CONSTRUCTION OF MINI HYDRO ELECTRIC POWER PLANT USING WASTE WATER

A thesis report submitted to the department of Mechanical Engineering for the partial fulfillment of the degree of Bachelor of Science in Mechanical Engineering

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APPROVAL

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ABSTRACT

Demand for energy is increasing in an alarming rate. This is due to the rapid outgrowth of population and urbanization. Conventional energy sources are not sufficient to face the phenomena of energy shortage. In this condition, renewable energy can be a substitute of conventional energy. Water is an attractive alternative energy for electricity generate. Using water for generate electricity known as hydroelectric power plant. Production of electricity in hydroelectric power plant process results in “net zero” carbon dioxide emission and no Sox or NO_x emission hydroelectric power plant construct in large scale or small scale. It’s depending on source of water and demand of electricity. Aim of this project and thesis work is designing, constructing of a waste water micro hydroelectric power plant. Waste water discharge from a multistoried building. Multistoried waste water are available huge amount in urban area which discharges in directly and it is not use for another purpose. If electricity produces by the house hold waste water, it will save overall electricity in a town.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

Chapter 1
Introduction

1.1 General:

Demand for energy and its resources, is increasing day by day. This is due to the rapid outgrowth of population and urbanization. Present sources of energy are not sufficient to overcome the increasing needs. The major energy demand is fulfilled from the conventional energy resources like coal, petroleum and natural gas. The huge amount of fossil fuels use, the environment can be in danger. The slandered quality life of a nation depends on energy consumption.

Bangladesh is a developing country & one of the most densely populated countries in the world which total population is 168.07 million. As of 2015, the natural gas reserves of Bangladesh are 14.16 trillion cubic feet. Oil production in 2013 was 4,500 bbl/d against a demand of 119,000 bbl/d. The electricity sector in Bangladesh has one national grid with an installed capacity of 16,525 MW as of 13 September 2018. The total installed capacity is 20,000 MW (combining solar power).

Recently Bangladesh started construction of the 2.4-gigawatt (GW) Rooppur Nuclear Power Plant expected to go into operation in 2023. According to the Bangladesh Power Development Board in July 2018, 90 percent of the population had access to electricity. Bangladesh's total installed electricity generation capacity (including captive power) was 15,351 megawatts (MW) as of January 2017 and 20,000 megawatts in 2018. The largest energy consumers in Bangladesh are industries and the residential sector, followed by the commercial and agricultural sectors.

As of 2015, 92% of the urban population and 67% of the rural population had access to electricity. An average of 77.9% of the population had access to electricity in Bangladesh. Bangladesh will need an estimated 34,000 MW of power by 2030 to sustain its economic growth of over 7 percent. As of 2011, 79 natural gas wells were present in the 23 operational gas fields which produce over 2000 millions of cubic feet of gas per day (MMCFD). It is well short of over 2500 MMCFD that is demanded, a number which is growing by around 7% each year. In fact, more than three-quarters of the nation's commercial energy demand is being met by natural gas. This influential sector caters for around 40% of the power plant feed-stock, 17% of industries, 15% captive power, 11% for domestic and household usage, another 11% for fertilizers, 5% in compressed natural gas (CNG) activities and 1% for commercial and agricultural uses. According to the Bangladesh's Power Sector Master Plan 2016 (PSMP–2016), the country has the potential to generate a combined 3.6 GW of electricity from renewable energy sources.

Another research has estimated that the potential from wind power alone stands at 20 GW . In this time, we think to produce electricity by hydroelectric from waste water. Its help full to reduce pressure of our national power grid. This electricity can be supply to another area. In city or town available of waste water because of many multipurpose building are constructed. Waste water is commonly produced by household. Every year huge amount of waste water is produced.

1.2 Objectives:

i. To Study about mini hydroelectric power plant.

ii. To design and construct a model of mini hydroelectric power plant.

iii. To Test the performance of constructed project.

