BENEFIT COST ANALYSIS OF AUTOMATIC TRASH RACK CLEANING MACHINE FOR TRASH REMOVAL

A Dissertation

Submitted in partial fulfilment of

requirement for the award of the degree

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MASTER OF TECHNOLOGY

in

ALTERNATE HYDRO ENERGY SYSTEMS

By

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CANDIDATE DECLARATION

I hereby certify that the work which is being presented in this Dissertation, entitled, **"BENEFIT COST ANALYSIS OF AUTOMATIC TRASH RACK CLEANING MACHINE FOR TRASH REMOVAL"** in partial fulfillment of the requirement for the award of the degree of **Masters of Technology** with specialization in "**Alternate Hydro Energy Systems**", submitted in **Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee** is an authentic record of my own work carried out during the period from July 2015 to May 2016 under the supervision of **Dr. S. K. Singal**, Associate Professor, Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, India.

I have not submitted the matter embodied in this Dissertation for award of any other degree.

Dated: /05/2016

Place: Roorkee. **(AJAY CHANDRA UPRETI)**

CERTIFICATE

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

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Dated: /05/2016 **(AJAY CHANDRA UPRETI)**

ABSTRACT

Hydropower is the one of the important source of power generation. The share of hydropower is 15.22% of total electricity generation in India. Hydropower plant needs trash rack to prevent garbage and floating trashes from entering in water conductor system. It can harm the turbine's blades which will affect the power production. So trash rack is very important part of setting up a hydropower plant.

The garbage stopped by trash rack is gathered in front of trash rack, that start blocking the mechanism of flowing water, which results in loss in head and that in turn reduces the power production. So these trashes must need to be cleaned frequently to prevent loss in head. Manual cleaning is used since many years which is not that effective and also not much frequent. Due to this inconsistent cleaning of trash rack, the trashes stuck with trash rack for a long time which continuously results in loss in head. It has been studied that manual trash rack cleaning is facing many problems like, not having frequent cleaning, needs labors for cleaning, it takes long time etc, All these reasons are causing head loss which reducing the quantity of power generated.

Automatic trash rack cleaning machine is not a new invention. It is in use since many years but still it is not the first choice for trash rack cleaning at hydropower plant. There are many hydropower projects which are not using automatic cleaning machine for trash rack cleaning. The reason behind this is the cost for the installation of automatic trash cleaning machine. Research has shown that using automatic trash rack cleaning is much beneficial than having manual cleaning.

By having automatic trash rack cleaning machine frequent cleaning of trash rack is possible which decrease loss in head due to sticking of trashes on the trash rack bar screen. The report includes the types of automatic trash rack cleaning machine and the mechanism of their working. It also has the data from some site visit which shows that use of automatic trash rack cleaning machine can increase the power production of any hydropower station.

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NOMENCLATURE

MW	=	Megawatt
KW	=	Kilowatt
KWh	=	Kilowatt-hour
P	=	Power
γ	=	Unit Weight Of Water
Q	=	Discharge
H	=	Net Head
η	=	Overall Efficiency Of The Turbine
MU	=	Million Units

CHAPTER 1
INTRODUCTION

1.1 ENERGY SCENARIO IN INDIA

Energy is one of the most important parts of our world. We cannot see our life growing without energy. The whole economy of a country is totally depending on its energy resources. So availability of energy resources and a capability to extract the energy from the source is the most important factor affecting the development of a country. India, having almost 1.32 billion people accounting for more than 18.2% of world's population. The electricity consumption per capita for India is 1010 KWh. The Indian economy is utilizing a variety of energy resources, both renewable and non-renewable.

Over the past years, the enormous growth in demand of energy can be fulfilled mainly through being more dependent on non-renewable energy resources like coal, oil, and natural gas. The supply system for energy which is set up over the past few years is becoming more and more dependent on non-renewable energy resources. The availability of non-renewable energy sources is severely limited. Moreover, excessive uses of these resources have created a polluted environment with having a lot of serious problems. These facts have raised many questions about the availability of such a system for energy supply for a long time. Moreover, with the heavy and instantaneous raise in demand of petroleum products, India is becoming a large importer of oil. India's substantial and continuously developing economic growth is asking a huge demand of energy sources.

The present situation indicate that in the absence of appropriate measures for the proper management for controlling the demand of non-renewable sources, India may have to face the situation of importing other forms of energy and this fact will raised issues of long-term energy security of the country. For the present time India's power production is mainly based on coal. Approximately 60% of power is generated by coal. This fact is forcing India to import coal from other countries.

At the same time excessive use of these non-renewable resources also increase the threat to our environment as the harmful gases (carbon di oxide, sulfur di oxide, carbon mono oxide)

emitted due to their burning which can be dangerous to our environment. So control to their use is necessary which can help to save their reserve for long enough. Non-renewable reserves in India is shown in Table 1 and their distribution is shown in Fig 1.1.

Table 1-: Non Renewable Reserves of India

RESOURCES	RESERVE (IN BILLION TONNES)
COAL	285.86
LIGNITE	40.90
CRUDE OIL	737.44
NATURAL GAS	1240.92

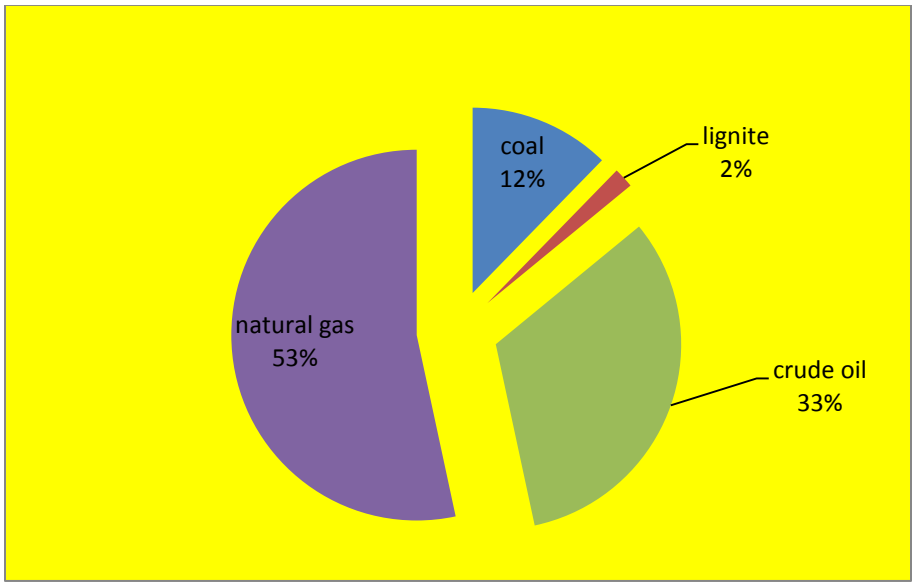

Fig 1.1 Total Reserves of Non Renewable Energy Resources in Billion Tonnes

The total installed capacity of India is 284.30GW.This includes the generation of power through thermal power plants (by using coal, gas and diesel),nuclear power plants, hydro power plants and other renewable sources(like solar energy, wind energy , biomass energy etc.). The capacity of thermal power is 173017 MW from coal, 24473 MW from the gas and 993 MW from diesel. The capacity of hydro power is 42623 MW, nuclear energy is 5780 MW and other renewable energy sources 37415 MW. Renewable energy sources include solar energy, waste to

energy and cogeneration bagasse. The region wise installed power potential of power plants of India is shown in Table 2 and their region distribution is shown in Fig 1.2.

Table 2-: Region Wise Installed Power Potential (MW) Of India

Region	Coal	Gas	Diesel	Nuclear	Hydro	Renewable Resources	Total
Northern	42263.50	5331.26	0.00	1620	18246.77	7899.14	75310.67
Western	68139.01	10815.41	0.00	1840	7447.50	13373.17	101615.09
Southern	33222.50	6473.61	917.48	2320	11478.83	15459.96	69871.83
Eastern	2982.87	190	0.00	0.00	4209.12	459.54	33.941.53
North eastern	310	1662.70	36	0.00	1262	262.62	3513.32
Islands	0.00	0.00	40.05	0.00	0.00	11.10	51.15
All India	173017.88	24473	993.53	5780	42623.42	37415.53	284303.39

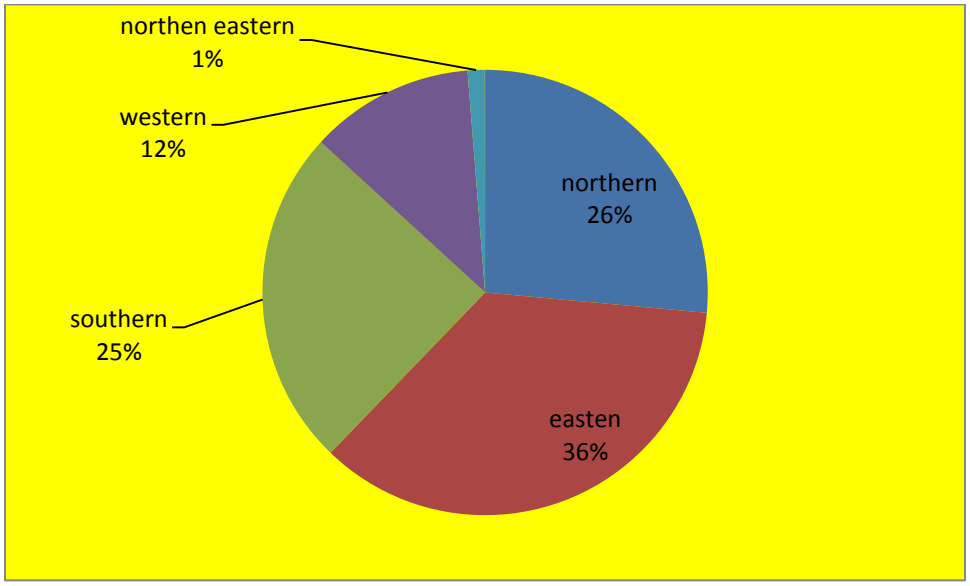

Figure 1.2 Region Wise Distribution of Installed Capacity

Now a days, the demand of energy is very high because of the developing behavior of our country. The demand of power in industrial field is raising enormously .As India has progressed after the independence, a large number of industries are established which plays a important role in increasing the power demand. Due to this large amount of electricity needs the supply of power is not meeting the demand. The need of extra power is forcing us to harness the energy from the non-renewable resources excessively.at the same time we are also developing the technology of harnessing the energy from the nature which is renewable energy. Renewable energy can help us to fulfill the extra power demand.

1.2 RENEWABLE ENERGY IN INDIA

Renewable energy is basically the energy which is produced by the source available in nature like wind, water and sun. This energy is available in limitless amount. All we need to do is to develop technology by which these raw energy can be harness from its resource. . The need of the extra power in future can be fulfill by developing the technology for generating renewable energy. India has the huge availability of renewable energy sources and it is one of the country which having largest programs to harness the renewable energy.

India is the only country in the world which having a separate ministry for the development of renewable energy which is known as Ministry Of New and Renewable Energy (MNRE). By the superior efforts of MNRE, India has achieved a remarkable progress in the field of renewable energy. Renewable energy has a very great advantage that it is a clean energy source which to not affect the quality of our surrounding which means there is no chance of polluting the environment

The overall potential for renewable energy generation in India is estimated at 148364MW. This includes wind power potential of 102772 MW (69.27%), potential for SHP (small hydro power) is 19749 MW (13.31%), potential for Biomass power is 17,538 MW (11.82%) , 5000 MW (3.37%) power potential is coming from bagasse-based cogeneration in

sugar mills, potential of waste to energy is 2556 MW (1.73%) and solar power potential of 5130 MW (0.50%). state wise Estimated Potential of Renewable Power in India is shown in Table 3.

