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Hydro Power Plants : A Review

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ABSTRACT:

As opposed to many combustion technologies, which require "ramp-up" times, hydropower doesn't require any. This makes it significant from an operating perspective. To adjust its output practically quickly to changing demand, hydropower can raise or reduce the quantity of power it is sending to the system. Hydropower contributes significantly to guaranteeing dependable electrical delivery and to meeting customer expectations in a market-driven industry because of its strong loadfollowing capabilities, peaking capacity, and voltage stability characteristics. Additionally, the only significant technique to store electricity currently accessible is in hydroelectric pumped storage plants. Hydropower uses one of our most precious resources, water, yet it is a renewable resource. By enhancing hydropower projects and running them more efficiently, Reclamation assists the Nation in meeting its existing and future energy needs in a way that safeguards the environment.

Keywords : Hydroelectric power, renewable energy, power generation, Power distribution

Introduction :

Hydro power is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity. Because of hydropower plants can generate power to grid immediately, they provide essential backup power during major electricity outages. Hydropower provides benefits beyond electricity generation by providing flood control, irrigation support and clean drinking water. Hydropower works by harnessing the energy that comes from the flow of water through a turbine it into electricity. Most hydropower plants store water in a dam, which is controlled by a gate or valve to measure the amount of water that flows out. Based on the pressure head hydro plants are classified as large, medium , small and micro head power plants, here we are going to discuss one by one detailly and the amount of electricity generated and some of experiments conducted in order to increase its efficiency.

1.1 High head Hydroelectric Power Plant

One of the biggest dams in India is the Konya Dam. It is a dam made of concrete and rubble that was built on the Konya River, which originates in Mahabaleshwar, a hill town in the Sahyadri hills. The foundation of the concrete gravity dam is 70 metres wide and 103 metres high. The top of the 2648-foot-long concrete dam, which is constructed of rubble, is 764 metres above sea level. When a 1967 earthquake with a 6.5 magnitude struck the area, the upstream water head was 91.7 m [1]. In terms of electricity generation, this project is divided into four stages, the first and second of which share a power plant with a total of eight Pelton turbines. Two stages each feature four turbines with a capacity of 75MW for the second stage and 65MW for the first stage. Additionally, a dam foot power house was built, and water discharged from the Konya dam is utilised to generate electricity for irrigation. It features two 20 MW each Francis turbine units. The foot power house at the dam and the two stages together have an installed capacity of 600MW. This dam impounds the stage 1 and stage 2 tail race water in stage 3 [2].

1.1.1 ***Power and water distribution:***

The dam's primary function is to supply hydroelectricity, along with some agricultural facilities in nearby areas. The distribution of 1960MW of electricity to diverse businesses, agriculture, and domestic uses. West Maharashtra receives water from the Konya dam, which also provides hydroelectric electricity to nearby communities. During the monsoon season, the dam is essential for controlling flooding. The catchment region traps the Konya River to create the roughly 50 km long Shivsagar Lake. the Konya Wildlife Sanctuary, which has a total size of 423.55 km^2 [3].

1.1.2 Dam safety and risk analysis:

Dam safety based on risk analysis methodologies demand quantification of the risk of the dam-reservoir system. This means that, for a given initial state of the system, and for the several failure modes considered, it is necessary to estimate the probability of the load events and the conditional probability of response of the system for a given load event, as well as estimating the consequences on the environment for the obtained response of the system.

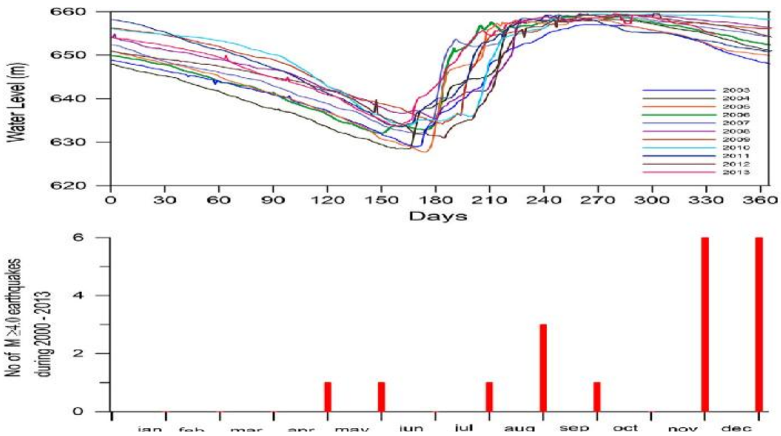

Fig1: shows graph between earth quack and months in a year [9]

Due to its generic composition, it is believed that its application to any other type of dam and for any other failure mode, particularly for those that are primarily "structural," can be carried out quite easily. These are a few, and risk assessment is also carried out using examples from past events like landslides and earthquakes [8].

