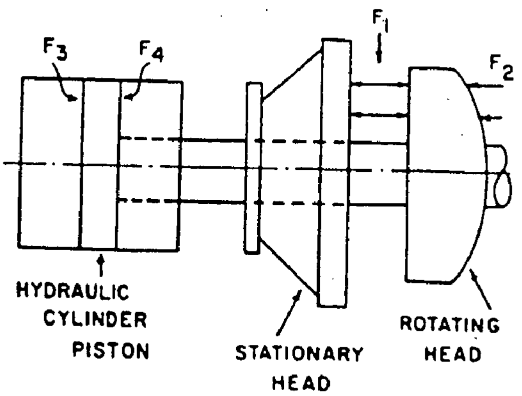


FIGURE 11-4 Position the head by balancing the four forces shown.

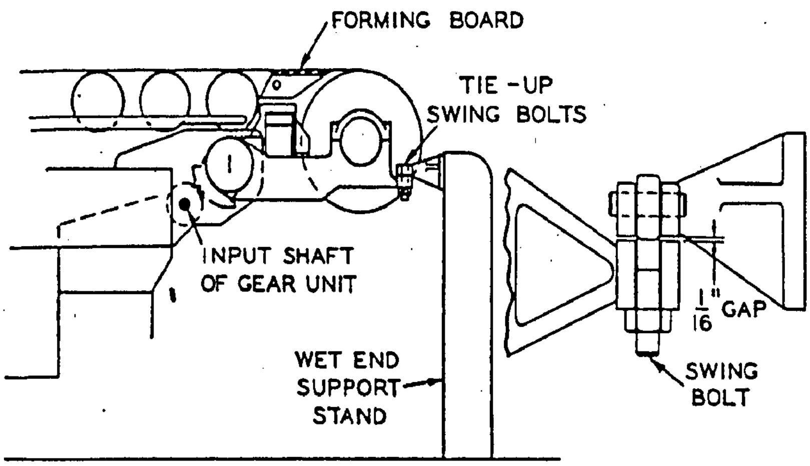


FIGURE II-5 RAISING BREAST ROLL WITH GEAR UNIT

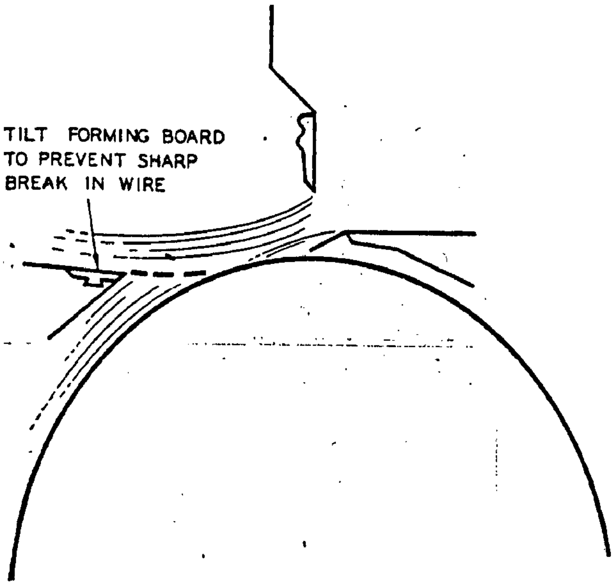


FIGURE II-6 TILTING FORMING BOARD TO ACCOMMODATE WIRE