Table 3-: State wise Estimated Potential (MW) of Renewable Power in India

Statewise Estimated Potential(MW) of Renewable Power in India							**Total**	
States/ UTs	**Wind Power**	**Small Hydro Power**	**Biomass Power**	**Cogeneration-Bagasse**	**Waste to energy**	**Solar energy**	**Estimated Potential**	**Distribution (%)**
Andhra Pradesh	14497	978	578	300	123	357.34	16514.44	11.16
Arunachal Pradesh	236	1341	8	0	0	0.265	1593.65	1.07
Assam	112	239	212	0	8	0	584.76	0.39
Bihar	144	223	619	300	73	0	1370.2	0.92
Chattisgarh	314	1107	236	0	24	73.18	1699.27	1.14
Goa	0	7	26	0	0	0	33.88	0.02
Gujarat	35071	202	1221	350	112	1024.15	36991.77	25.04
Haryana	93	110	1333	350	24	12.8	1914.56	1.29
Himachal Pradesh	64	2398	142	0	2	0	2639.84	1.77
Jammu & Kashmir	5685	1431	43	0	0	0	7270.05	4.85
Jharkhand	91	209	90	0	10	16	418.18	0.27
Karnataka	13593	4141	1131	450	0	104.22	19339.7	13.08
Kerala	837	704	1044	0	36	12.025	2627.11	1.78
Madhya Pradesh	2931	820	1364	0	78	678.58	5254.66	3.52
Maharashtra	5961	794	1887	1250	287	378.7	10243.32	6.9
Manipur	56	109	13	0	2	0	190.63	0.12
Meghalaya	82	230	11	0	2	0	330.86	0.22
Mizoram	0	169	1	0	2	0	181.09	0.12
Nagaland	16	197	10	0	0	0	230.29	0.15
Odisha	1384	295	246	0	22	66.92	1972.78	1.32
Punjab	0	441	3172	300	45	200.32	3960.81	2.68
Rajasthan	5050	57	1039	0	62	1264	6350.31	4.21
Sikkim	98	267	2	0	0	0	371.94	0.25
Tamil Nadu	14152	660	1070	450	151	761.235	16500.67	11.17
Tripura	0	47	3	0	2	5	72.41	0.04
Uttar Pradesh	1260	461	1617	1250	176	140	4766.08	3.23
Uttarakhand	534	1708	24	0	5	5	2293.83	1.54
West Bengal	22	396	396	0	148	7.21	978.8	0.65
Delhi	0	0	0	0	131	6.712	133.05	0
Others	489	8	0	0	1031	15.706	1528.79	0.69
All India Total	**102772**	**19749**	**17538**	**5000**	**2556**	**5129.813**	**148363.98**	**100**
Distribution (%)	**67.28**	**12.92**	**11.48**	**3.27**	**1.67**	**3.38**	**100**	

1.3 SMALL HYDRO PROJECTS IN INDIA

Hydro power plants are the most efficient way to harness the energy from the flowing water. Generally in hydropower system water is released from reservoirs, used to moving turbines which produces electricity. Hydro power plants are classified in five categories on the basis of their installed capacity. Hydro power projects having installed capacity up to 25 MW station are categorized as Small Hydro Power (SHP) projects. They are further classified as Mini, Macro and Pico by the Ministry Of Renewable Energy. Classification of Hydro Power Plants on the basis installed capacity is shown in Table 4.

Table 4-: Classification of Hydro Power Plants on the Basis Installed Capacity

S. No.	Type of Hydro Project	Capacity
1	Large	Greater than 100 MW
2	Medium	25-100 MW
3	Small	1-25 MW
4	Mini	100 KW -1 MW
5	Micro	5-100 KW
6	Pico	Less than 5 KW

Now a days, Small Hydro Power (SHP) Program is one of important resource of generating renewable power. Small hydropower projects can play a significant role in improving the overall energy scenario of India and mainly for remote and inaccessible areas. The development of small hydro projects is excessively encouraged by Ministry of renewable energy in both sector, public as well as in private. The involvement of private sector in small hydropower projects is started during 1995-96.Since then private sector are playing an important role in developing hydro power in India. Government is also providing many opportunities for the private sector. A budget for the development of private sector a budget of Rs.385 crores has been already sanction for the last two years of the 12th Plan(2012-17). However, there is no direct subsidy has been granted for private sector. Private sector has total installed capacity of 1241 MW with having 215 sites for the power generation. Statewise distribution of private sector small hydro projects is shown in Table 5.

Table 5-: State wise Distribution of Private Sector Small Hydro Projects

S. No.	State	Total Number	Total Capacity
1	Andhra Pradesh	42	102.93
2	Assam	1	0.1
3	Gujarat	2	4
4	Himachal Pradesh	51	248.25
5	Haryana	2	7.4
6	Jammu & Kashmir	2	17.5
7	Karnataka	76	623.05
8	Kerala	3	36
9	Madhya Pradesh	1	2.2
10	Maharashtra	8	53
11	Orissa	2	32
12	Punjab	17	25.5
13	Tamil Nadu	1	0.35
14	Uttrakhand	12	82.5
15	West Bengal	5	6.45
	Total	**215**	**1241.23**

Basically small hydro projects are increasing the overall installed capacity of power generation in a country. These are the permanent solution for electrifying the remote area. In India estimated potential of about 20,000 MW exists for small hydropower projects and the total installed capacity is 3990 MW. The database created by the Ministry of New and Renewable Energy have 6,474 potential sites for developing small hydro projects with an overall capacity of 19,749.44 MW for small hydropower projects. The ministry is aiming to improve the total installed capacity of small hydro power projects to 7000 MW by the end of 12^{th} hydro development plan. State wise total installed capacity of small hydro project is shown in Table 6.

Table 6-:Small Hydro Project Total Installed Capacity in India

S. No.	State	Potential		Project Installed		Project Under Implementation	
		No.	Total Capacity(MW)	No.	Capacity(MW)	No.	Capacity(MW)
1	Andhra Pradesh	387	978.4	69	223.03	12	30.04
2	Arunachal Pradesh	677	1341.38	149	103.905	44	22.23
3	Assam	119	238.69	7	37.11	2	9
4	Bihar	93	223.05	29	70.7	5	17.7
5	Chattisgarh	200	1107.15	9	52	4	115.25
6	Goa	6	6.5	1	0.05	-	-
7	Gujarat	292	201.97	5	15.6	-	-
8	Haryana	33	110.05	7	70.1	2	3.35
9	Himachal Pradesh	531	2397.91	158	638.905	33	76.2
10	Jammu & Kashmir	245	1430.67	37	147.53	7	17.65
11	Jharkhand	103	208.95	6	4.05	8	34.85
12	Karnataka	834	4141.12	147	1026.658	24	178.09
13	Kerala	245	704.1	25	158.42	11	52.75
14	Madhya Pradesh	299	820.44	11	86.16	3	4.9
15	Maharashtra	274	794.33	58	327.425	9	43.7
16	Manipur	114	109.13	8	5.45	3	2.75
17	Meghalaya	97	230.05	4	31.03	3	1.7
18	Mizoram	72	168.9	18	36.47	1	0.5
19	Nagaland	99	196.98	11	29.67	3	3.2
20	Odisha	222	295.47	10	64.625	4	3.6
21	Punjab	259	441.38	47	156.2	11	19.45
22	Rajasthan	66	57.17	10	23.85	1	-
23	Sikkim	88	266.64	17	52.11	-	0.2
24	Tamil Nadu	197	659.51	21	123.05	1	-
25	Tripura	13	46.86	3	16.01	-	-
26	Uttar Pradesh	251	460.75	9	25.1	-	-
27	Uttarakhand	448	1707.87	99	174.82	-	174.04
28	West Bengal	203	396.11	23	98.4	46	84.25
29	A & D islands	7	7.91	1	5.25	17	-
	Total	**6474**	**19749.44**	**1006**	**3938.678**	**253**	**895.4**

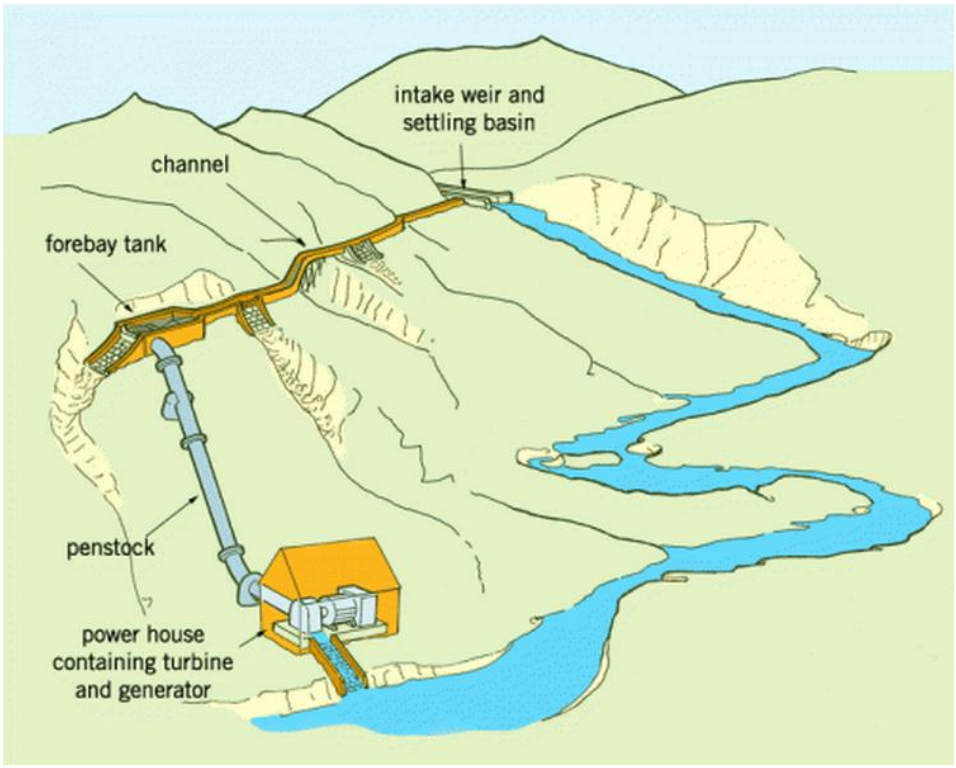

Fig 1.3-:Layout of SHP

The small hydroelectric plant involves generation of energy from different ways like run-off river scheme, pumped storage scheme and canal based scheme. A typical layout for a small hydro power plant is shown in Fig 1.3. The components of small hydro power plant are

Weir-: It helps in diverting the water from the river to the canal or to the intake structure.

Intake structure-: This structure is constructed to assure the supply of quality water with for the power production.

Trash rack-: This structure captured the floating materials which is harmful for the working of the turbine.

Settling tank-: In these tanks the settable solids are allowed to settle so that they cannot damage the turbine blades.

Channel-: This structure is constructed to guide the water to a tank from which it is send to the turbine.

Forbay tank-: It a reservoir type structure which stored water for the power production action.

Penstock-: These are the pipes which carry water from the forbay tank to turbine.

Power house-: This is the structure which containing whole assembly of turbine connected to the generator.

1.4 TRASHRACK

The efficiency of a hydro power plant is directly related to the head loss. If head loss is more then the power production of the power plant site would be affected, so the measures to reduce the head loss must be taken. There are lots of objectionable materials present in the water which is used to produce electricity. These materials can damage the turbine and other equipment. So we need a trash rack system to prevent dese trashes and garbage away from the power production process. Trash racks are comprised of arrays of vertical bars that are generally held together by horizontal beams. Trashracks, particularly when not get cleaned produce unwanted energy-losses that directly reduce energy production.

Various types of trash can accumulate in front of hydro power station and waste water intakes. This results in operation disturbances and at times even shutdown of a generator unit. This trash must be cleaned otherwise this will become the cause of head loss which reduced the power generation efficiency. So it is clear here that proper trash rack cleaning is the a top priority at a hydro power station. Depending on the site conditions and location for smooth operation of the power station care should be taken to choose the right technology trash rack for cleaning without losing efficiency.

The purpose of trash rack structures regarding hydropower plant is restricting the entrance of materials of considerable dimension present in water, which could cause damage to generating machine particularly to pre distributors, distributors and spiral casing and the runner of the turbine.

1.4.1 Energy Losses Due To Trash Rack

Trash rack generally choked up with the garbage and trashes. When trash rack is not

cleaned it can produce unwanted energy losses. Energy losses across the submerged trash rack was the effect of trash rack bar thickness and spacing, velocity of flow and the angle of the approaching flow.

- Stuck trashes blocked the flow of water. Different kinds of blockages and varying discharge produce vortices having irregular patterns and frequencies. This increase the velocity at trash rack which creates eddies of high velocity, it leads to higher head loss because head loss is directly proportional to square of velocity of the flow.
- Stuck trashes also increase the angle of approach of the flow which increase the head loss. For angle of approach 0-10 degree head loss is negligible but it increased to 6-32% for angle of flow 20-30 degree.
- Trashes decrease the spacing of bar which increase velocity of bar which results in higher head loss.
- Shape of bar also play a role in head loss. Because of its shape stream lining flow occurs. Trashes affect the stream line motion which generates losses. If stream line flow occur only one side then the losses are more.