1.2 Medium Head Hydroelectric Power Plant(30-300m)

In Hubei province, central China, downstream of the Three Gorges, there is a hydroelectric gravity dam called the Three Gorges Dam which is the medium head dam that crosses the Yangtze River by the town of Sandouping in Yuling District, Yichang. Since 2012, Three Gorges Dam (22,500 MW) has held the title of largest power plant in the world in terms of installed capacity. Scientists tested whether the dam could withstand the test of time after 19 years of construction and continue to provide electricity for the next 75 years.

1.2.1 Power Generation and capacity

Each of the primary generators weighs roughly 6,000 tonnes and can generate up to 700 MW of power. The generator's intended hydraulic head is 80.6 metres (264 ft). Depending on the available head, the flow rate ranges from 600 to 950 cubic metres per second (21,000 to 34,000 cu ft/s). Less water is required to generate full power as the head increases. Francis' turbines are used at Three Gorges. The turbine has a 9.7/10.4 m diameter and rotates at 75 revolutions per minute (VGS design/Alstom design). This means that the generator's rotors need 80 poles in order to produce power at 50 Hz. The majority of generators use water cooling. Some of the more recent ones use air cooling, which is easier to maintain and has lower design and manufacturing requirements. [12]

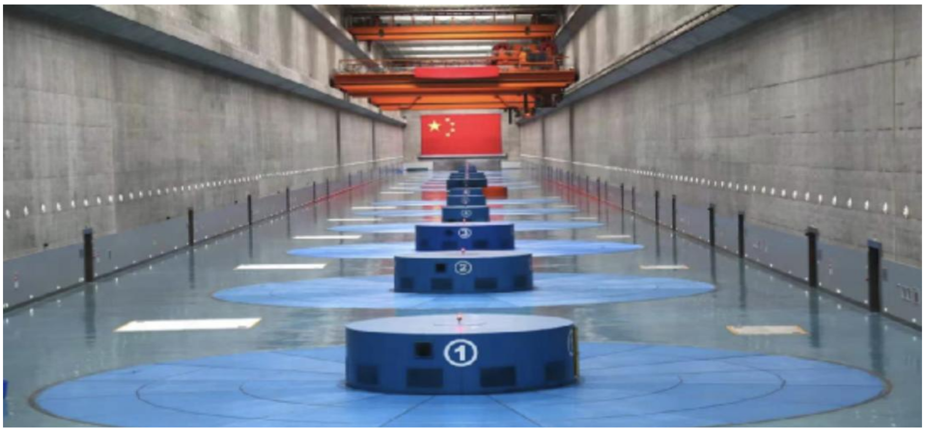

Fig2 : Installation of 32 Francis turbine and generators for producing electricity[12]

Several 500 kV transmission lines are used for the distribution of power. Three direct current (DC) lines carrying 7,200 MW each from Three Gorges to Shanghai (3,000 MW), Three Gorges to Changzhou (3,000 MW), and Gezhouba to Shanghai (3,000 MW) to the East China Grid (1,200 MW). The Central China Grid's alternating current (AC) lines have a combined capacity of 12,000 shas a capacity of 3,000 MW.

Fig 3: shows the distribution of electricity through power grids

1.2.2 Erosion and Sedimentation

The dam has been specifically linked to two risks. One is that there is disagreement on sedimentation projections, and the other is that the dam is situated on a seismic fault. At present rates, the area's 80% of the land is eroding, adding around 40 million tonnes of sediment to the Yangtze per year. There will be less sediment downstream as a result of the sediment settling there rather than going downstream due to the slower flow above the dam. There are three consequences if there is no downstream silt: Some hydrologists predict that riverbanks downstream will be more susceptible to flooding. Shanghai is located on a vast geological plain more than 1,600 kilometres (990 miles) away.