Chapter 2
Literature Review

2.1 Historical Background

By using water for power generation, people have worked with nature to achieve a better lifestyle. The mechanical power of falling water is an age-old tool. It was used by the Greeks to turn water wheels for grinding wheat into flour, more than 2,000 years ago. The world's first hydroelectric project was used to power a single lamp in the Crag side country house in Northumberland, England, in 1878. Four years later, the first plant to serve a system of private and commercial customers was opened in Wisconsin, USA, and within a decade, hundreds of hydropower plants were in operation. By the turn of the century the technology was spreading round the globe, with Germany producing the first three-phase hydro-electric system in 1891, and Australia launching the first publicly owned plant in the Southern Hemisphere in 1895. In 1895, the world's largest hydroelectric development of the time, the Edward Dean Adams Power Plant, was created at Niagara Falls.By 1900 hundreds of small hydropower plants were in operation as the emerging technology spread across the world. In China, in 1905, a hydroelectric station was built on the Xindian creek near Taipei, with an installed capacity of 500 kW. [13] In Bangladesh Kaptai hydroelectric power plant established 1962 which capacity is 230MW previously research has been done of this topic by many scholars from which we get enthusiastic on this particulars topics.

Research of design of the river flow floating portable micro-hydro power plant. The river flow can convert to electrical energy as the renewable-energy source. Indonesia is one of a country has many rivers; however, for now, river flow that used as renewable energy is very least. Therefore, researchers have designed floating portable micro-hydro that is easy to develop by conventional people or rural people. It also uses easily obtained of materials. The micro-hydro intended to use low-priced materials; however, low RPM (Radius per Minute) generator is still expensive because it imported from another country. The floating portable micro-hydro will have other several advantages. That is, ability to adjust to the water surface, enabled to move around, easy installation, and it is maintainable. We expected for common people could be motivated to develop maintainable simple micro-hydro.

Designing Marine Current Micro-Hydro Power Plants Indonesia is an archipelago country. Today, Indonesian government continues to increase support to entrepreneurs engaged in renewable-energy. Based on the observation of the researchers, Barrang Lompo is one of the islands in the province of South Sulawesi that inhabited by about 4000 people still using diesel power plants. Costly diesel oil and oil transportation constraints cause the diesel power plant to be used only at 6 pm to 12 pm. Develop a Marine Current Micro-Hydro Power Plants can be a solution for people in the small island because it is too difficult to connecting electricity from power source in the main island. We hoped with these design people can be easy to build their marine current power plant.

Research paper about micro hydro power plant: Micro hydro power is a type of hydroelectric power that typically produces up to 100 kW of electricity using the natural flow of water. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks. There are many of these installations around the world, particularly in developing nations as they can provide an economical source of energy without the purchase of fuel. Micro hydro systems complement photovoltaic solar energy systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum. Micro hydro is frequently accomplished with a pelton wheel for high head, low flow water supply. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to small generator housing. Micro hydro systems are very flexible and can be deployed in a number of different environments. They are dependent on water flow from the source (creek, river, and stream) as well as the flow's velocity. Energy can be stored in battery banks at sites that are far from a facility or used in addition to a system that is directly connected so that in times of high demand there is additional reserve energy available.[3]

Research paper about micro hydro power plant Micro hydro power is a type of hydroelectric power that typically produces up to 100 kW of electricity using the natural flow of water. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks. There are many of these installations around the world, particularly in developing nations as they can provide an economical source of energy without the purchase of fuel. Micro hydro systems complement photovoltaic solar energy systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum. Micro hydro is frequently accomplished with a pelton wheel for high head, low flow water supply. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to small generator housing. Micro hydro systems are very flexible and can be deployed in a number of different environments. They are dependent on water flow from the source (creek, river, and stream) as well as the flow's velocity. Energy can be stored in battery banks at sites that are far from a facility or used in addition to a system that is directly connected so that in times of high demand there is additional reserve energy available.

A comprehensive study of micro hydro power plant and its potential in Bangladesh with its emerging commerce and industries, is facing a daunting task to cope up with the power crisis. There is a lack of sufficient power generation capacity, and the existing national grid network is unable to power the whole nation. In total Bangladesh has 232 rivers including the main rivers and their branches. So, if proper selection criteria are maintained, it will not be very difficult to find the potential sites where run of MHP plant can be set up. The electricity produced from these sites can play a very vital role in facilitating the local farmers to have proper irrigation facility and life development.

2.2. Overview of hydroelectric power plant

2.2.1 Largest hydroelectric power station

Large-scale hydroelectric power stations are more commonly seen as the largest power producing facilities in the world,. Although no official definition exists for the capacity range of large hydroelectric power stations, facilities from over a few hundred megawatts are generally considered large hydroelectric facilities.

