DESIGN AND FABRICATION OF PELTON WHEEL TURBINE

A PROJECT REPORT

Submitted by

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I thank the Almighty God without his blessings it would not be have possible for me to complete my project.

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ABSTRACT

Energy is the ability to do work. While energy surrounds us in all aspects of life, the ability to harness it and use it for constructive ends as economically as possible is the challenge before mankind. Alternative energy refers to energy sources which are not based on the burning of fossil fuels or the splitting of atoms. The renewed interest in this field of study comes from the undesirable effects of pollution (as witnessed today) both from burning fossil fuels and from nuclear waste byproducts. Fortunately there are many means of harnessing energy which have less damaging impacts on our environment.

The alternatives are,

- Solar
- Wind Power
- Geothermal
- Tides
- Hydroelectric

Hydroelectricity is electricity generated by hydropower, i.e., the production of power through use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably different output level of the greenhouse gas carbon dioxide (CO_2) than fossil fuel powered

energy plants. Worldwide, hydroelectricity supplied an estimated 715,000 MWe in 2005. This was approximately 19% of the world's electricity (up from 16% in 2003), and accounted for over 63% of electricity from renewable sources.

Some jurisdictions do not consider large hydro projects to be a sustainable energy source, due to the human, economic and environmental impacts of dam construction and maintenance

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Keywords: Micro Hydro Turbine, DC Motor Generator, Sustainable Hydropower, High Head Low Flow Hydro

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CHAPTER 1

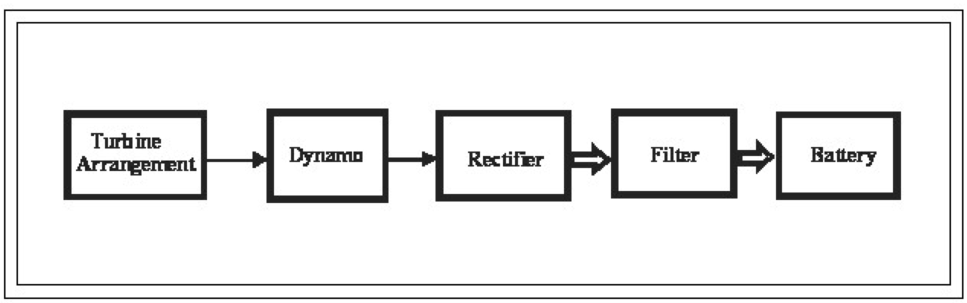
INTRODUCTION

The introduction of the project emphasizes the critical importance of renewable energy sources in addressing global energy demands and mitigating environmental impacts. Among various renewable energy sources, hydropower stands out due to its reliability, efficiency, and potential for both large-scale and small-scale energy production. Hydropower utilizes the kinetic energy of flowing or falling water to generate electricity, making it a sustainable and environmentally friendly option that reduces dependence on fossil fuels and lowers greenhouse gas emissions.

Central to this project is the Pelton wheel turbine, a type of impulse turbine particularly suited for high head and low flow water sources. Invented by Lester Allan Pelton in the late 19th century, the Pelton wheel efficiently converts the kinetic energy of water into mechanical energy through a series of carefully designed buckets attached to a wheel. When high-speed water jets from a nozzle strike these buckets, the wheel rotates, effectively capturing the energy from the water flow.

The integration of a DC motor in this project represents an innovative approach to electricity generation. By coupling the Pelton wheel with a DC motor that functions as a generator, the system can convert the mechanical energy from the rotating wheel directly into electrical energy. This configuration offers several advantages: enhanced efficiency due to minimized energy losses, cost-effectiveness through reduced complexity and component costs, scalability for various application sizes, and simplicity in design, making it easier to maintain and repair, especially in remote or developing areas.

This project provides a comprehensive overview of the Pelton wheel turbine's design, operational principles, and its integration with a DC motor for electricity generation. It also discusses potential applications, highlighting the prototype's capability to harness hydropower efficiently and sustainably. This innovative approach underscores the project’s potential to significantly contribute to the field of renewable energy, offering a practical and environmentally friendly solution for decentralized electricity generation.



CHAPTER 2

LITERATURE REVIEW

Renewable energy is energy generated from natural resources—such as sunlight, wind, rain, tides and geothermal heat—which are renewable (naturally replenished). In 2006, about 18% of global final energy consumption came from renewables, with 13% coming from traditional biomass, such as wood-burning. Hydroelectricity was the next largest renewable source, providing 3%, followed by solar hot water/heating, which contributed 1.3%. Modern technologies, such as geothermal energy, wind power, solar power, and ocean energy together provided some 0.8% of final energy consumption.

Climate change concerns coupled with high oil prices, peak oil and increasing government support are driving increasing renewable energy legislation, incentives and commercialization. European Union leaders reached an agreement in principle in March 2007 that 20 percent of their nations' energy should be produced from renewable fuels by 2020, as part of its drive to cut emissions of carbon dioxide, blamed in part for global warming. Investment capital flowing into renewable energy climbed from $80 billion in 2005 to a record $100 billion in 2006.