Fig 4: Sedimentation and erosion identified in dam

1.3 Small head Hydro Power Plant:

Less than 50 megawatts are used by small hydropower plants (MW). In both industrialised and developing nations, small hydropower methods are now used to produce electricity for rural electrification. In locations where water or other fluids, such as sewage discharge or saline water, flow to the appropriate height, small hydropower plants are used. Small hydro is the scaled-down creation of hydroelectric electricity for a small community or industrial facility. The amount of energy consumed per person has a significant impact on society development and economic growth.More and more electricity must be produced in order to meet the energy needs. Currently, fossil fuel-based power plants provide 74.4% of the energy needed worldwide. However, such generating stations are a hindrance to environmental cleanliness. 26% of the energy produced globally comes from renewable sources [1].

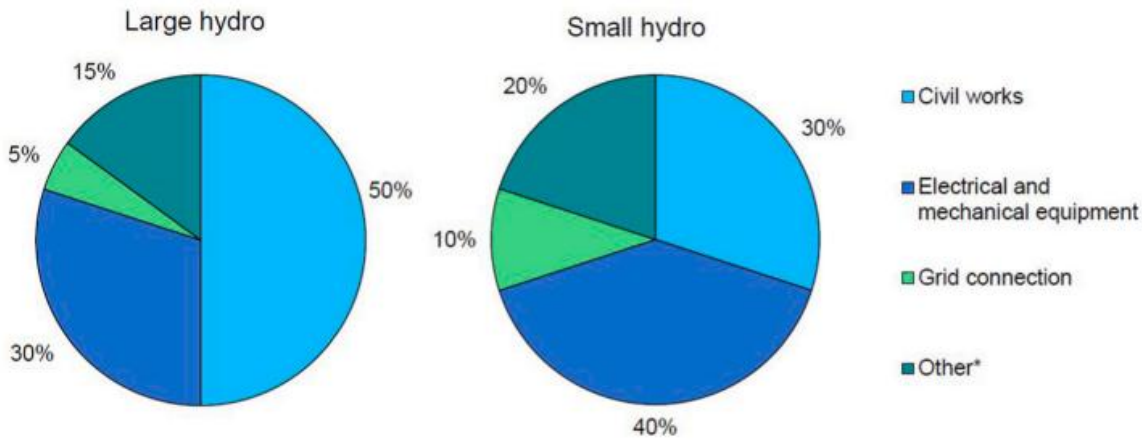

Fig.5 Large and small hydropower plants typical investment cost distribution

For the year 2030, the International Energy Agency (IEA) published the first comprehensive predictions for three main forms of hydropower: reservoir, run-of-river, and pumped storage facilities. Up to 2030, reservoir hydropower plants—which include dams that enable long-term water storage—might generate nearly half of all new hydropower. Cross-border export opportunities, cost-effective power availability, and the use of dams for multiple purposes are the main forces for reservoir project expansion. Pumped storage facilities can store power by pumping water from a reservoir at a lower level to a reservoir at a higher level. The water is then released through turbines during peak electricity demand hours. They represent 30% of the net hydro-power additions in that forecast through 2030. A record number of pumped storage facilities are anticipated to be built between 2021 and 2030 as a result of the rising demand in various markets for the system flexibility and storage needed to enable the integration of higher proportions of variable renewable energy sources. Run-of-river hydropower, which may produce energy through natural water flow with little storage capacity, will continue to expand because it already includes a large number of small-scale plants under 10 MW. Therefore, it is anticipated that run-of-river technology incorporated into small- or micro-scale hydropower will be sufficiently cost-effective to draw private investment and partnership financing.

1.4 Micro head Hydro Power Plant:

Micro hydro is a type of hydroelectric power that typically produces from 5 kW 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. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to a small generator housing. they can convert potential energy into mechanical then convert into electrical.

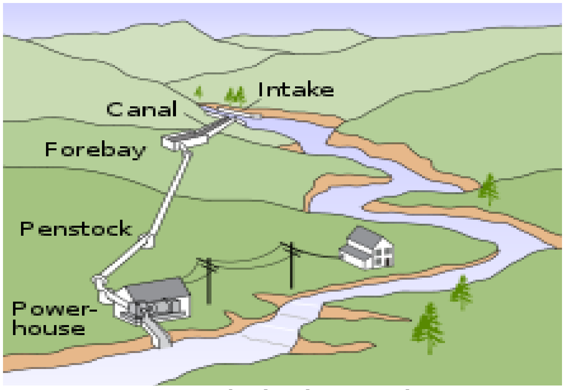

Fig.6 Micro head Hydro Power Plant

Construction details of micro hydro power plant was specific the most important include was intake where the water diverted from natural stream, river or water fall. Canal which is used to transport the waterForebay the purpose of forebay was to store water and control the floods Penstock which increase the pressure of water to down ward direction Power house the turbines are located in that area and the generated power can passes through the transforms.[31]