CHAPTER 2
TRASH RACK CLEANING

2.1 TRASH RACK CLEANING

Generally trash rack cleaning done by manually. Manual cleaning is not very much effective. It is not frequent too. So the stuck trashes keep on resulting the head loss. Research work towards improvement in cleaning technology is going on continuously. There are following three issues that need to be addressed:-

- Floating barriers should be placed some distance away from the intake. These barriers restrict trash from approaching intake. After that boats and barges can be used for the collection of trash from the barriers.
- Wedge shaped bar are also beneficial in refining the flow conditions close to trash rack screen.
- Automatic trash rack machine are very useful in removing trashes. It collects material from trash rack bar. It's possible in some devices that sucks up trash from the surface of water, lift it up, separates it out at the top and returns the clean water in the surface.

2.1.1 Manual Trash Rack Cleaning

In Hydropower plants intakes are always been equipped with trash racks for keep floating debris, leaves, trash, etc., away from the turbines, and these trash racks always need to be cleaned.

Initially, trash racks were cleaned by hand with hand rakes of different types. Even in those early years, employees influenced the development and design of trash rack cleaning equipment for example, one hand rake was equipped with wheels. Bigger plants required an enormous amount of staff. That's why already at the transition from the 19th to the 20th century machinery for mechanical trash rack cleaning was being constructed.

The development of design changes has resulted in the large wire rope trash rack cleaners, which are known for their use at the big river power stations. At the end of the 20th century, hydraulic trash rack cleaners for small Hydropower plants were developed. The prior tendency, to adapt hydraulic steel structures designed for large Hydropower plants by

downscaling them for small Hydropower plants, was reversed. The hydraulic jib trash rack cleaners were up scaled to fit as much as possible the needs of the large plants.

Earlier Hydropower plants with water wheels were so designed that coarse swimming debris can't reach the water wheels. Water wheels will function despite having leaves and small debris, but measures need to be taken against the coarse trash.

The first turbine began its operation in 1827. Turbines have discharge which is very large than water wheels, but the through flow sections in small turbines are far more sensitive to trash than the water wheels. Therefore the first turbine plants were pre equipped with trash racks. As long as trash racks are in use, they need to be cleaned.

Traditionally, trash racks were cleaned manually with equipment developed by the people of management and staff as shown in Fig 2.2. Thus the hand rakes, shown in Fig 2.1 became easier and easier to handle.

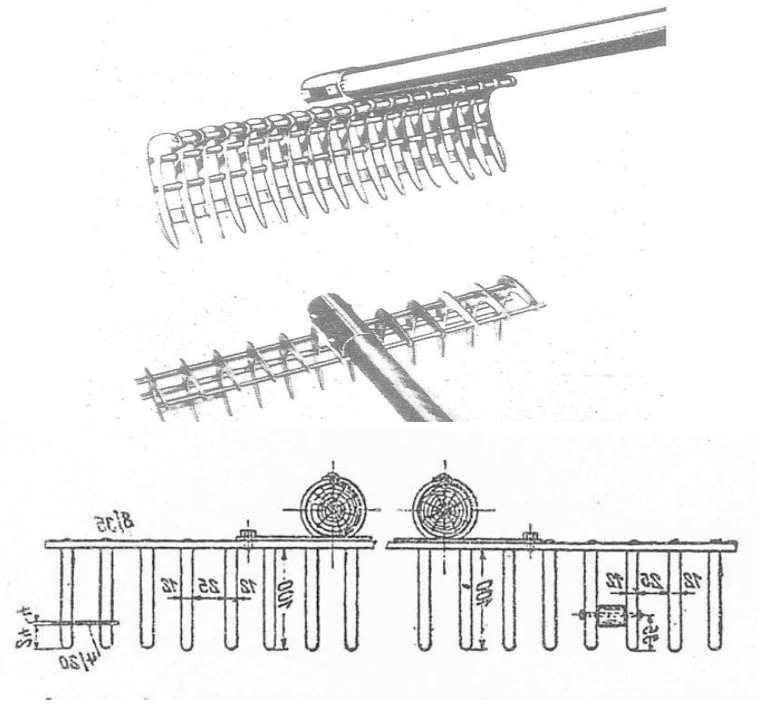

Fig 2.1-: Light Weight Hand Rakes

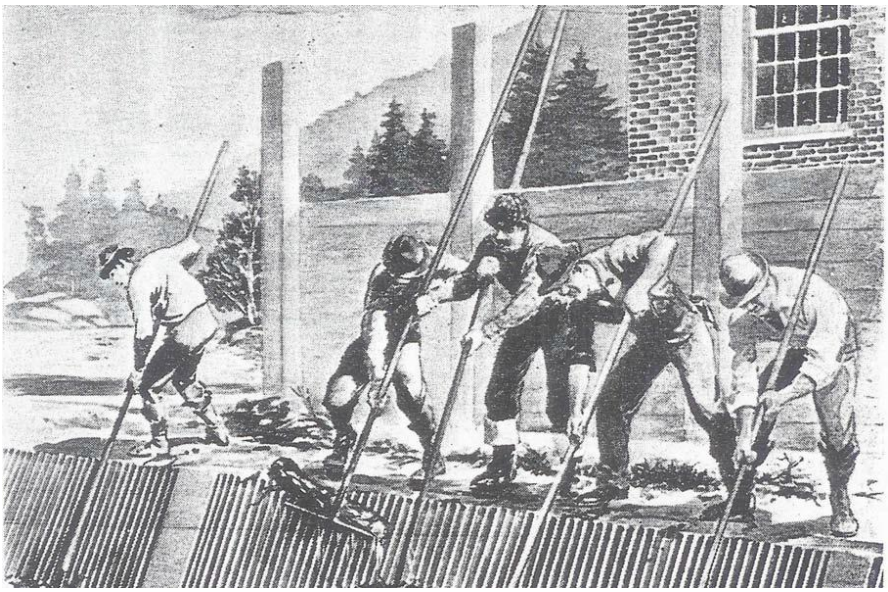

Fig 2.2-: Hand Raking of Trash Racks

The size and location of trash racks were affected by the necessities of manual trash rack cleaning. The depth of water at the trash rack was limited to 5 meters and maximum 6 meters. The rate of flow initially was rather high at 1.2 m/sec. As a result, there were so many serious problems, at other power plants, they had to reduce the flow rate to between 0.4 and 0.7 m/sec (relative to the inclined height).

The cost of cleaning of manual trash rack at that time was more than two times than mechanical cleaning. Thus the mechanization of trash rack cleaning was already tackled a hundred years ago. It was something that was obviously destined to come into being.

2.1.2 Automatic Trash Rack Cleaning Machine

As there in old age manual cleaning facing too much difficulty, so some new ways of cleaning must be needed at that time to reduce the head loss due to trash rack and to increase the efficiency of power plant. So the first attempt in this direction is attempted when at the power and pumping plant erected in 1902 near Gluder, in Solingen, a stationary trash rack cleaning machine was installed. The machine, constructed by Amme, Giesecke and Konegen in Braunschweig, as shown in Fig 2.3, was primarily designed to remove leaves. The trash rack was

crossed upwards by a chain driven scraper. The generated trash was dumped into a cross belt. The drive of the conveyor belt was a three-phase A.C. motor with 3 HP.

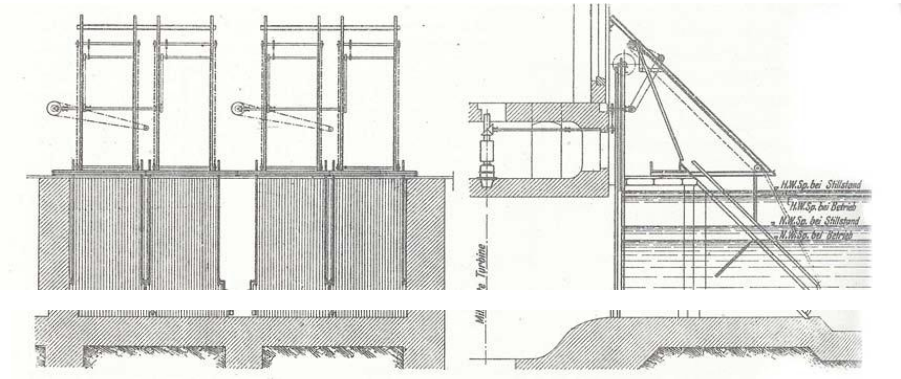

Fig 2.3-: Trashrack Cleaning Machine Solingen (Amme, Giesecke U. Konegen)

Presently, chain driven trash rack cleaning machines having modern design are still in practice at small Hydropower plants.

For trash racks with long extension, the acquisition of stationary trash rack cleaners like the one in Solingen would be too expensive. Here the use of a traveling trash rack cleaning machine that cleans the trash rack areas successively would be more practical. At the electric power station in Chèvres, patented equipment of this type, shown in Fig 2.4 has been in operation since May1910.

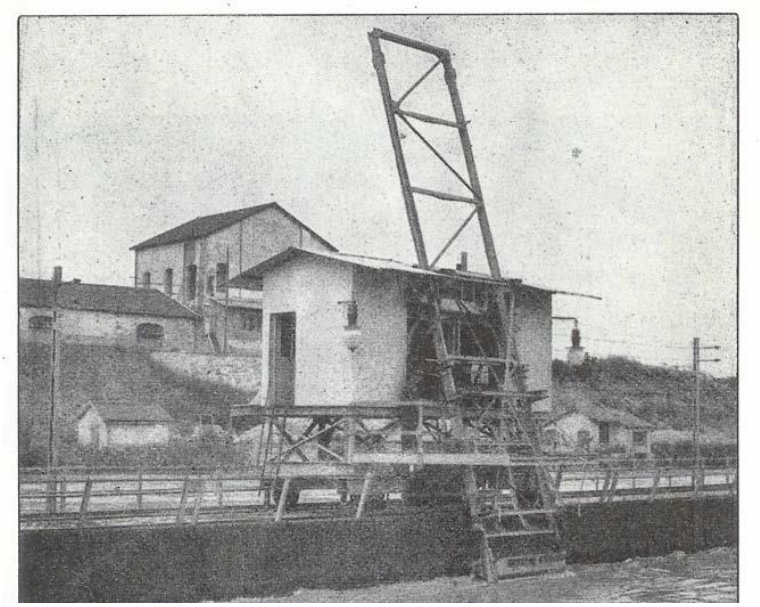

Fig 2.4-:Trashrack Cleaning Machine Chèvres In Operation

To operate this kind of rake, three people are required: one operator at the machine and two others to control the rake and to unload the collected trash. It is a small step to the classical wire rope trash rack cleaning machine which is being used presently.

Over the past various types of trash rack cleaning machines have been developed. For Hydro power plants of medium size and cleaning lengths up to 20 m only two types of trash rack cleaning machines are used. The classic wire rope trash rack cleaner and recently, the hydraulic jib trash rack cleaner, have become more important. For large-scaled Hydropower plants the wire rope trash rack cleaner is the only option that available.

2.2 TYPES OF TRASH RACK MACHINE BASED ON CLEANING MECHANISM

According to the mechanism used by trash rack cleaner for the trash removal,the trash rack cleaner has two types-:

- Wire rope type trash rack cleaner
- Hydraulic jib trash rack cleaner

2.2.1 Wire Rope Type Trash Rack Cleaner

The cleaner, shown in Fig 2.5, has been in operation since the beginning of the use of Hydropower for the production of electric energy for about 100 years. The main components of this machine type are-:

- Base frame having travelling device
- Winch with rake
- Debris storage and/or debris disposal

Fig 2.5-: Wire Rope Type Trash Rack Cleaning Machine (HPP Feistritz, Austria)

The essential feature of this machine type is the rake's toothed rake plate. While cleaning, the teeth get meshed with the trash rack bars. Subsequently, objects which are stuck between the trash rack bars can be collected and removed. Even the frazil ice (ice similar to slush) can be removed with the help of toothed rake.

Various solutions pertaining to the debris storage problem have been generated, influenced mainly by the practicality of transportation. Examples are integrated containers as buffer storage containers being towed by the cleaner and trucks that follow the trash rack cleaning machine under their own power or by being positioned on a platform connected to the cleaner.

All the possibilities of the materials handling technology can be used. Accessories such as timber grabbers or orange peel buckets may be mounted on cranes to remove large objects. Surface rakes which can be lowered are used to collect and drift floating debris. Wire rope type trash rack cleaners can be used for nearly unlimited cleaning lengths. The trash rack cleaner of Itaipu/Brasil has a cleaning length of more than 60 meters. Trash rack should have an inclination of 10 degrees with the vertical.