Fig. 2.1: Panoramic view of the Itaipu Dam, American Society of Civil Engineers elected the Itaipu Dam as one of the seven modern Wonders of the World.

Currently, only four facilities over 10 GW (10,000 MW) are in operation worldwide, see table below.[15]

2.2.2 Small hydro

Small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant. The definition of a small hydro project varies but a generating capacity of up to 10 megawatts (MW) is generally accepted as the upper limit of what can be termed small hydro. This may be stretched to 25 MW and 30 MW in Canada and the United States. Small-scale hydroelectricity production grew by 29% from 2005 to 2008, raising the total world small-hydro capacity to 85 GW. Over 70% of this was in China (65 GW), followed by Japan (3.5 GW), the United States (3 GW), and India (2 GW).

2.2.3 Micro hydro

Micro hydro is a term used for hydroelectric power installations that typically produce up to 100 kW of power. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks. There are many of these installations around the world, particularly in developing nations as they can provide an economical source of energy without purchase of fuel.

Fig. 2.2: A micro-hydro facility in Vietnam [vef]

Fig. 2.3: Pico hydroelectricity in Mondulkiri, Cambodia [vef]

2.2.4 Pico hydro

Pico hydro is a term used for hydroelectric power generation of under 5 kW. It is useful in small, remote communities that require only a small amount of electricity. For example, to power one or two fluorescent light bulbs and a TV or radio for a few homes. Even smaller turbines of 200-300W may power a single home in a developing country with a drop of only 1 m (3 ft). A Pico-hydro setup is typically run-of-the-river, meaning that dams are not used, but rather pipes divert some of the flow, drop this down a gradient, and through the turbine before returning it to the stream.

2.2.5 Underground power station

An underground power station is generally used at large facilities and makes use of a large natural height difference between two waterways, such as a waterfall or mountain lake. An underground tunnel is constructed to take water from the high reservoir to the generating hall built in an underground cavern near the lowest point of the water tunnel and a horizontal tailrace taking water away to the lower outlet waterway.