1.4.1 Types of turbines used:

The type of turbine that can be used in a micro hydro installation depends on different factors such as, head of water, the volume of flow, and such factors as availability of local maintenance and transport of equipment to the site commonly used turbines are impulse, reaction, screw and Francis. Run of the river micro hydro power systems consist of these basic components Water pipeline that deliveries the water Turbine and pump-transforms the energy into electricity Generator-transforms the rotational energy into electricity Regulator-control the electricity. [32]

1.4.2 Challenges:

There are numerous challenges in using the Francis turbine, starting from the design itself.The modern design process of the Francis turbine involves the optimization of blade shape using Computational Fluid Dynamics.Lack of skilled manpower at the power plant has been a problem in Nepalese micro hydropower since the beginning and it’s going to be troublesome to have unskilled plant operator at a plant with Francis- turbine as it requires continuous condition controlling.[33]

1.4.3 Dam failures:

Fig.7Dam failure

A dam failure is a catastrophic type of structural of failure. characterized by the sudden, rapid, and uncontrolled release of impounded water such an uncontrolled release. Between the years 2000 and 2009 more than 200 notable dam failures happened worldwide.

1.5 A Micro Hydro Power Generation System for Sustainable micro grid Development in Rural

In this paper talks about the how the micro power plants are installed in irrigations areas and canal and also the tests done on the power plants and find out the efficiency of these micro hydro power plant . Some of the components play a major role in these micro hydro power plant .they are as shown in the below**[36]**.

Fig 8 :Micro Hydro Power Generation System

1.5.1 Water Turbine:

The designed diameter and width of the water wheel are 4.5 m and 0.6 m, respectively. The hollow mechanical shaft Located at the centre of the water turbine has the diameter of 13 cm. The 16 blades (integer times of 4) and the shaft of the Water turbine are made of black iron to effectively withstand large impact stresses from the flowing irrigation water.

1.5.2 Gearbox : The gearbox has a specially designed transformation ratio to increase the water turbine's low rotational speed of around 10-20 rpm to the required self-excitation rotational speed of the two SEIGs around 1300 rpm. Several gears with proper Mechanical strength inside the gearbox are fully lubricated to Maintain .[1]has a well-designed spillway whose Entrance point is in front of the cross regulator. Its function is to flow excessive water in the ditch when the irrigation water Level is higher than the specified civil-construction limit that the ditch can withstand.

1.5.3 Blades of Water Turbine: There are total 16 adjustable-angle blades on the outer Edge of the water turbine. The angle of these blades can be Simultaneously controlled by an external motor located on the Mechanical shaft of the water turbine to change the Mechanical force of the flowing water applied on the blades. Its function is similar to the pitch angle control system of Modern wind turbines.

1.5.4 Micro hydro power plant ageing

Hydropower has the ability to generate electricity without emitting greenhouse gasses. However, it can also cause environmental and social threats, such as damaged wildlife habitat, harmed water quality, obstructed fish migration, and diminished recreational benefits of rivers. Micro hydro power plant is the seasonal way to generate the power the age of the micro hydro power plant is around 10-20 years .mean will the damages may be repeat by the large flow it may be damage the parts of the micro hydro power plant[37] .

2.Conclusion

From an operational perspective, hydropower is significant since it doesn't require the "ramp-up" time that many combustion technologies do. To adapt to changing demand, hydropower can quickly raise or decrease the quantity of power it is sending to the system. Hydropower contributes significantly to guaranteeing dependable electrical supply and to meeting customer expectations in a market-driven industry thanks to its strong load-following capability, peaking capacity, and voltage stability qualities. Additionally, the only significant technique to store electricity currently accessible is in hydroelectric pumped storage plants. In addition to being emissions-free and renewable, hydropower also provides the aforementioned operational advantages that add value to the electric system through increased efficiency, security, and reliability. Our nation's effort to deregulate the electric business depends critically on the electric benefits supplied by hydroelectric resources. Hydropower uses one of our most precious resources, water, yet it is a renewable resource. As an expert in controlling hydropower at the national level. By enhancing hydropower projects and operating them more efficiently, Reclamation assists the Nation in meeting its present and future energy needs in a way that safeguards the environment.

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