These types of arrangement should be used-:

- Where narrow space condition is present on the dam.
- Where deep intakes is present up to 100m/300ft.
- In the circumstances when existing civil structure demand a rope type machine.

2.2.2 Hydraulic Jib Trashrack Cleaner

The cleaner shown in Fig 2.6, is been manufactured in the recent years. The main components of this machine type are:

- Base frame having travelling device.
- Pivoted machine house having booms and grab rake.

Fig 2.6-: Hyduallic Jib Trashrack Cleaner

The revolving superstructure of the machine allows dropping of the trash behind or beside the railway of the trash rack cleaner. The trash is thus dropped in a concrete bin or a container which is disposed of later.

The grabbing rake is designed to pick up oversized trees as well as to push floating debris to the weir. It has a scraper which slides along the trash rack bars, but without meshing between the trash rack bars. So the space between the trash rack bars can’t be cleaned. Also frazil ice cannot be removed. The grab rake can be rotated to conform to the position of a tree or other debris. Thus floating debris can be pushed to the weir to be drifted and large debris, such as trees, can be picked up by the grab rake and disposed of. The length of cleaning for hydraulic jib trash rack cleaners from today's point of view is limited by financial and architectural reasons (overall height) to about 15 to 20 meters. Larger cleaning lengths require the usage of telescopic beams which results in complex design and massive weight. This type of arrangement should be

- for bulky and oversized debris.
- where trash is in the form of carpet on the water surface.
- where cleaning depth is limited to 7m-32m/20ft-110ft.
- for the removal of large rocks from the bottom of the rocks.
- for cleaning of vertical and inclined trash racks.

2.3 TYPES OF TRASH RACK MACHINE BASED ON SITE CONDITION

According to its application on a specific and particular type of trashrack the automatic trashrack cleaner are associated with following type-:

- Stationary hydraulically operated trashrack cleaners, Type RRH
- Traversing hydraulically operated trashrack cleaners, Type RRH-F
- Stationary chain driven trashrack cleaners, Type RRM
- Stationary and traversing cable driven trashrack cleaner, Type RRS

2.3.1 Stationary Hydraulically Operated Trashrack Cleaners

Units pertaining to type RRH, shown in Fig 2.7, are comprised of a wide reaching articulating boom with a cleaning rake/wiper bar, attached in a direction perpendicular to the flow. This boom has two individually jointed arms which are been operated by hydraulic cylinders.

Fig 2.7-: Stationary Hydraulically Operated Trashrack Cleaners

For intake screen sizes 0.5-8 meters wide and 0.8-10 meters long which are placed at inclinations from 30 – 75° hydraulically operated stationary units are used. Parts of hydraulically operated trashrack cleaner is shown in Fig 2.8.

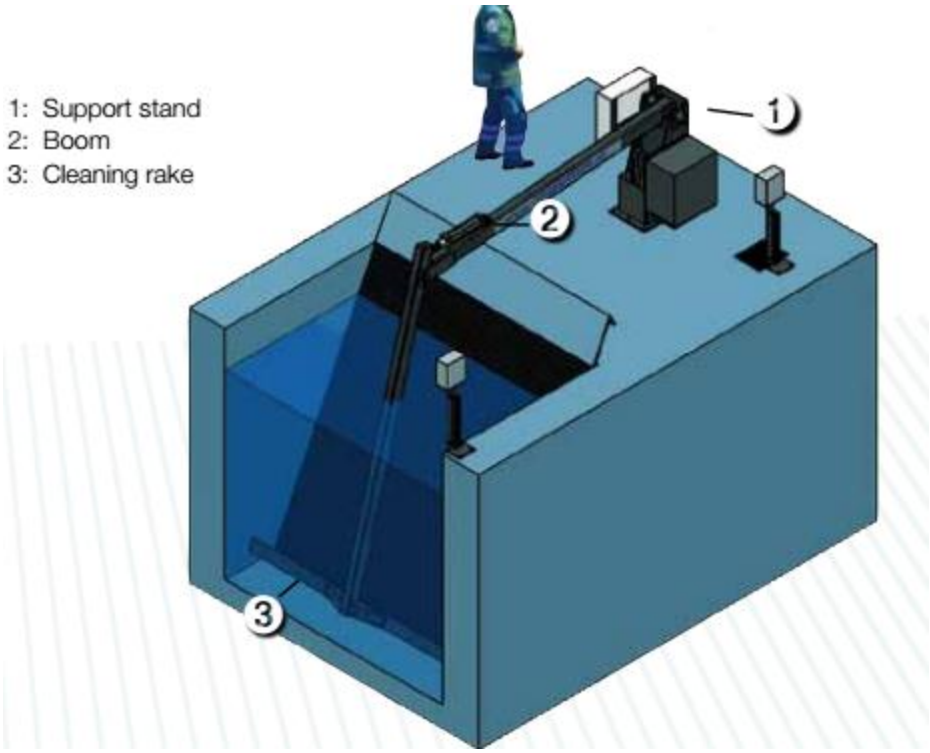

Fig 2.8-: Parts Of Hydraulically Operated Trashrack Cleaner

- **Support Stand-** The rigidly designed heavy steel support stand can be bolted directly to the operating platform.

- **Boom-** The boom is connected to the support stand by two axles with flange bearings to permit the desired rotation. Despite having life-long lubrication, the flange bearings are also equipped with grease nipples. Both the arms are fabricated of heavy-wall steel tubing, which essay exceptionally large torsional strength.

- **Cleaning Rake-** The cleaning rake head consist of an angular steel profile, to which a wiper edge is fastened, ensuring thorough trash rack cleaning and removal of debris even of the smallest size. Perfect alignment of the trash rack bars is not absolutely essential since the cleaning rake does not engage in between the steel bars.

- **Hydraulic Power Unit-** This system provides the oil pressure required to operate the

servomotors. Pressure relief valves help in overload protection. Specially formulated environment friendly safe hydraulic oil should be used.

- **Control Functions-** The control system supplied affirms fully automatic operation of the rake with an option of integrating the control functions of Trash Conveyor System even at a later stage.

2.3.2 Traversing Hydraulically Operated Trashrack Cleaners

If the intake width of the screen goes beyond the maximum rake width, or if many intake bays exist, the hydraulic machine can be constructed with a horizontal traversing carriage,shown in Fig 2.9 and Fig 2.10, thus cleaning each intake area in sequence. Hydraulically operating machines can clean screen panels having width up to 50 m.. and length upto 10 m which are inclined at 30 – 75°.

Fig 2.9-: Traversing Hydraulically Operated Trashrack Cleaners

- **Carriage-**Movable machines of the type RRH are designed similarly to the smaller, stationary types, but compared with these, are of heavier design. The whole unit travels on rails from one intake bay to the next by means of an electric motor driven carriage.
- **Container**- For holding the debris while machine is moving, the carriage is provided with a standardized container. It is conveyed to a pick-up truck directly from the operating deck. where no intermediate storage of the debris required. A smooth transfer

from the screen into the container is possible without any problem by using a screen apron.

- **Level Differential Control-**For registering individual water levels in front and behind of the trash rack pressure sensors are provided.

- **Cleaning Rake-**For minimizing any debris that might get lost during the procedure of cleaning, the rake head can be tilted.

- **Control Logic-**For the movement of carriage a programmable logic controller and the selector switch setting in AUTO mode is required. It also control the cleaning cycle and the machine function monitoring is also assured.

Fig 2.10-: Traversing Hydraulically Operated Trashrack Cleaner

2.3.3 Stationary Chain Driven Trashrack Cleaners-:

These Machines are of RRM type which is stationary trash rack cleaners with rotating rake heads and two endless chains used to pulled it as shown in Fig 2.11 and Fig 2.12. Stationary

chain-driven trash rack cleaners are suitable if the size of the rack screens is up to 15 meters wide, 10 meters long and the inclinations are from 35 to 68°.

Fig 2.11-: **Stationary Chain driven Trashrack Cleaners**

- **Drive-**The trash rack cleaner is supported on two support stands which are made by fabricated steel and fastens at the operating deck with the help of the bolts. Inside the drive stand, the overload protection torque dependent, is located. The drive and deflecting wheels, equipped with bearings with re-grease possibility, are located above the water line. The two wheels under water do not need any maintenance.

- **Cleaning Rake-** The cleaning rake head has a special I-beam carrier. It is also equipped with a heavy-duty rubber wiper which is highly wear resistant.

- **Chains-**By the means of easily accessible tensioning devices chains can re-tightened.

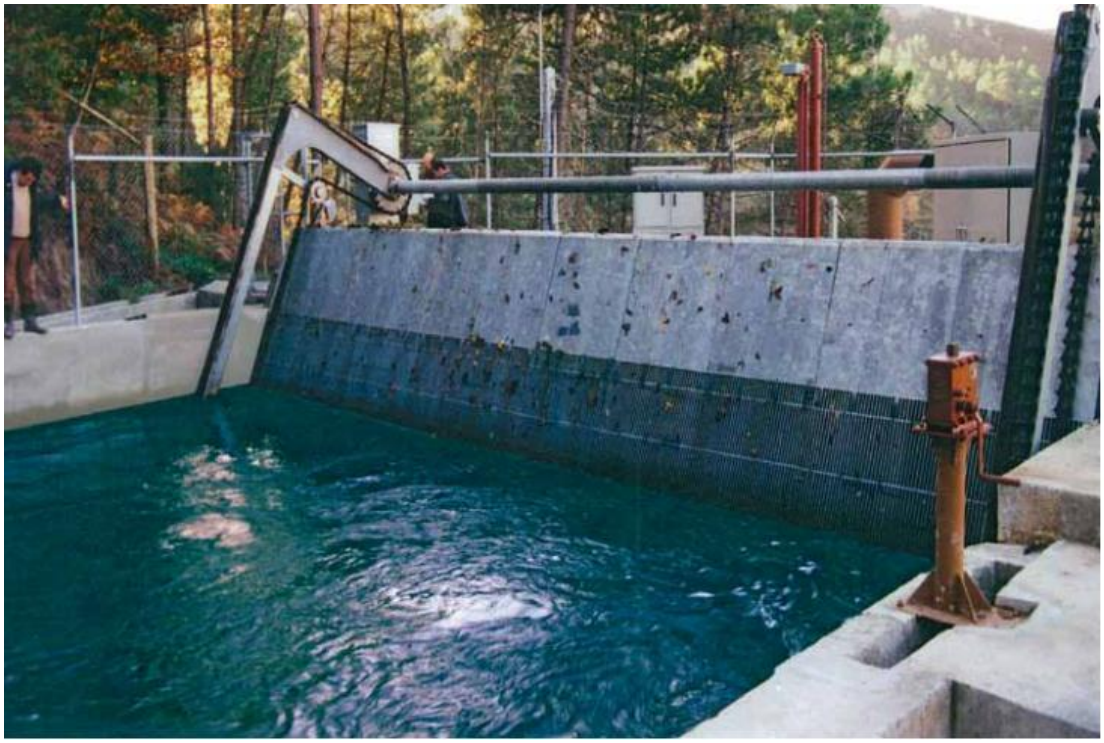

Figure 2.12-: Stationary Chain Driven Trashrack Cleaner

2.3.4 Stationary and Traversing Cable Driven Trashrack Cleaner

These Cable driven machines are of the RRS type. These include stationary or movable trash rack cleaners which can have intake depths of more than 10 meters. Stationary or traversing cable operated machines, as shown in Fig 2.13 and Fig 2.14, can be used for the lifting heights up to 25 meters and rake widths of 4 meters where the screen inclinations is from 75 – 85°.

Fig 2.13-: Stationary And Traversing Cable Driven Trashrack Cleaner

- **Cable Winch-**A hoisting winch is provided which is utilizing two tractions and one swivel actuating steel cable. The cleaning rake head is pulled over the screen surface by this hoisting winch which is driven by an electromotor. The conditions for overload and slack cable reliably monitored.

- **Cleaning Rake-**The decision whether to use a trough type or a gripper type rake head is mainly depend upon the intake structure and extent of debris accumulation. The down movement of the rake head is in the open position, which is effected by gravity. between the screen bars the heavy duty run and support wheels are restraint and guided. At the screen bottom the rake head is tilted to the close position and is hoisted up by using the cable winch. For a better decries discharge the apron can be tilted by utilizing the trough type rake head. The gripper type rake head is always in fully tilted in condition.