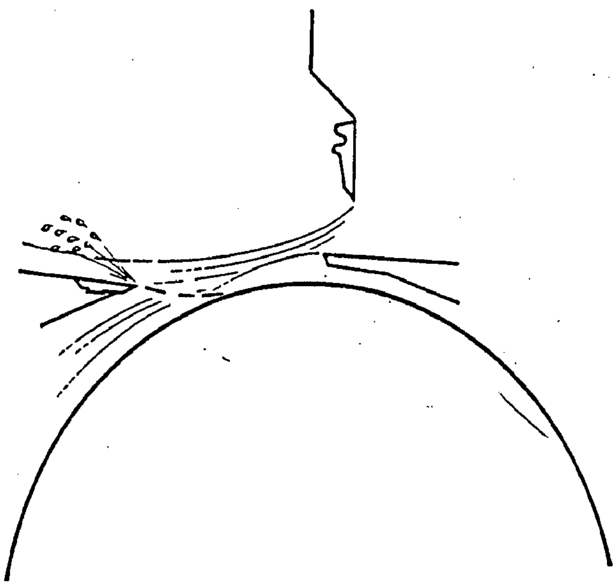


FIGURE II-7 DISTURBANCE TO FLOW FROM DAMAGED FORMING BOARD TIP

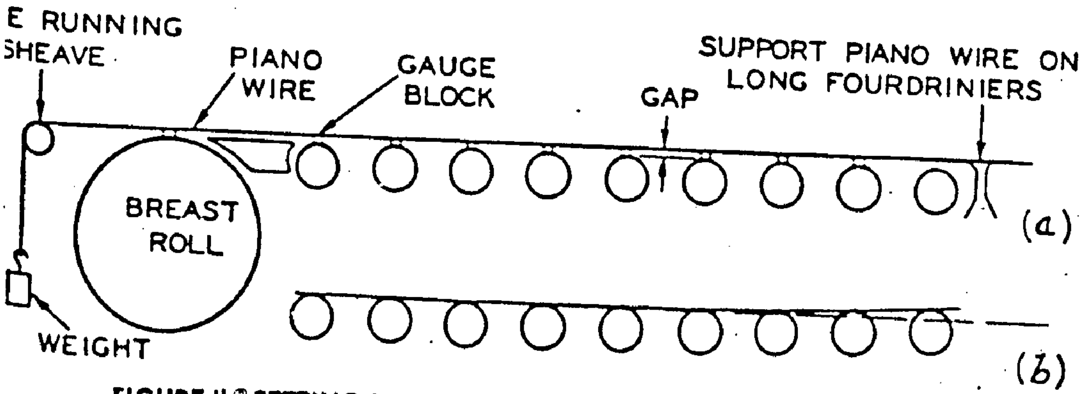


FIGURE 11-8 SETTING VERTICAL ALIGNMENT OF TABLE ROLLS

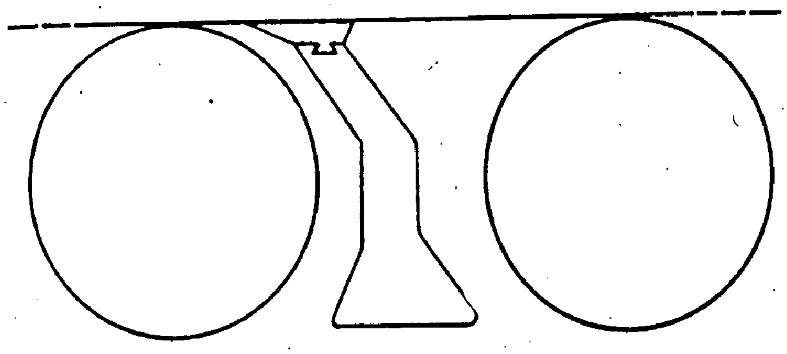


FIGURE 11-9 SUPPORTING WIRE WITH FLAT-TOP DEFLECTOR