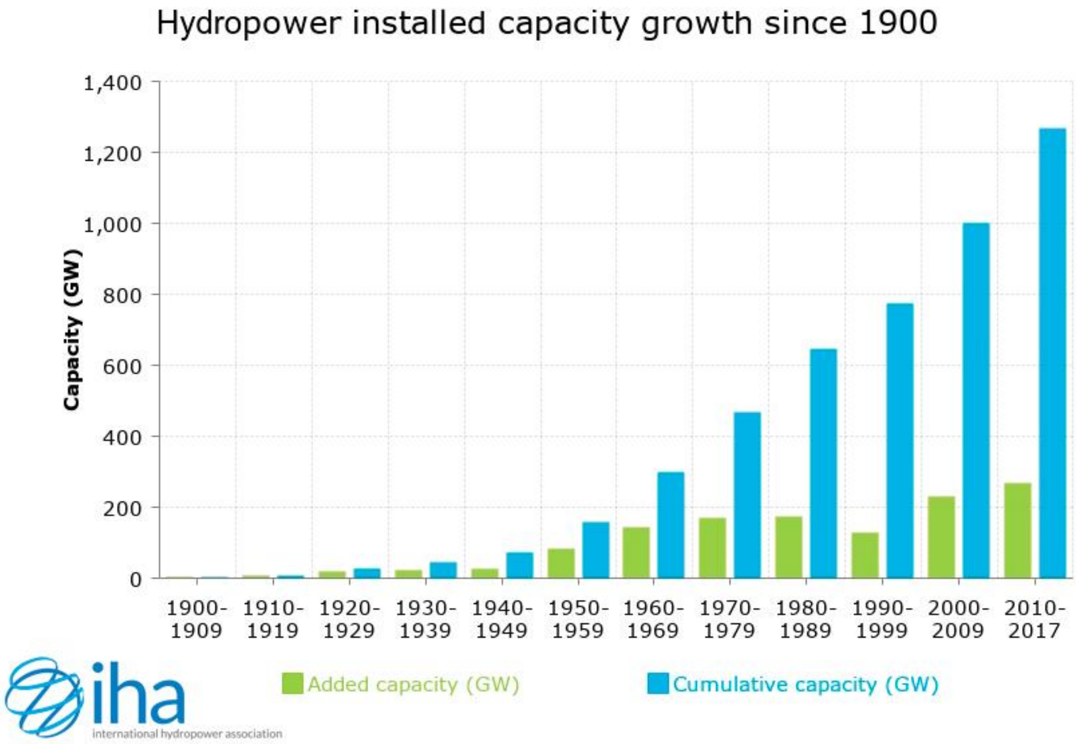

Table: 2.2 Hydropower installed capacity growth 1900-2017

2.3 Multilateral agreements and goals

The past decade has seen greater recognition of hydropower's role in achieving internationally agreed development outcomes, such as through the Sustainable Development Goals and climate goals including the Paris Agreement which have influenced national policytargets. Small hydropower projects (under 20 MW) in particular have benefited from the Clean Development Mechanism which was introduced under the Kyoto Protocol, the precursor to the Paris Agreement, to encourage clean and sustainable development.

2.4 Inventions in turbine technology

Some of the key developments in hydropower technology happened in the first half of the ninteenth century. In 1827, French engineer Benoit Fourneyron developed a turbine capable of producing around 6 horsepower – the earliest version of the Fourneyron reaction turbine.In 1849, British–American engineer James Francis developed the first modern water turbine – the Francis turbine – which remains the most widely-used water turbine in the world today. In the 1870s, American inventor Lester Allan Pelton developed the Pelton wheel, an impulse water turbine, which he patented in 1880.Into the 20th century, Austrian professor Viktor

Kaplan developed the Kaplan turbine in 1913 – a propeller-type turbine with adjustable blades. [13]

2.5 Advantages of hydroelectric power plant

2.5.1 Flexibility

Hydropower is a flexible source of electricity since stations can be ramped up and down very quickly to adapt to changing energy demands. Hydro turbines have a start-up time of the order of a few minutes. It takes around 60 to 90 seconds to bring a unit from cold start-up to full load; this is much shorter than for gas turbines or steam plants. Power generation can also be decreased quickly when there is a surplus power generation.

2.5.2Low cost/high value power

The major advantage of conventional hydroelectric dams with reservoirs is their ability to store water at low cost for dispatch later as high value clean electricity. The average cost of electricity from a hydro station larger than 10 megawatts is 3 to 5 U.S. cents per kilowatt-hour.[15] When used as peak power to meet demand, hydroelectricity has a higher value than base power and a much higher value compared to intermittent energy sources.Hydroelectric stations have long economic lives, with some plants still in service after 50–100 years.Operating labor cost is also usually low, as plants are automated and have few personnel on site during normal operation.

2.5.3 Suitability for industrial applications

While many hydroelectric projects supply public electricity networks, some are created to serve specific industrial enterprises.

2.5.4 Reduced CO_2emissions

Since hydroelectric dams do not use fuel, power generation does not produce carbon dioxide. The low greenhouse gas impact of hydroelectricity is found especially in temperate climates. Like other no fossil fuel sources, hydropower also has no emissions of sulfur dioxide, nitrogen oxides, or other particulates.

2.6 Disadvantages of hydroelectric power plant

2.6.1 Ecosystem damage and loss of land

Hydroelectric projects can be disruptive to surrounding aquatic ecosystems both upstream and downstream of the plant site. Generation of hydroelectric power changes the downstream river environment. Water exiting a turbine usually contains very little suspended sediment, which can lead to scouring of river beds and loss of riverbanks. Since turbine gates are often opened intermittently, rapid or even daily fluctuations in river flow are observed.

2.6.2 Water loss by evaporation

A 2011 study by the National Renewable Energy Laboratory concluded that hydroelectric plants in the U.S. consumed between 1,425 and 18,000 gallons of water per megawatt-hour (gal/MWh) of electricity generated, through evaporation losses in the reservoir. [16]Where there are multiple uses of reservoirs such as water supply, recreation, and flood control, all reservoir evaporation is attributed to power production.

2.6.3 Siltation and flow shortage

Siltation can fill a reservoir and reduce its capacity to control floods along with causing additional horizontal pressure on the upstream portion of the dam. Eventually, some reservoirs can become full of sediment and useless or over-top during a flood and fail.Changes in the amount of river flow will correlate with the amount of energy produced by a dam. Lower river flows will reduce the amount of live storage in a reservoir therefore reducing the amount of water that can be used for hydroelectricity. The result of diminished river flow can be power shortages in areas that depend heavily on hydroelectric power. The risk of flow shortage may increase as a result of climate change.