- **Disposal of Debris**-Different types of debris disposal are available. A Container is provided into the rake carriage with a conveyor belt or water flush disposal trough.

Fig 2.14-: Stationary and Traversing Cable Driven Trashrack Cleaner

2.4 ADVANTAGES OF TRASH RACK MACHINE

- Its installation is very simple. its parts can be easily fit and also very easy in transportation.
- To make use of this machine power is needed. The power demand is low for hydraulic drive.
- Its control is very easy.it has programmable logic controller which makes it easily accesable.so we don't need any skill person for using it.
- Noise operations during trash rack cleaning are low permanently and these machines need very less maintenance.
- This machine is very efficient in collecting materials from water surface.
- Complete supervision.
- Automation of operation.so its does need any other person to operate and also no need of Economic and aesthetic design with a lower environmental impact.

2.5 FUNCTIONAL REQUIREMENTS OF AUTOMATIC TRASH RACK CLEANING MACHINE

- Generally one trash rack cleaning machine required to clean the trash rack panels. The machine should be installed at above the trash rack arrangement. It should be able to remove all the trash carried by the flow (floating material, debris, wood logs, branches etc.) which are accumulated in front of the trash rack bar screen. The machine should carry an emergency mechanism to remove big trunks, wood logs, bulky material and large amount of accumulated materials. The machine should be able to do trash rack cleaning at the situation of maximum clogging and maximum turbine discharge.
- It must be ensure that the rake teeth do not damage the top and bottom members of the trash rack and screen tie rods. Also after the cleaning of the screen the debris is retained in the rake and not dropped back to the screens or on the sloping concrete surface. The rake should be designed to prevent the accumulation of sediments.
- The design of the trash rack cleaner should be such that it can be easily control and operate by both method manually (by an operator) and automatically (without an operator). The cleaner is mounted on the rail with power supplied by a flexible trailing

cable so that it can moves along the trashrack structure for cleaning the entire structure in which cleaning of one bay at a time is possible and can be parked at any of the one end of the structure. For fully automatic operation, the machine should be equipped with a head loss measuring device. The cleaner should install with sensors for measuring the pressure drop and connecting them to the raking machine for automation.

- The rake of the cleaner should be such that it can travel up and down the of trash racks and bring trash above the screen and dump it into a suitable trash skip. For this hoisting which is electrically operated and lowering gear shall be provided in the machine. Wire rope made up of steel should be provided to enable the trash racks to be cleaned from the operation level.
- The hoisting gear should equipped with a fluid coupling to protect the motor if the rake becomes jammed by an obstruction on rising. A slack rope device should be provided to operate a cut out to stop the motor. An electromechanical brake shall be incorporated in the hoist gear to prevent movement of the rake immediately the hoist motor stop or the electricity supply fails.
- The frame of the cleaner should be rigid and designed such that to carry the load of the hoist machinery and the maximum rake load with maximum lever arm.
- The double flanged wheels should be provided and carriages of wheels should be buffered at the outer side as well as solidly build retainers should be provided to prevent the cleaner from tilting at adverse conditions, like maximum rake load. For the situation of maximum rake load sufficient counter weights also should be provided.
- Trash collected in the rake bucket should be firmly held when the rake is running upwards. The buckets shall close automatically when the rake reaches the lowest point of each run.
- The rake should be equipped with self-lubricating bushing for all hinged joints ,wheel spindles, gears, etc. These should be well protected against the silt-laden water. All spindles should be made from stainless steel. The rake teeth shall be replaceable and they should be made of hardened or abrasion resistant steel.

- A well ventilated steel sheet cabinet should be provided to protect the main hoist of the cleaner. This cabinet should contain all the parts of the operating machinery of the cleaner, electrical components and ample room for inspection and maintenance.
- The operation of the trash rack cleaner should be done from a platform with rails and a light roof at one side which give a good view to the operator. The control cabinet should have easy operated controllers and an accurate and reliable indicator of the rake position. The tripping of the overload protection for the rake as well as at slack rate hoisting wire shall be clearly indicated. The cabinet shall have a switch for automatic rake stopping at the bottom of the intake trash racks.
- Electric power for the trash-rack cleaner shall be supplied through an insulated conductor rail along the front concrete, and with a lockable main.

CHAPTER 3
LITERATURE REVIEW

In 1980 A.V. Dmitrieva has told about the trash rack head losses at the hydroelectric power plants. He said that the supporting structure of trash rack at any large capacity power plant is very complex construction and comprises a system of longitudinal and transverse members which ensure the rigidity of the components. The disadvantage of this is a large area of the trash rack is obstructed by the trashes in the water. So in the present of trashes and garbage use of such kind of frame becomes difficult [3].

In 2010 Shawn P.Clark, Jonathan, M.Tsilkata and Mellisa Haresign had presented a paper in which they talked about the losses which were happening due to submerged portion of the trashrack. They also got the amount of losses caused by different reason like due to increase in velocity, due to change in inclination of bar of trash rack etc. They told that head loss is the function of blockage ratio ,flow angle and the velocity. They also gave the equations to find out different type of head losses [6].

In 2006 engineer W.Radhuber had presented a paper in 14th international seminar on hydropower plants in which he mentioned that there are numerous types and designs of trashrack cleaners on the market, so the user has a lot of option from which to choose. In general, now a days trash rack cleaners are much better in quality that one could decide the subjective factors such as personal preferences for certain drive systems, design varieties, etc. This paper is only about the large travelling trash rack cleaners with cleaning length of 10 meters and above. He compared the classical wire rope type trashrack cleaner (which is in operation since the beginning of the use of hydropower for the generation of electricity) with the hydraulic jib type, which, in the size discussed in his paper, has only been built for a few years. He had not discuss additional functions such as stop log handling, etc [8].

In the year 2008 at 15th international seminar W. Radhuber had talked about methods of trash rack cleaning in use since past and talked about the methods which are presently using by hydropower plant to clean trash rack. In his paper he said that Intakes of Hydropower plants have always been with trash racks to keep floating debris, leaves, trash etc., from the turbines, and these trash racks have always had to be cleaned. Initially, trash racks were cleaned by hand with

hand-rakes of different types. Even in those early years, employees influenced the development and design of trash rack cleaning equipment for example, one hand rake was equipped with wheels. Bigger plants required an enormous amount of staff. In Rheinfelden, Germany, for example, when the leaves were falling, one hundred men were required for trash rack cleaning. That's why already at the transition from the 19^{th} to the 20^{th} century machinery for mechanical trash rack cleaning was being constructed. The development of design changes finally resulted in the large wire rope trash rack cleaners, well known for their use at the big river power stations on the Danube,Rhine, and Parana (Itaipu) rivers, e.g. At the end of the 20th century, hydraulic trash rack cleaners for small hydropower plants were developed. The prior tendency, to adapt hydraulic steel structures designed for large hydropower plants by downscaling them for small Hydropower plants, was reversed. The hydraulic jib trash rack cleaners were upscaled to fit as much as possible the needs of the large plants [7].

In 2009 R.M. Khatsuria, former Addl. Director of central water and power research station, Pune, had presented a paper in which he talked about the causes for trash rack damage and remedies. He told that for the hydropower plants, floating trashes in the rivers is a big problem. Water flowing in the rivers catches the solid matter (like industrial waste, plastic, textiles, rubber and also trees, branches, leaves etc.) which collected near the intake. If this trash is not removed then it can enters into the turbines or start blocking the flow of water. It can be preventd by using structure like trash rack. However, these trashes can damage the trash rack structures which are the main concern of designers of several hydro plants all over world [5].

3.1 RESEARCH GAP

From the study of the literature following gaps are rectified-:

- As trash rack is a main constituent of power plant so there are lots of research works happening to improve the design of trash rack to reduce the head loss due to choking and clogging of trash rack. But not so much research had been done in the field of trash rack cleaning.

- No work has been done in the context for showing trashrack cleaning through automatic trash rack cleaning is much beneficial than manual cleaning.

- For the loss in power generation due to blocking of trash rack, no research is present which can show statistically the benefit of having automatic trash rack cleaning machine for trash removal.

3.2 OBJECTIVE

Trash rack cleaning by using automatic machine is the best option in comparison of manual cleaning. Although automatic trash rack cleaning machine are in existence since many years but they are not completely accepted for the cleaning. My objective of this dissertation is to put the light on the advantages of having automatic trash machine for cleaning at hydro power station. Some case study work should be needed to prove this statistically that automatic trash rack machine are much better option than manual cleaning. the main work done of this dissertation is following-:

- Data collection from the hydro power plant sites and analysis of the data which can proved that increase in power production of a small hydro plant by having automatic trash rack cleaning.
- Analysis of loss in power generation in rainy season due to blocking of trash rack is also visualized from the graphs.
- Statistically evaluate the extra benefit from the site having automatic trash rack cleaning machine

If we continuously remain reliable on the old manual cleaning method it would cost us waste of lots of power potential. Research work need to be done for the improvement of cleaning methods. Benefit of automatic trash rack cleaning can be reasonably find out by doing some case studies on the site which having automatic machine for the cleaning of trash rack.

CHAPTER 4
ANALYSIS FOR TRASHRACK ARRANGEMENT

As the requirement of the project following site are visited -:

- **Mohammadpur Powerhouse**
- **Pathri Hydroelectric Powerhouse**
- **Dhakrani Hydroelectric Power Plant**
- **Dhalipur Hydroelectric Power Station**

In this chapter the description of site visited is given and the graphs for the power production at Mohammadpur Powerhouse and Dhalipur Powerhouse. Calculation for the head loss at the Pathri and Dhakrani powerhouse is also shown in this chapter.

4.1 MOHAMMADPUR POWERHOUSE

Mohammadpur powerhouse is located in Haridwar district. It is a small hydro power project under Uttrakhand Jal Vidyut Nigam Limited. It is a runoff river scheme which is constructed on Upper Ganga Canal. The estimated potential of the powerhouse is 9.3MW having 3 turbine units with estimated potential of 3.1MW each. Head available at this site is near about 7m. The width of the river is about 60m having 12 trash rack bar screen of 5m each (Fig 4.1).

Fig 4.1-:Trashrack Machine in Operation at Mohammadpur Powerhouse

Generally the garbage's which are stopped by the trash rack are leaves, polythene, bushes and domestic wastes. This garbage interferes with the water which is flowing through the turbine for power production. It reduces the effective head at the turbine which automatically reduced the power production. So this garbage needs to be removed for better power production. The powerhouse authority was using manual method of cleaning for removing the trashes from the trash rack bar screen. But this manual cleaning cannot be available for whole day because of which we cannot clean the trash rack frequently. Also manual cleaning is not available if trashes come suddenly like in rainy season. Delay in cleaning can cause in loss of a large amount of power.

Also in the rainy season the quantity of this garbage is very large. It is also include the wood logs and many others heavy trashes which can create difficulties for manual cleaning. Also the trashes in rainy season comes continuously so it must needs a frequent trash rack cleaning system so that the power loss can be prevented.

In the year 2013 the powerhouse authority has installed the automatic trash rack cleaning machine for the cleaning of trash rack bar screens as shown in Fig 4.2.

Fig 4.2-:Trashrack Machine At Mohammadpur Powerhouse

The automatic machine installed there is hydraulically operated.it is fully automatic machine and it does not need any supervision.it has two cylinder, tracking and lifting cylinder. lifting cylinder is provided to lift the garbage and tracking cylinder helps in tracking the plate which lifted the garbage. this machine is available whole day for the cleaning which makes the frequent cleaning of the trash rack bar screens.it takes near about five minutes to clean a 5m trash rack bar screen.so at this site it takes only 1 hour to clean the whole 60m trash rack bar screens along the width of the river.

Trashes lifted by the machine are collected in the space provided in machine itself which is dumped in the pits near the site after the whole cleaning as shown in Fig 4.3.

Fig 4.3-: Trashes Collecting Arrangement In Trash Rack Machine

Above detail can tell that replacing manual trash rack cleaning by automatic trash rack cleaning machine has been proven a good decision of the Mohamadpur powerhouse authority.

The total cost of the machine including purchasing, transportation and installing was 3.5Crore.it seems quite high initially but machine cleaning is much beneficial than manual also its increases the power production and also takes less time in cleaning in comparison to the manual cleaning. Also it is frequently available at the site for the cleaning. You need not to be depends on anyone for the cleaning because it is automatically operated, shown in Fig 4.4.

