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Design Of Hydro Electric Powerplant.

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Abstract: *The Lonavala Shrivata Dam is set to create a hydroelectric power plant that will generate 1800 kW of clean, renewable energy. The design incorporates advanced engineering to optimize performance, reliability, and sustainability. The penstock, designed for optimal water flow and pressure delivery, is optimized using precision-engineered materials and Computational Fluid Dynamics (CFD) simulations. The Pelton turbine, chosen for its high-head, low-flow efficiency, is customized to suit the dam's hydrological profile. Key turbine specifications, such as jet diameter, number of buckets, and rotational speed, are calibrated to achieve the target generation capacity of 1800 kW. Environmental and economic considerations are prioritized, with minimal disruption to the aquatic ecosystem and cost-efficient materials and construction techniques. The power plant is expected to meet the region's growing electricity demands, reducing dependency on fossil fuels and contributing to India's clean energy initiatives. The project showcases the potential of small-scale hydroelectric plants in leveraging natural resources for sustainable energy solutions.*

Keywords – *Hydroelectric powerplant, optimal water flow, clean energy, Computational Fluid Dynamics (CFD).*

I. INTRODUCTION

. Hydroelectric power is a renewable energy source that converts the potential energy of falling or fast-flowing water into mechanical energy. In the early 21st century, it accounted for over 18% of the world's total power generation capacity. Water is collected or stored at a higher elevation and led downward through pipes or tunnels (penstocks) to a lower elevation, known as the head. The falling water causes turbines to rotate, which drive generators to convert the turbines' mechanical energy into electricity. Transformers convert the alternating voltage suitable for generators to a higher voltage suitable for long-distance transmission. The structure that houses the turbines and generators is called the powerhouse. Hydroelectric power plants are typically located in dams that impound rivers, raising the water level behind the dam and creating a high head.

Fig no. 1.1 Gravity dam

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II. LITERATURE REVIEW

1. General:

The global energy crisis is affecting agricultural countries, leading to the development of sustainable energy sources like hydropower, geothermal energy, biomass, and wind energy. Water resources, such as waterways and tides, can also be harnessed for energy using hydro power or mechanical operations. Hydro power plans can be limited or large, depending on local conditions and energy demand. Running water, a universally accessible and inexhaustible resource, can be harnessed to create power, providing a sustainable energy source that can improve livelihoods and increase working profitability. Developing or rural regions can benefit from limited-scale hydro power, providing a locally accessible, reliable energy source where no other energy age is achievable.

1. Review of Journal Papers:

1.1. Mohibullah Mohd, Amran Mohd, Radzi Mohd and Iqbal Abdul Hakim, Basic Design Aspects of Micro Hydro Power plant and its Potential development in Malaysia (2004) - This paper explores the potential of micro hydro power in Malaysia, focusing on the design of a 50-kW power plant and its programming using MATLAB software.

1.2. Ravi Kiran Karre, Kasangottu Srinivas, Khaja Mannan, et al, A review on hydro power plants and turbines (2024) - This article discusses hydro power plants and turbines, highlighting their significant environmental and commercial significance. It provides a general depiction of turbine structures, parts, and execution, providing a standard for suitable hydropower structures and turbines for various hydropower projects.

1.3. Kanchan A Patil, S.Y M. Arch (second year) M.G.M.S Jawaharlal Nehru Engineering College, Aurangabad, Maharashtra, India, Electricity Generation from Micro Hydro Power Plant at MGM Gandheli Campus, Aurangabad (2019) – A micro hydro power plant is planned for MGM Gandheli campus in Aurangabad, Maharashtra, with significant potential for electricity generation. The site is selected using Remote Sensing and GIS methods, and the plant is technically and economically feasible, meeting energy demand and reducing CO_2 emissions by replacing diesel backup.

1.4. David tsuanyol , Boris Amougoul, Abdoul Aziz, Bernadette Nka Nnomo, Davide Fioriti and Joseph Kenfack, Design models for small run-of-river hydropower plants: a review (2023) - This paper reviews models for techno-economic design of run-of-river hydropower plants, discussing technical modeling of penstock diameter, turbine selection, energy production system estimation, and project cost estimation. Test modeling approaches aid in technical, economical, and financial feasibility studies, with limitations and validity clarified for future technology and market conditions.