2.6.4 Methane emissions (from reservoirs)

Lower positive impacts are found in the tropical regions, as it has been noted that the reservoirs of power plants in tropical regions produce substantial amounts of methane. This is due to plant material in flooded areas decaying in an anaerobic environment and forming methane, a greenhouse gas.

2.6.5 Relocation

Another disadvantage of hydroelectric dams is the need to relocate the people living where the reservoirs are planned. In 2000, the World Commission on Dams estimated that dams had physically displaced 40-80 million people worldwide.

2.6.8 Failure risks

Because large conventional dammed-hydro facilities hold back large volumes of water, a failure due to poor construction, natural disasters or sabotage can be catastrophic to downriver settlements and infrastructure.

Chapter 3
Theoretical Aspects

3.1 Fundamental of Mini Hydropower Plant by Using Waste Water

We have to use a lot ofwater in our daily life. If we can use the waste water to do any specific work, we can even be benefited through the wasted water. This concept makes us to build our project called **“Mini Hydro Water Power Plant”.**

Hydropower plants capture the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy. We have used this concept to build our project.

3.2 Working Procedure of Mini Hydropower Plant

Let’s consider a six storied Building. Every floor contains bathroom (excluding sewerage), washroom, kitchen room etc. So, we have a lot of waste water. We can store that wasted water in a reservoir.

We will rotate the turbine using the pressure of water flowing through the master tank outlet. Thus we will get power from the generator according to the rotation of the turbine. From AC generator we will get AC power and can operate AC loads directly. And from DC generator we will get DC power and can operate DC loads.

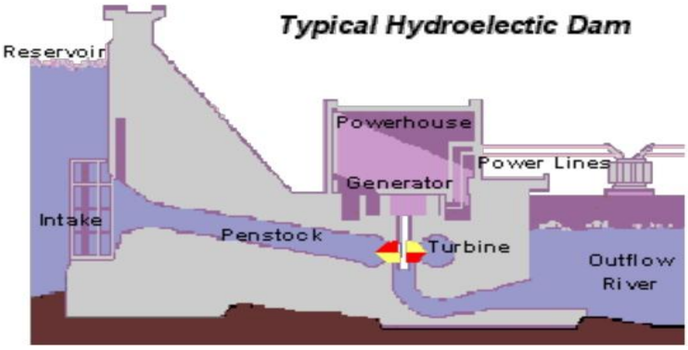

Fig.3.1: Typical Hydroelectric Dam

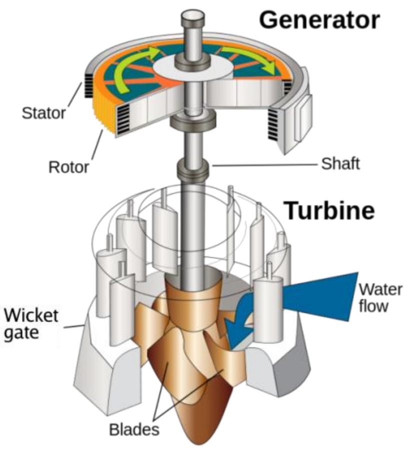

Fig.3.2: Conversion Energy

In our project we have used DC generator. So, we can operate DC loads directly. We can store the DC power in the battery and can use the power as our needs. If we want to operate

AC loads using this DC power, we need to use inverter to convert the DC power to AC power. We have attached an inverter with the battery to drive the AC loads.

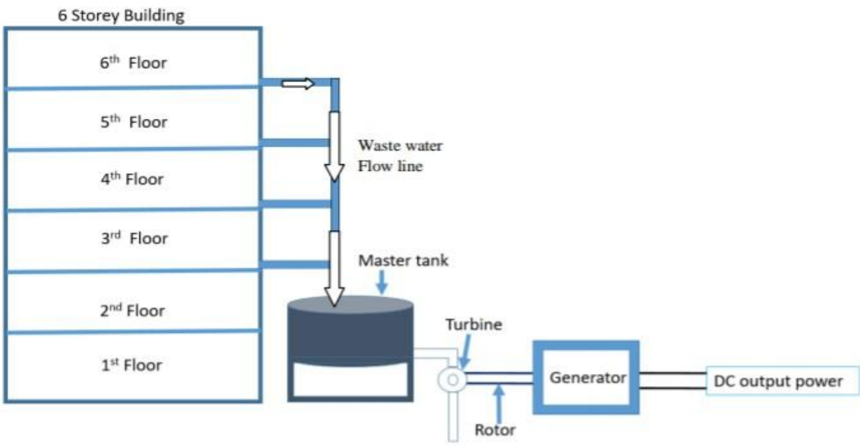

Fig.3.3: Details of mini hydroelectric power plant using household waste water

3.3 WORKING PRINCIPAL OF TURBINE

Turbines are usually fixed in place, so when a fluid flows through it there is a drop in pressure at the back edge of each blade that causes the turbine to turn. The principle is the same for air or water and the faster the medium is moving, the greater the pressure drop, and the faster the turbine spins.