Fig 4.4-: Operation Panel of Trashrack machine

If the machine is not operated for a day then the approximate loss in power at the site is 200000Kwh.

The last four years production at Mohammadpur site was following:

- In 2012-:31.487 million units.

- In 2013-:33.824 million units.
- In 2014-:52.408 million units.
- In 2015-:50.267 million units

As we can see that after installation of trash rack machine the power production increases by enormous amount. Although the renovation of the site have been taken place in the last few year which is also a reason of increasing power production but installation of trash rack cleaners has also a very huge impact on increase in power production. It has reduce head loss to a very large extent. The powerhouse has produced 15.736 million units in the year of 2016.

Although this machine is helping a lot in cleaning but it has very small problem as seen at the site. Sometime the trash fall out the plate which is lifting it. This trash collected above the trash rack and again falls into the water by the effect of winds and the animals and starting choking it, shown in Fig 4.5.

Fig 4.5-: Trashes Remain Above Trashrack after Cleaning

Overall we can say that having a automatic trash rack cleaning system is much beneficial for this hydropower plant. Yes it has high initial installation cost but it is giving benefit in increasing power production.

Table 7-: Power Generation At Mohammadpur Site

	Power Generated In Million Units			
Month	**2012**	**2013**	**2014**	**2015**
January	3.08	1.804	4.862	4.83
February	2.773	1.797	4.291	3.226
March	2.686	1.8	4.293	3.414
April	3.769	1.901	4.772	3.694
May	3.674	2.021	4.564	5.017
June	3.514	1.86	5.015	4.443
July	3.174	3.258	4.248	4.375
August	3.121	5.03	4.847	5.3
September	0	4.83	4.645	5.515
October	2.314	1.701	0.508	4.305
November	1.446	2.272	4.869	0.854
December	1.936	5.55	5.494	5.294

Monthly power generation at Mohammadpur site in the years 2012-2015 is shown in Table 7 and Fig 4.6, Fig 4.7, Fig 4.8 and Fig 4.9 respectively. This table has clearly shown that the power production at the site has increased after the installation of trash rack cleaning machine. Head losses in rainy season also decreases. Quantity of trash is much more in the rainy season. In India, monsoon season is from July to September. The production in the rainy season are less for the year 2012(6.295 MU) in comparison of the year 2015(15.19 MU). Trash rack is proven very beneficial for the particular site. Comparative analysis of power generation in the years 2012-2015 is shown in Fig 4.10

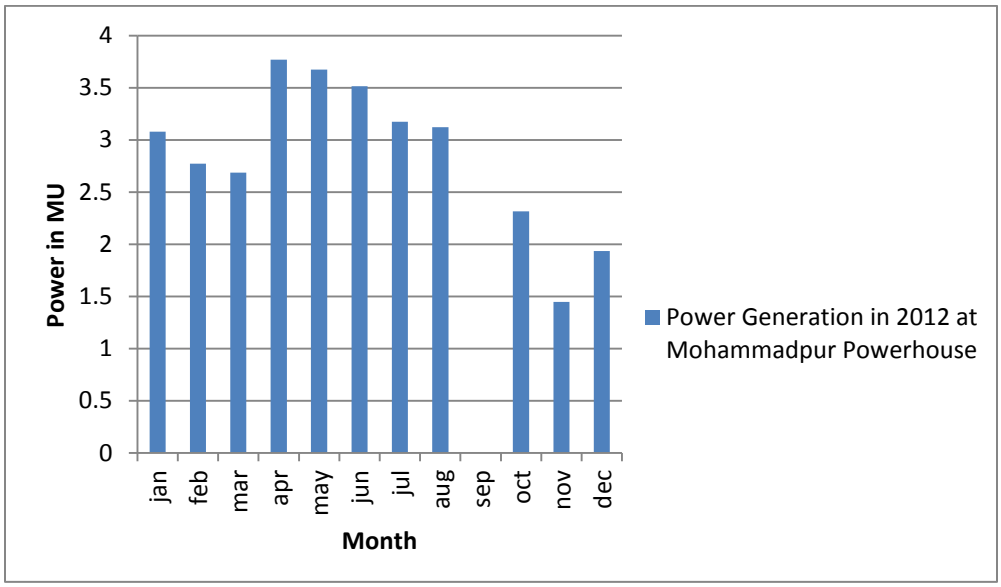

Fig 4.6 Power Generation in 2012 at Mohammadpur Powerhouse

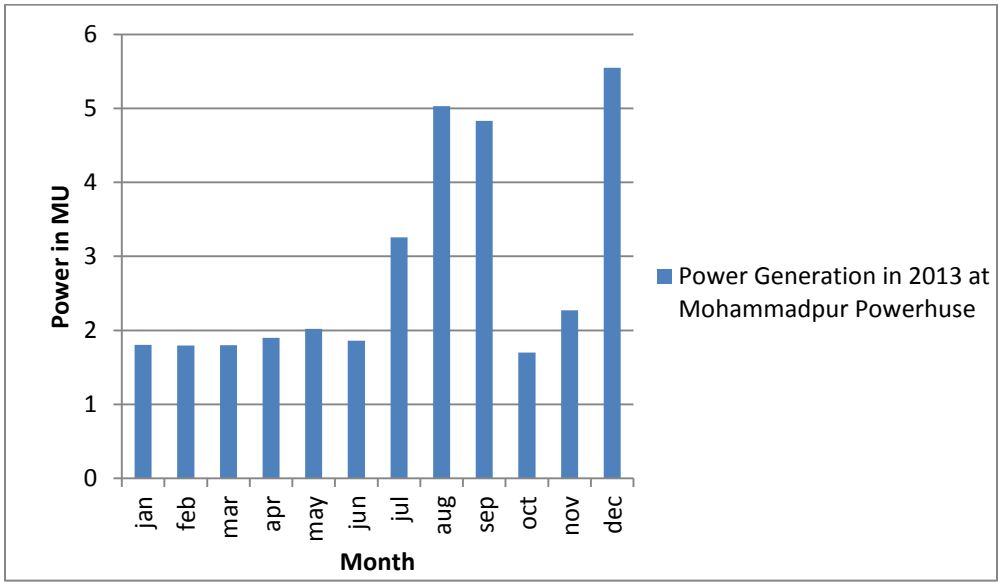

Fig 4.7 Power Generation in 2013 at Mohammadpur Powerhouse

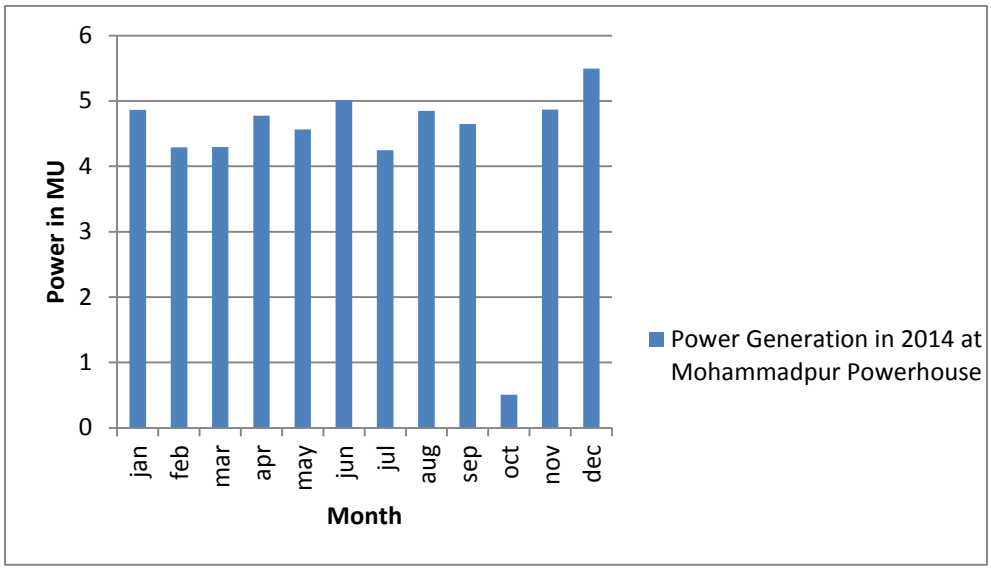

Fig 4.8 Power Generation in 2014 at Mohammadpur Powerhouse

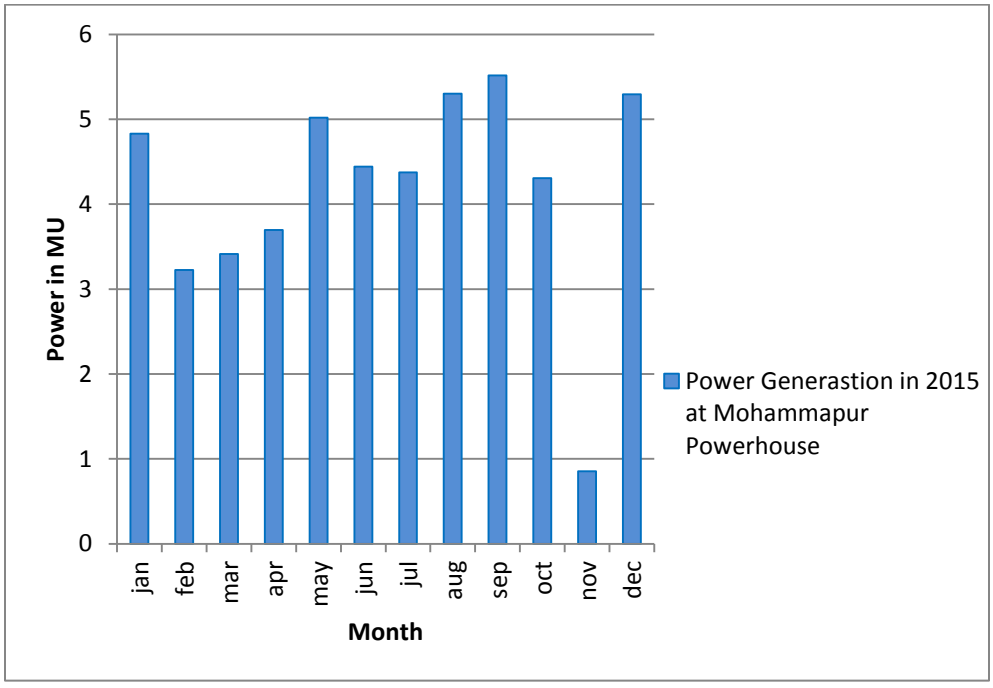

Fig 4.9 Power Generation in 2015 at Mohammadpur Powerhouse

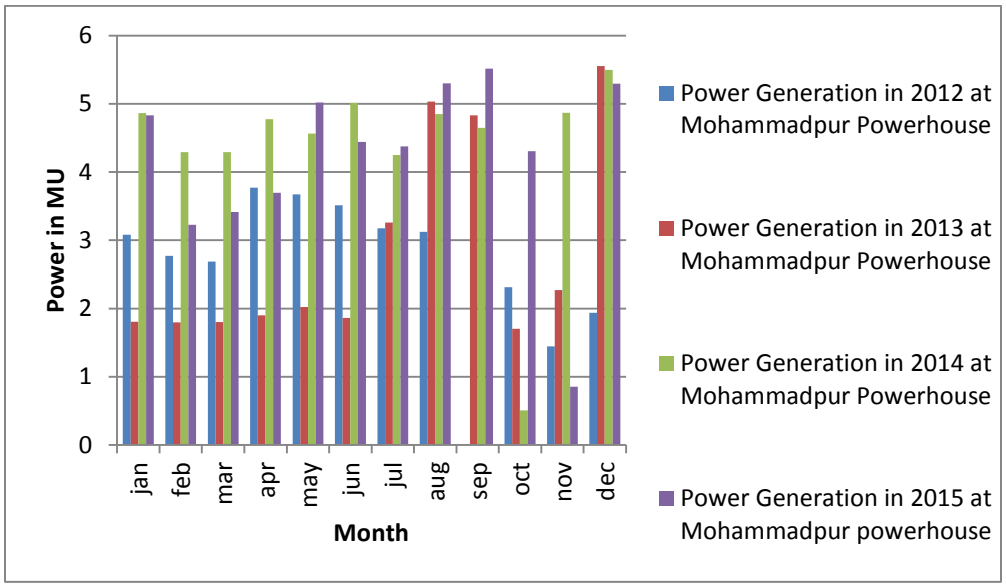

Fig 4.10-:Comparison of Power Generation at Mohammadpur Powerhouse in last years

4.2 PATHRI HYDROELECTRIC POWERHOUSE

Pathri hydroelectric powerhouse, is located in Bahadrabad, 10 km west of the city Haridwar. It is a runoff river scheme which is constructed on Upper Ganga Canal. The estimated potential of the powerhouse is 20.4MW having 3 turbine units with estimated potential of 6.8 MW each. Since the condition of low head and high discharge is available at the site so Kaplan turbine are used for power production. Head available at this site is near about 9.75m.