1.5. Askari Mohammad Bagherl, Mirzaei Vahid, Mirhabibi Mohsen, Dehghani Parvin Department of Physics, Payame Noor University, Tehran, Iran Faculty of Physics, Shahid Bahonar University, Kerman, Iran, Hydroelectric Energy Advantages and Disadvantages (2015) - Meeting growing electricity demands presents challenges for countries, especially in the context of climate change. Hydropower, a mature technology with low greenhouse gas emissions, is a renewable and premium energy source. However, its development has been controversial due to social and environmental concerns.

1.6. Vineet Kumar Singh, S.K. Singal, Operation of hydro power plants-a review (2017) - The study reviews previous research on reservoir-based and river hydro power plant operations, identifying parameters like head, discharge, turbine, and generator, and focusing on optimization techniques and environmental impact.

1.7. Sahazati Md Rozali, Rozilawati mohd nor, Norfariza Ab Wahab, Aliza Che Amaran, Saleha Mohamad Saleh, Muhammad Nizam Kamarudin (2022) - Electric potential energy is used to generate electricity, but fossil fuels and natural gas are facing extinction. A small electrical generator model is proposed using water flow pressure in hydroelectric stations. This model integrates a microcontroller with an external passage to reduce environmental impact. The turbine, designed using polyvinyl chloride (PVC) with a 10 cm radius, produces higher voltage at 5.8 V compared to other materials and radius

1.8. Samanar Khan Afridi, Abdul Satter Sand, Abdul Rafay Khatri, Mohsin Ali Koondhar, Wonsuk Ko, Sisam Park, Hyeong-Jin Choi, Waqas Ahmed (2023) - The research aims to address energy scarcity in remote areas by developing an automatic and floating hydro power plant. The project integrates a Pico hydro turbine, generator, and control system, with IoT technology for real-time monitoring. The project offers a reliable, eco-friendly power source for off-grid communities, extending access to electricity. The project's adaptability and potential to alleviate energy deficits in under-served areas make it a beacon of ingenuity and progress in renewable energy.

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III. MATERIALS AND METHODOLOGY

1. Materials:

1.1. penstock:

A penstock is a high-pressure pipe used in hydroelectric power plants to transport water from reservoirs to turbines for electricity generation. It controls water flow, harnessing energy stored in water. Penstocks, made from durable materials like steel or fiberglass, have valves and gates to regulate water flow and protect against wear and corrosion.

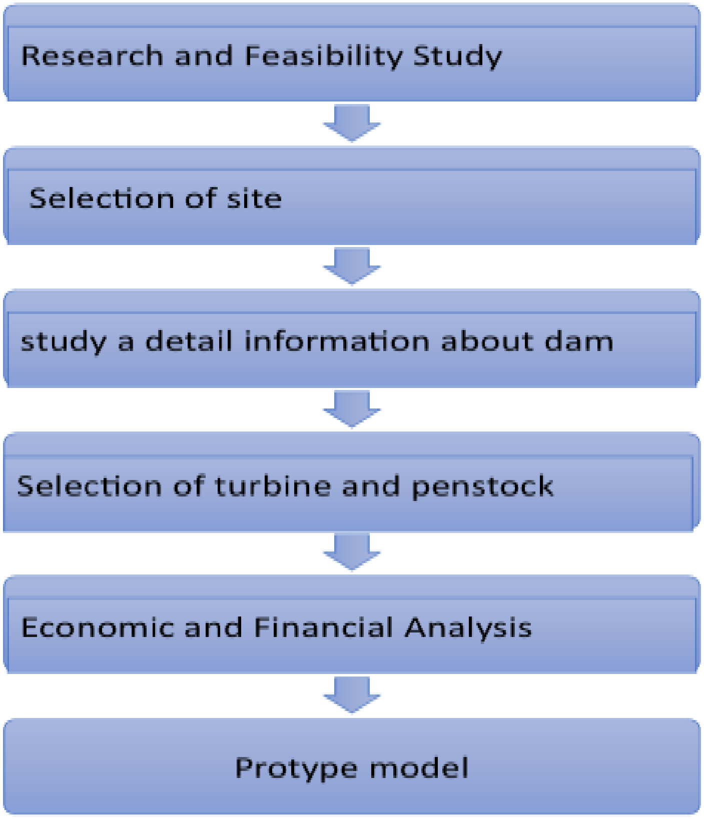
1.2. Pelton wheel:

The Pelton wheel is a type of impulse water turbine used in hydroelectric power plants to generate electricity. It is particularly effective in high-head, low-flow conditions where water is directed with significant pressure and speed. The wheel consists of spoon-shaped buckets or cups that capture and redirect water flow, converting kinetic energy into mechanical energy.

3.1.3 generator:

A hydroelectric power plant generator converts water flow into electrical energy. It consists of a rotor and a stator, which spin to create a rotating magnetic field. This generates AC electricity, which is then transmitted via a transformer. Hydroelectric generators are durable, efficient, and can be adjusted to respond to varying water flow and electricity demand, making them a crucial part of renewable energy infrastructure worldwide.

2. Methodology:



2.3 Study about dam

SR. NO	**DISCRIPTION**	**VALUE**
1	Type Of Dam	Gravity Dam
2	Height Of The Dam	38.71 M
3	Area Of Dam	28.47 Sq.Km
4	Total Capacity	1800 Mw
5	Storage Capacity	10800 MWH
6	Type Of Embankment	Gravity Dam Facing In Crushed Rubble Masonry & Hearting In Random Rubble.
7	Dam volume	460 Km^3
8	Length Of The Concrete Dam	178.40 M
9	Type Of Soil	Clay, Clay Loamy And Sandy Loam

2.2 Dimension of penstock

	PENSTOCK	
1	Type	Steel Lined
2	No Of Penstock	6 Nos
3	Diameter Of Penstock	4.80m Each
4	Length Of The Penstock	1126.06m
5	Design Discharge Of Each Penstock	112.06 Cumec

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2.3 turbine design

	TURBINE	
1	Type	Francis Turbine
2	No Of Turbine	6 Nos
3	Head Of Turbine	301.13 M Each
4	Discharge Of Turbine	112.06 cumec
5	Turbine Efficiency	92%
6	Rotation Speed	250 Rpm

2.3.1 Result Caluculation of turbine

SR . NO.	**PARAMETER**	**VALUE**
1	Hydraulic Power (pH)	331.03 MW
2	Shaft power (Ps)	304.55 MW
3	Specific Speed (Ns)	2.11
4	Runner diameter (D)	4.11 m
5	Peripheral velocity (U)	57.46 m/s
6	Flow velocity (Vf)	61.24 m/s
7	Whirl velocity at inlet (Vw1)	51.4 m/s
8	Absolute Velocity at inlet (V1)	79.94 m/s
9	Inlet Flow angle (α1)	50.7◦
10	Outlet blade angle (ß2)	46.5◦
11	Blade inlet angle (ß1)	80.6◦
12	Guide Vane angle (θ)	50.7◦
13	Number of runner blade (Zr)	23 os

2.4 Design of generator

- Generator Specifications (Synchronous Generator)

Parameter	Value
Power Output	304.55 MW (after efficiency loss)
Efficiency	92%
Voltage	15 kV
Current	~13,000 A
Frequency	50 Hz
Speed	250 RPM
Number of Poles	24
Power Factor	0.9
Excitation	Brushless or Static
Cooling System	Hydrogen and Water Cooling

IV. CONCLUSION

Designing a hydroelectric power plant involves careful planning to ensure efficient energy production while minimizing environmental impact. Key factors include site selection, water flow analysis, and the integration of turbines and generators for optimal performance. Environmental concerns, such as preserving ecosystems and addressing community needs, must be considered to reduce disruption. Proper design also tackles issues like sedimentation and fish migration. Hydroelectric plants, when thoughtfully constructed, provide a reliable and renewable energy source, lowering reliance on fossil fuels and contributing to climate change mitigation. This balance of efficiency and sustainability makes them a crucial component of global energy solutions.

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