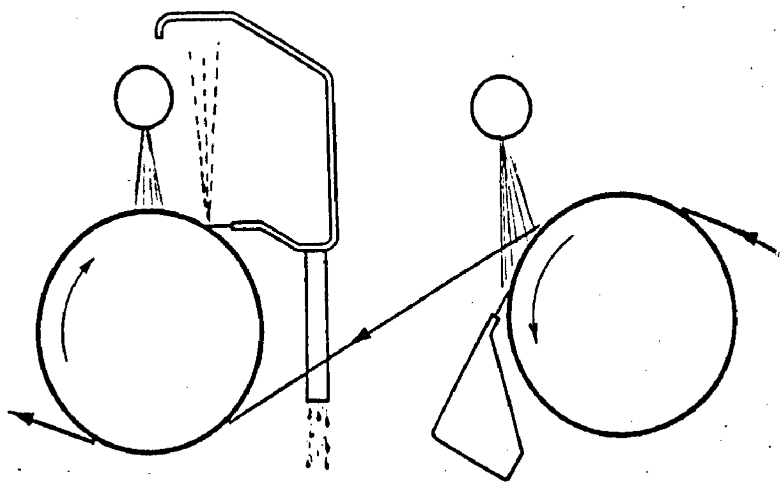


FIGURE 11-10 MOUNTING SHOWERS AND DOCTORS ON WIRE RETURN ROLLS

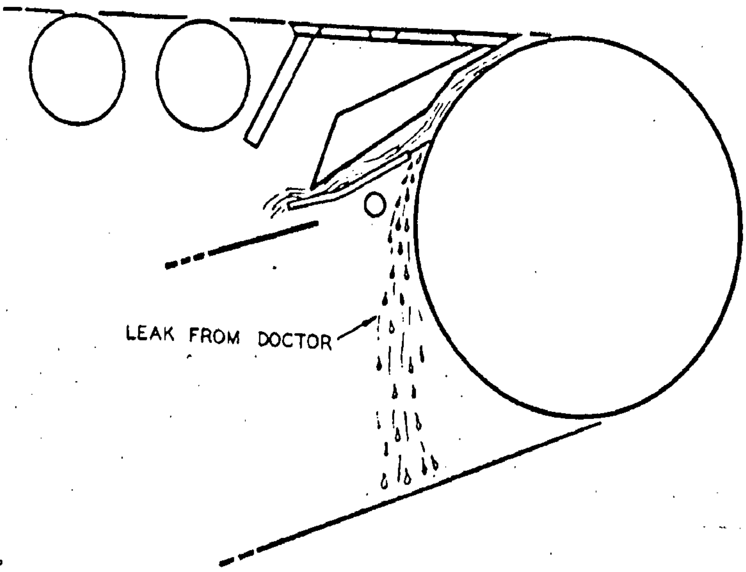


FIGURE 11-11 JAMMING OF WATER FROM BREAST ROLL BECAUSE OF RESTRICTED PASSAGE

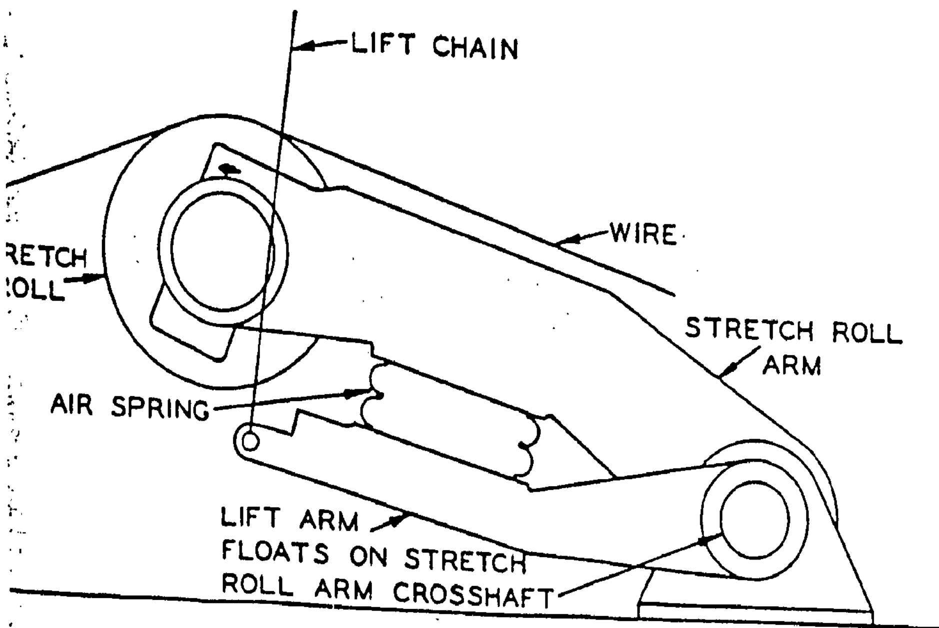
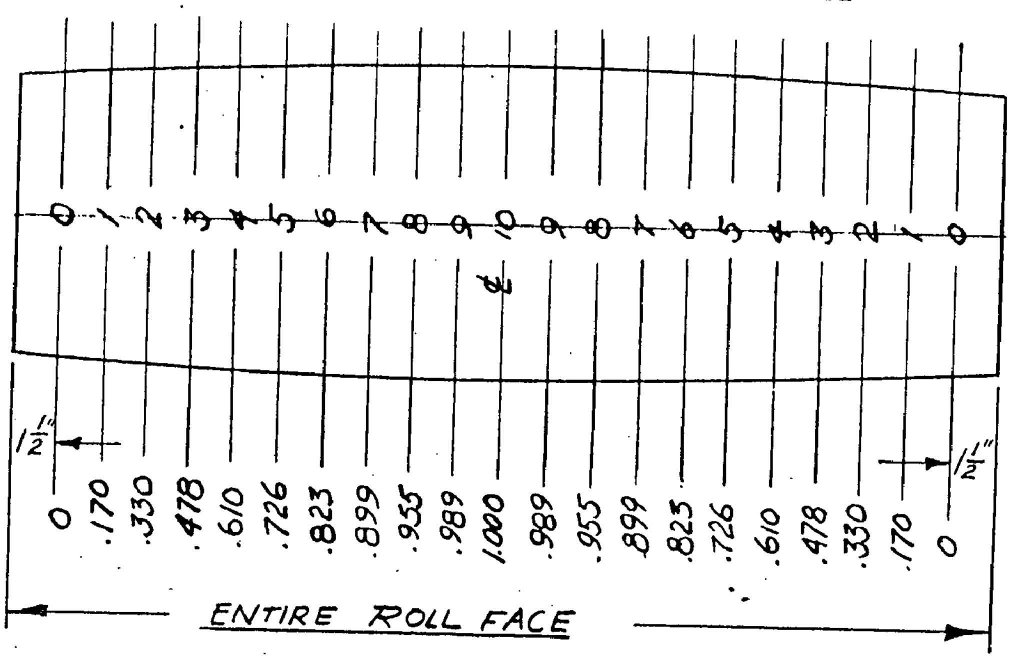