Like the other powerhouse it also face the problem of blocking of water due to the collected trash at the trashrack bar screen.

Fig 4.11-:Trashrack at Pathri Powerhouse

For cleaning of the trashrack the site have the trashrack cleaners machine which is electrically operated rope type trashrack cleaner, as shown in Fig 4.11. The trashrack cleaner collected the garbage in the trolley attach to the machine which is connected to the pulley system. With the help of the pulley system the garbage in the trolley is disposed,as shown in Fig 4.12.

Fig 4.12-:Trash Trolly And Pully Arrangement To Disposed The Trash

The collected trash is removed by the trashrack cleaner at regular interval in a day to keep the flow of water unobstructed. Generally the head loss after which trashrack cleaner is in used is 0.15m to 0.3m. The total expanses in the maintenances of the trashrack cleaner are 4 to 5 lakhs per annum.

In the rainy season the quantity of trash is too much such that it fully blocked the flow of water. To get rid of this trash instantly the water is allow to flow in side channel by opening its gate as shown in Fig 4.13.

Fig 4.13-: Side Channel Provided for the Removal of Extra Water

4.3 DHAKRANI HYDROELECTRIC POWER PLANT

Dhakrani hydroelectric power plant, is located in Dhakrani in the district Dehradun. It is a run off river scheme which get the diverted water from east Yamuna canal. The water is diverted through Dakpathar barrage. The estimated potential of the powerhouse is 33.75MW having 3 Kaplan turbine units with estimated potential of 11.25MW each. Head available at this site is near about 19.8m.

Fig 4.14-:Trashrack At Dhakrani

For the trashrack cleaning at Dhakrani(Fig 4.14), both manual ways and trachrack cleaner is used, as shown in Fig 4.15. The trashrack cleaner is rope type having jaw drum. It is electrically operated trashrack cleaner installed in 1962.

Fig 4.15-:Trashrack Cleaner at Dhakrani

The mechanism for trashrack cleaning is very simple. The jaw plate pick up the trashes from the blocked trashrack and then the trashes is manually disposed to the place which is available for trash disposal. When the quantity of trashrack is too much manual cleaning and trashrack cleaner operation take place simultaneously. The expanses in manual cleaning are 4-5 lakhs per annum and the maintenance expenses for trashrack cleaner are 2-5 lakhs per annum.

The problems which the trashrack cleaner is facing at Dhakrani site are following-:

- Sands cannot be removed from the bottom of the floor since the spacing of the jaws of the trashrack cleaner is very large so that it cannot lift the sand.
- Sometime the trash stuck between the jaws of cleaner which creates problem in lifting the trashes.

4.4 Analysis of Head Loss at Pathri and Dhakrani

At the time of visit the power produced by three units of turbines at Pathri is shown in Table 8.

Table 8-: Power Generation at Pathri

S.No.	Power Generation (MW)	Discharge(cumecs)
UNIT -1	6.1	76.265
UNIT-2	5	62.345
UNIT-3	4.9	62.205

Power produced at Dhakrani by their 2 working turbines are shown in Table 9.

Table 9 -: Power Generation at Dhakrani.

S.No.	Power Generation (MW)	Discharge(cumecs)
UNIT-1	3.2	19.84
UNIT-2	2.9	17.935

As we know the formula for power production is-:

$$P=Ŋ*\gamma*Q*H$$

- The available head at Pathri is 9.75m and at Dhakrani is 19.8m.The utilized head at the turbine after the all the losses can be calculated from the above formula.
- As the both sites using the Kaplan turbine whose efficiency varies from 85% to 90%. Assuming the efficiency of the turbine is 85%.

- Unit weight of the water is 9810 N/m^3.
- So calculating the utilize head by having the value of power and discharge, is shown in Table 10 and 11.

Table 10 -: Head Utilize At Pathri Powerhouse

S.No.	Head Utilize At The Site(m)
UNIT-1	9.59
UNIT-2	9.61
UNIT-3	9.44

Table 11 -: Head Utilize At At Dhakrani Powerhouse

S.No.	Head Utilize At The Site(m)
UNIT-1	19.34
UNIT-2	19.39

So the head loss at the site due to blockage of the trash rack can be calculated by subtracting the head utilize at the site from the total head available at the site. Head loss table at Pathri and Dhakrani powerhouse are shown in Table 12 and Table 13 respectively.

Table 12 -: Head Loss At Pathri Powerhouse

S.No.	Head Loss At The Site(MW)
UNIT-1	0.16
UNIT-2	0.14
UNIT-3	0.31

Table 13 -: Head Loss At Dhakrani Powerhouse

S.No.	Head Loss At The Site(MW)
UNIT-1	0.44
UNIT-2	0.41

As the day proceeds the trashes keep sticking at the trash rack screens. Sticking trashes increase the obstructed area for the flowing water which results in the extra head loss.

Power loss at the site increase as the day passes if the trash rack is not get cleaning .The head loss and power loss at the site after a period of 2 hours is shown in the Table 14 and Table 15.

Table 14 –: Loss of power At Pathri Powerhouse

S.No.	Power Generaed(MW)	Discharge(Cumecs)	Head Utilize At The Site(m)	Head Loss Due To Blocking Of Trashrack(m)	Power Loss(MW)
UNIT-1	6.1	78.637	9.30	0.45	0.3
UNIT-2	5	63.548	9.44	0.31	0.16
UNIT-3	4.9	62.549	9.39	0.36	0.19

Table 15-:Loss of power At Dhakrani Powerhouse

S.No.	Power Generated(MW)	Discharge(Cumecs)	Head Utilize At The Site(m)	Head Loss Due To Blocking Of Trash Rack(m)	Power Loss(MW)
UNIT-1	3.1	19.415	19.15	0.65	0.1
UNIT-2	2.9	18.115	19.20	0.60	0.09

So as we can see in the above table the power loss in remarkable. The total power loss is approximately 0.7MW at Pathri powerhouse and about 0.2MW at Dhakrani power plant in a very short interval.

4.5 DHALIPUR HYDROELECTRIC POWER STATION-:

Dhalipur hydroelectric power station, shown in Fig 4.16, is located in Dhalipur in the district Dehradun. It is a run off river scheme which get the diverted water from east Yamuna canal. The water is diverted through Dakpathar barrage. The estimated potential of the powerhouse is 51MW having 3 Francis turbine units with estimated potential of 17 MW each. Head available at this site is near about 30.48m.

At Dhalipur the trashrack cleaning ways are old. It still using manual cleaning.due to not having trashrack cleaner the cleaning of trashrack is not frequent and the trashes blocked the way of flowing water which results in head loss.

In the rainy season the situation is worst because the quatity of trashes is very large which can not be removed instantly and easily by the labours available at the site.The equipment which are used for cleaning are very old.

Fig 4.16-:Trashrack At Dhalipur

For cleaning the trashrack, labors used the hand rakes, as shown in Fig 4.17, which having teeth type structure in the front which catches the trash from the trashrack and drag it to the floor above the trashrack bar screen.

Fig 4.17-:Hand Rakes For Cleaning The Trash

Table 17-:Power Generation At Dhalipur Powerhouse

Month	Power Generated In Million Units					
	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
January	7.624	8.481	13.663	13.799	21.524	20.537
February	11.542	12.324	23.042	17.538	24.995	23.9
March	12.403	15.698	25.856	20.414	27.976	27.147
April	23.526	27.785	30.951	25.339	28.907	30.235
May	25.243	27.081	25.468	29.598	21.601	29.002
June	25.351	20.851	31.338	31.03	32.175	26.606
July	15.238	31.395	24.246	21.676	28.355	15.804
August	10.804	19.718	14.725	11.608	15.608	10.77
September	8.002	13.865	10.572	8.98	11.503	9.279
October	6.452	11.931	9.765	7.916	10.048	8.414
November	6.556	9.987	8.336	17.118	12.096	9.361
December	5.569	11.708	11.614	25.561	20.166	20.166

Monthly Power Generation at Dhalipur Powerhouse Station for the years 2009-2015 is shown in Table 8 and Fig 4.18, Fig 4.19, Fig 4.20, Fig 4.21, Fig 4.22 and Fig 4.23. For the site power production in the rainy season is quite low. Every year there is large decrease in power production in the monsoon season. Trash comes heavily with flowing water which totally block the way of water flowing over trash rack. Manual cleaning cannot compete with the quantity of trash. The trends for the power production are given following for last few years-:

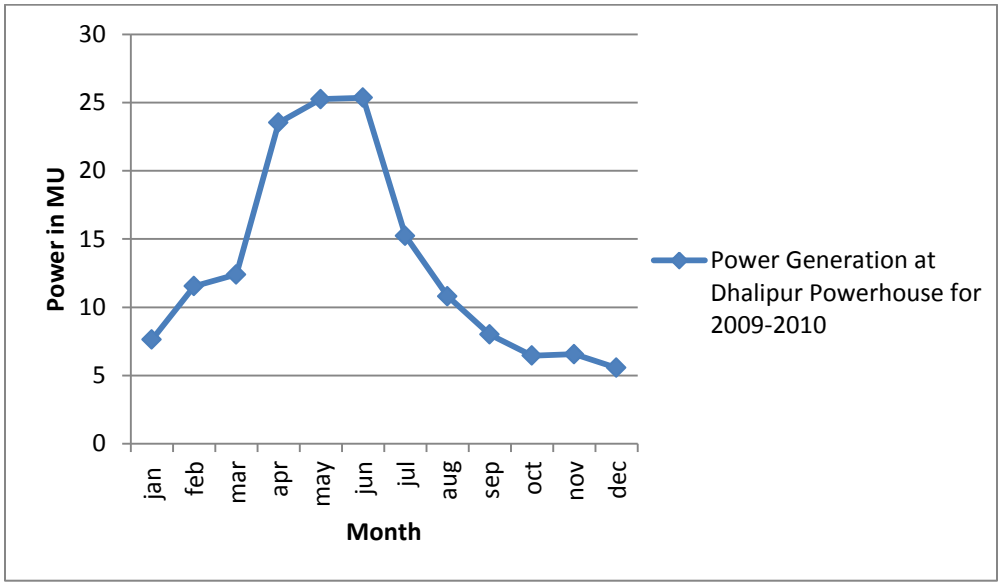

Fig 18 Power Generation at Dhalipur Powerhouse for 2009-2010

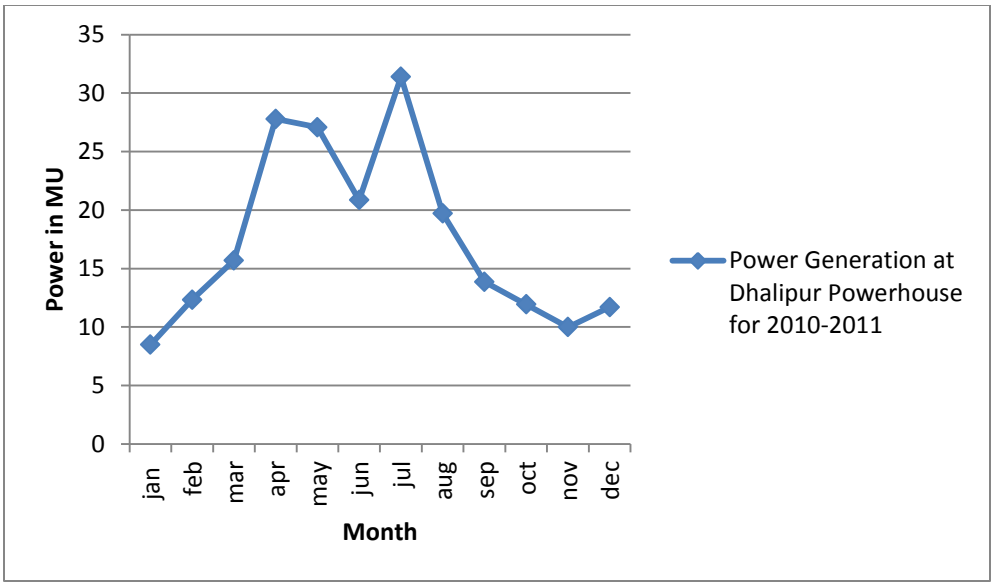

Fig 4.19 Power Generation at Dhalipur Powerhouse for 2010-2011

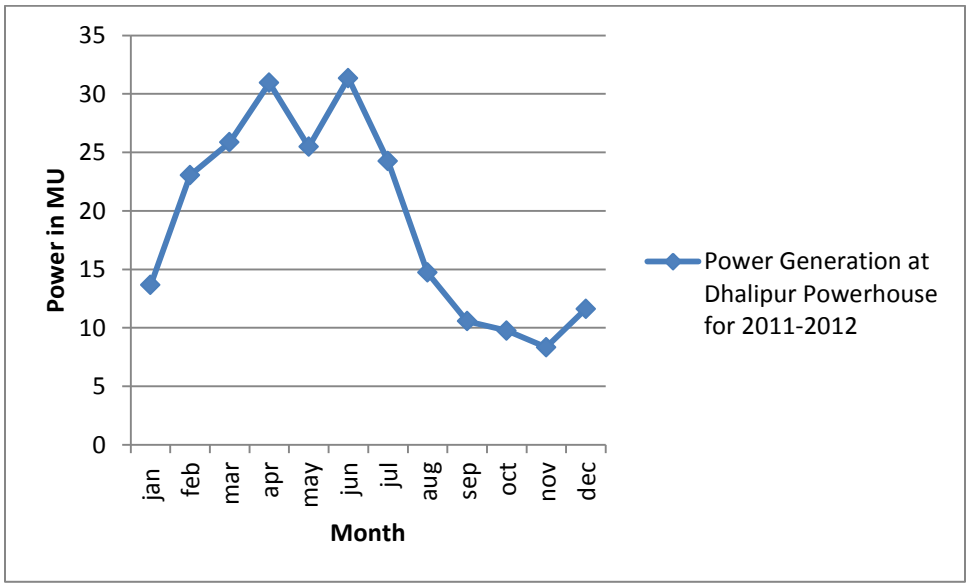

Fig 4.20 Power Generation at Dhalipur Powerhouse for 2011-2012

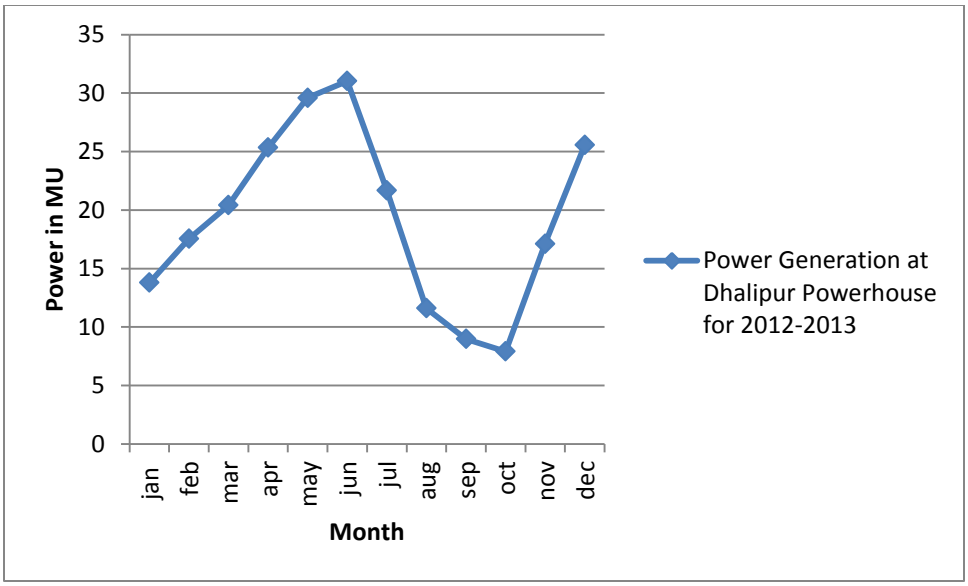

Fig 4.21 Power Generation at Dhalipur Powerhouse for 2012-2013

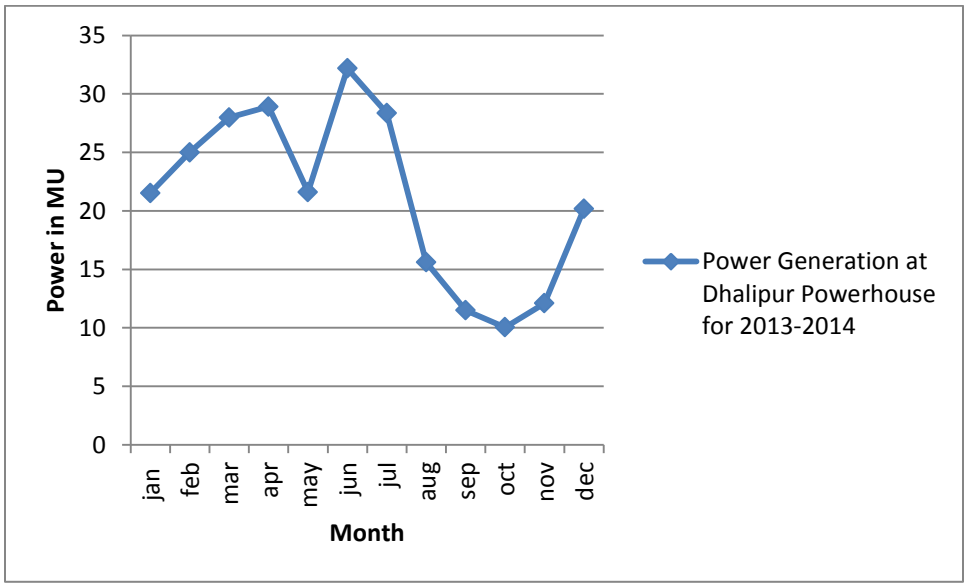

Fig 4.22 Power Generation at Dhalipur Powerhouse for 2013-2014

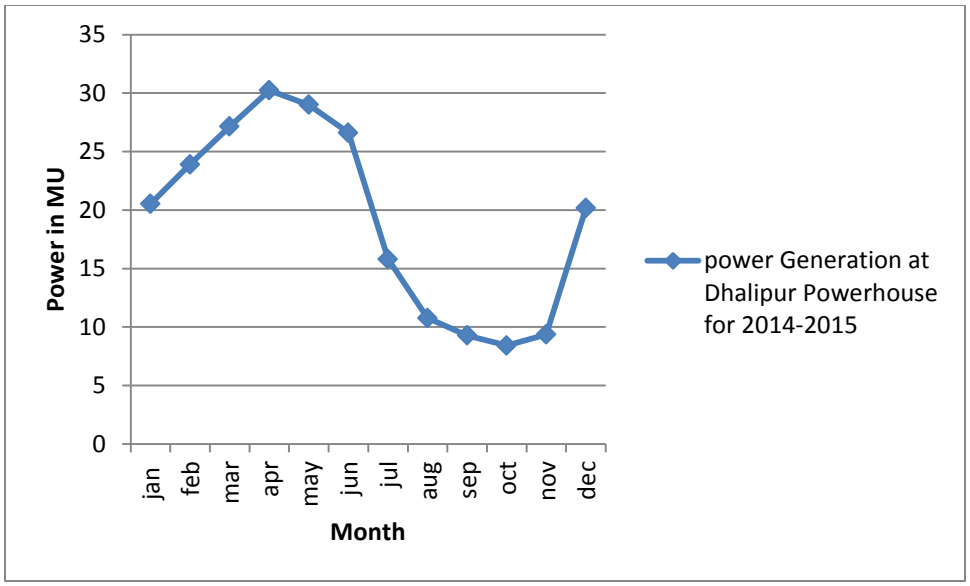

Fig 4.23 Power Generation at Dhalipur Powerhouse for 2014-2015

From the above trends it is quite visible that at Dhalipur powerhouse the power generation is decrease after the month July when the monsoon starts and quantity of trash is increases in water. This increase in quantity cannot b remove by manual cleaning instantly so the head loss at the trash rack is started.

CHAPTER 5
RESULTS AND DISCUSSION

5.1 RESULTS

On the basis of the study the following results are concluded-:

5.1.1 Pathri And Dhakrani Powerhouse-:

As it is shown in the previous chapter that the loss of head at the site is due to blockage of head is quite high for a short interval. On an average let us take the total loss for the whole day is twice the calculated value and the price of 1 unit of power is Rs.4.5. Table 16 show total loss at different unit of Pathri and Dhakrani powerhouse in terms of power and money.

Table 17 -: Annual loss at Pathri and Dhakrani power house

Unit	Power Loss (MW)	Price Of Electricity (Rs./Kwh)	Loss Of Money Per Day(Rs.)	Total Annual Loss(Rs.)
Pathri				
Unit-1	0.6	4.5	2700	985500
Unit-2	0.32	4.5	1440	525600
Unit-3	0.38	4.5	1710	624150
Total				**2135250**
Dhakrani				
Unit-1	0.2	4.5	900	328500
Unit-2	0.18	4.5	810	295650
Total				**624150**

As shown in Table 16, money which the powerhouse is losing every day or annually, are quite high. This money can be saved by having a proper and good trash rack cleaning mechanism.

The total amount for the fully installation of a automatic trash rack cleaner is about Rs.4 crores. the machine may require some maintenance work because the trashes can harm the machine.

From the visiting site it is quite clear that the amount for the maintenance of the trash rack cleaner is about 2-3 lakhs per annum.

The cost of machine can be automatically recovered by the saving of power because of proper cleaning. From the above calculation it is cleared that the cost of the machine can easily be recover in 10-15 years. After that the saved power increases the benefit of the powerhouse and increases its efficiency.

5.1.2 Mohammadpur Powerhouse-:

From the trends of power generation of the site for different year it is visible that the generation of power at the power plant is marginally increased in the last few years after the installation of automatic trash rack cleaning. The power generation for the year 2012 was 33.824 MU which is increased to 50.267 MU for the year 2015.

5.1.3 Dhalipur Powerhouse-:

From the graphs of power generation at Dhalipur site it is illustrated that the trackrack blocking is very large in the monsoon season which results in large head loss at the site. Power generation at the site is sharply lowered in the monsoon season (month of July, August, September, October).

5.2 DISCUSSION

From the above description it is depicted that trash rack blocking have a measure role in increasing the power loss so it need to be cleaned frequently which can only be done by the having automatic trash rack cleaning machine.

This head loss continued to happen if the trash rack is not getting cleaned. The head loss which leads to loss in power is quite considerable in these cases. So cleaning of the trash rack can be much better solution for increase the efficiency of powerhouse to some extent. As the

both sites have been equipped with trash rack cleaner so the trash can be cleaned which can prevent extra head loss.

But the sites like Dhalipur which are not equipped with trash rack cleaner are facing power loss problems. Trashes are unstoppable. Trashes will continue collect and stick to the trash rack as the water continues to flow for the production of power. So proper cleaning of the trash rack is the only way to get rid of the head loss happening due to trashes. Manual cleaning is not sufficient. It is cannot be done frequently and also not effective when it about cleaning the trash rack properly. So switching from manual cleaning to automatic trash rack cleaning can prevent the major head loss at the trash rack and also increase the efficiency of the power plant.

CHAPTER 6
CONCLUSION

6.1 COCLUSIONS

From the study following conclusion are drain-:

- Automatic trash rack cleaning can improve the profit for power generation even though its initial cost is marginally high. Analysis for Pathri and Dhakrani Powerhouse has proved that the automatic trash rack can save a large quantity of power which increase the profit from the power generation.
- Blocking of trash rack severely results in head loss which reduce the the power production of any particular site. In monsoon season these losses become very large which affect the efficiency of small power plant very badly. It is visible from the analysis Dhalipur Powerhouse that power production reduces sharply in the month of monsoon
- Automatic trash rack cleaning can save a large amount of power in the rainy season by reducing the head loss due to trash rack blocking. As shown in the trends for Mohammadpur Powerhouse, power generation is increased (33.824 MU in 2013 to 50.267 MU in 2015) in last few years after the installation of automatic trashrack cleaning machine

6.2 RECOMMEDATIONS

On the basis of the whole study following recommendations are given-:

- Automatic trashrack cleaning is much beneficial than manual cleaning. So it should be used for the cleaning which can increase the efficiency of a power plant.
- More case studies should be done to know the extent on head loss due to trashrack blockage.
- Research should be done to prove this more statistically that automatic trashrack cleaning can save a large amount of power.

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