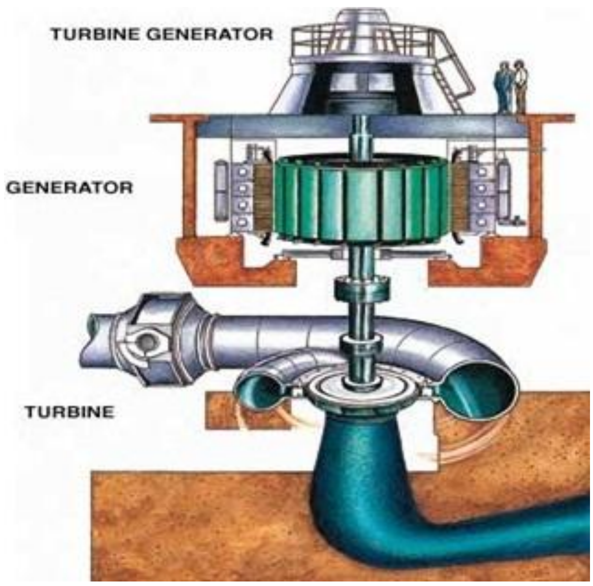

Fig.3.4: General picture of Water turbine

3.4 Working Principle of Generator:

An electrical Generator is a machine which converts mechanical energy (or power) into electrical energy (or power). It is based on the principle of production of dynamically (or motionally) induced e.m.f (Electromotive Force). Whenever a conductor cuts magnetic flux, dynamically induced e.m.f. is produced in it according to Faraday's Laws of Electromagnetic Induction. This e.m.f. causes a current to flow if the conductor circuit is closed. Hence, the basic essential parts of an electric generator are:

A magnetic field and

A conductor or conductors which can so move as to cut the flux.

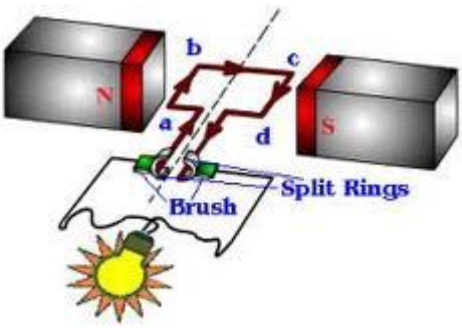

Fig.3.5: DC Generator

3.5 Working principle of inverter

An inverter is an electronic device that changes direct current to alternating current. We should remember that inverter never produce any power, the power is provided by the DC source.

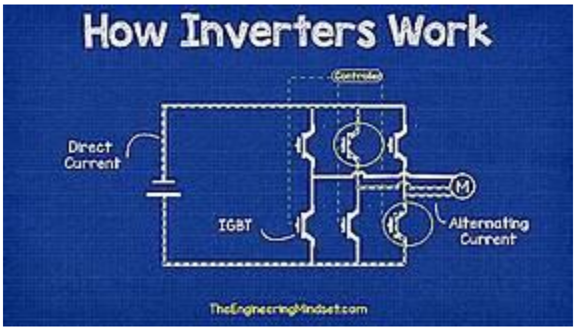

Fig.3.6: Working principal of Inverter

3.4 .1 Benefits of new constructed mini hydroelectric power plant

1. From our mini power plant we can create our own power plant. Thus we can save our electricity and use the wasted water.

2. This power plant is fueled by water, so it's a clean fuel source, meaning it won't pollute the air like power plants that burn fossil fuels, such as coal or natural gas.

3. The energy generated through hydropower relies on the water cycle, which is driven by the sun, making it a renewable power source, making it a more reliable and affordable source than fossil fuels that are rapidly being depleted.
4. Some hydropower facilities can quickly go from zero power to maximum output. Because hydropower plants can generate power to the grid immediately, they provide essential back-up power during major electricity outages or disruptions.