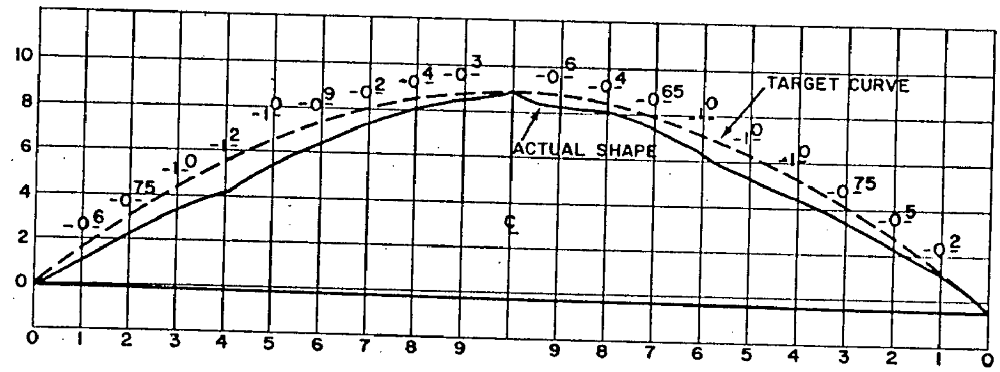
FIGURE 11-12 WIRE TENSION CONTROLLER

CROWN MULTIPLIERS FOR STANDARD CROWN SHAPE

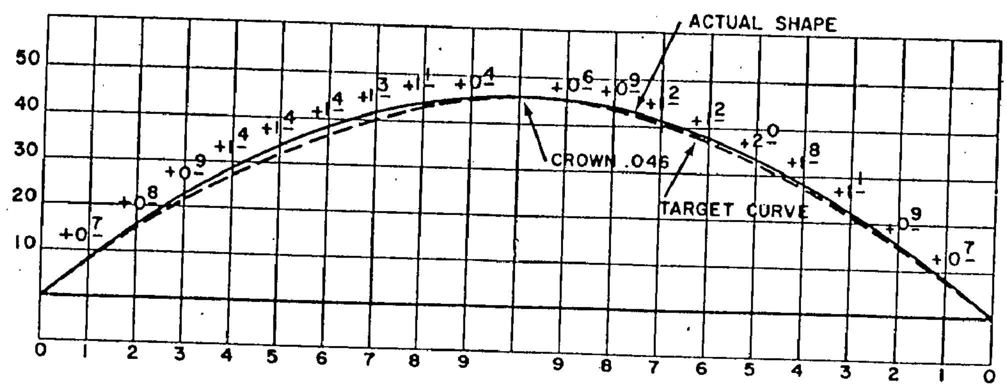


1. Caliper readings should be taken starting on either end at point "0" with dial indicator set on zero, and readings made at 10 equally spaced points, to point number 10 (center line), and then repeat this procedure commencing at opposite end.

2. Proper reading for each point is equal to the multiplier times the crown being applied, i.e.: If crown = .015 inches; the reading at point 5 for each end must be .015 × .726 = .0108 inches.



Poor Roll Shape. Deviations from target in thousandths and ten thousandths of an inch.



Good Roll Shape. Deviations are shown from the target in thousandths and ten thousandths of an inch.

FIGURE 11.13 HOW TO MEASURE AND CHECK ROLL FOR PROPER SHAPE.

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