3.5 Draw backs of new constructed mini hydroelectric power plant

1. As our tank needs to be situated at a high position, so the water of first floor is still wasted.
2. As the capacity of our tank is limited we cannot produce electricity as much as we want.
3. Since we do not use our water whole day, we cannot produce electricity anytime.
4. We can produce electricity only when the tanks have enough water to flow.
5. Due to the characteristic of waste water plant (mainly turbine) will damage for corrosion and other chemical reaction with oil, suspended solid etc.
6. In this plant water flow is not continuous. If waste water not come from building plant will be stop.
7. This plant is not able to generate huge amount of electricity.

Chapter 4
Theoretical Aspects

4.1 System Component
The components used to build the project are:

4.1.1 Apparatus:

1. Water Tank
2. Pipe
3. Turbine
4. Generator
5. Battery
6. AC Light Bulb
7. DC Light Bulb
8. Stand

9. Inverter

4.1.2 Measurement(Small scale design) :

Table. 4.1 Measurement of parts

Parts	Height	Length	Width	Diameter	Materials	Comments
Water tank	24 Inch			26 Inch	G.P Sheet	
Pipe		11 Inch		1 Inch	G.I	
Turbine				9 Inch	Steel	
Frame	5 Feet	30 Inch	30 Inch			
Generator						48 Watt

4.1.3 Description of system :

In our project a master tank is used to store the water. We need to collect a large amount of water. So, the master tank should be able to store the water we want to store. That's why we used a big water tank in our project. It can store 250 liters of water. A turbine is a rotary mechanical device that extracts energy from a fluid flow and converts it into useful work. The work produced by a turbine can be used for generating electrical power when combined with a generator. A turbine is a turbomachine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor.Generator is a machine that converts mechanical energy into electrical energy. It works based on principle of faraday law of electromagnetic induction. The faradays law states that whenever a conductor is placed in a varying magnetic field, EMF is induced and this induced EMF is equal to the rate of change of flux linkages. This EMF can be generated when there is either relative space or relative time variation between the conductor and magnetic field. An inverter converts the DC voltage to an AC voltage. In most cases, the input DC voltage is usually lower while theoutput AC is equal to the grid supply voltage of either 120 volts, or 240 Volts dependingon the country.The inverter may be built as standalone equipment for applications such as solar .

4.2 Final constructed apparatus

Fig.4.1: Final constructed apparatus

Chapter 5
Result and Discussion

5.1 Experimental data :

Table: 5.1Experimental data

Amount of Water	Voltage	Current	Power
250 Liter	12 V	500 mA	6 W
200 Liter	7.5 V	468.75 mA	3.51 W
100 Liter	5 V	312.5 mA	1.56 W

5.2 TURBINE EFFICIENCY

In this project we find out,

h= 11 inch=0.2794m(From data table4.1.2)

Q= 250liter=0.25m^3 (From data table 5.1)

P= 6 Watt (From data table 5.1)

We Know, Water density, ρ=1000 Kg/m^3

Gravitational acceleration=9.81m/s^2

So, Efficiency of turbine, η=?

The formula of power calculation,

$P = \eta \times \rho \times g \times h \times Q$

Putting all value,

$6 = \eta x 1000 x 9.81 x 0.2794 x 0.25$

So, η=0.0087x100 =0.87%

So, Turbine efficiency= 0.87%

5.3 Discussion :

Designing and constructing of a mini hydraulic power plant by using building waste water as a power source. According this model overall performance is satisfactory.

After completing this process we satisfactory that waste water of a multistoried building/ house is the source of electricity generate.

Chapter 6
Conclusion

6.1 Conclusion:

A mini hydroelectric power plant design and construction has been proposed by using waste water as power source. This is an electricity generation process and helps to reuse the household waste water. It is proven and possible that household waste water can use for produce electricity. For this mini power plant setup need individual small space in multistoried building. If set up this type of power plant in building may be it help the small solution of present energy crisis. Micro-hydro power plant is an Important Part of words electricity supply especially in remote areas. It is providing reliable and economic source of electricity.as no fossil fuel required in hydro power plant it can help to save other source of Energy.

6.2 Scope of future work :

Need to develop of small size generator and turbine technology.

Encourage the building owner for establish this type of mini hydro electric power plant For produce Extra Electricity.

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