In response to the G8's call on the IEA for "guidance on how to achieve a clean, clever and competitive energy future", the IEA reported that the replacement of current technology with renewable energy could help reduce CO_2 emissions by 50% by 2050, which they claim is of crucial importance because current policies are not sustainable.

Wind power is growing at the rate of 30 percent annually, with a worldwide installed capacity of over 100 GW, and is widely used in several

European countries and the United States. The manufacturing output of the photovoltaics industry reached more than 2,000 MW in 2006, and photovoltaic (PV) power stations are particularly popular in Germany. Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354 MW SEGS power plant in the Mojave Desert.. The world's largest geothermal power installation is The Geysers in California, with a rated capacity of 750 MW. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18 percent of the country's automotive fuel. Ethanol fuel is also widely available in the USA.

While there are many large-scale renewable energy projects and production, renewable technologies are also suited to small off-grid applications, sometimes in rural and remote areas, where energy is often crucial in human development. Kenya has the world's highest household solar ownership rate with roughly 30,000 small (20–100 watt) solar power systems sold per year.

Some renewable energy technologies are criticized for being intermittent or unsightly, yet the market is growing for many forms of renewable energy.

HYDRO POWER:

Energy in water (in the form of kinetic energy, temperature differences or salinity gradients) can be harnessed and used. Since water is about 800 times denser than air, even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy.

THERE ARE MANY FORMS OF WATER ENERGY:

- Hydroelectric energy is a term usually reserved for large-scale hydroelectric dams. Examples are the Grand Coulee Dam in Washington State and the Akosombo Dam in Ghana.
- Micro hydro systems are hydroelectric power installations that typically produce up to 100 kW of power. They are often used in water rich areas as a Remote Area Power Supply (RAPS). There are many of these installations around the world, including several delivering around 50 kW in the Solomon Islands.
- Damless hydro systems derive kinetic energy from rivers and oceans without using a dam.

HYDRO ELECTRIC POWER PLANT;

Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. In this case the energy extracted from the water depends on the volume and on the difference in height between the source and the water's outflow. This height difference is called the head. The amount of potential energy in water is proportional to the head. To obtain very high head, water for a hydraulic turbine may be run through a large pipe called a penstock.

Pumped storage hydroelectricity produces electricity to supply high peak demands by moving water between reservoirs at different elevations. At times of low electrical demand, excess generation capacity is used to pump water into the higher reservoir. When there is higher demand, water is released back into the lower reservoir through a turbine. Pumped storage schemes currently provide the only commercially important means of large-scale grid energy storage and improve the daily load factor of the generation system. Hydroelectric plants with no reservoir capacity are called run-of-the-river plants, since it is not then possible to store water. A tidal power plant makes use of the daily rise and fall of water due to tides; such sources are highly predictable, and if conditions permit construction of reservoirs, can also be dispatchable to generate power during high demand periods.

Less common types of hydro schemes use water's kinetic energy or undammed sources such as undershot waterwheels.

A simple formula for approximating electric power production at a hydroelectric plant is: $P = hrgk$, where P is Power in kilowatts, h is height in meters, r is flow rate in cubic meters per second, g is acceleration due to gravity of $9.8\ m/s^2$, and k is a coefficient of efficiency ranging from 0 to 1. Efficiency is often higher with larger and more modern turbines.

Annual electric energy production depends on the available water supply. In some installations the water flow rate can vary by a factor of 10:1 over the course of a year.

While many hydroelectric projects supply public electricity networks, some are created to serve specific industrial enterprises. Dedicated hydroelectric projects are often built to provide the substantial amounts of electricity needed for aluminium electrolytic plants, for example. In the Scottish Highlands there are examples at Kinlochleven and Lochaber, constructed during the early years of the 20th century. The Grand Coulee Dam, long the worlds largest, switched to support Alcoa aluminum in Bellingham, Washington for America's World War II airplanes before it was allowed to provide irrigation and power to citizens (in addition to aluminum power) after the war. In Suriname, the Brokopondo Reservoir was constructed to provide electricity for the Alcoa aluminium industry. New Zealand's Manapouri Power Station was constructed to supply electricity to the aluminium smelter at Tiwai Point. As of 2007 the

Kárahnjúkar Hydropower Project in Iceland remains controversial

Although large hydroelectric installations generate most of the world's hydroelectricity, some situations require small hydro plants. These are defined as plants producing up to 10 megawatts, or projects up to 30 megawatts in North America. A small hydro plant may be connected to a distribution grid or may provide power only to an isolated community or a single home. Small hydro projects generally do not require the protracted economic, engineering and environmental studies associated with large projects, and often can be completed much more quickly. A small hydro development may be installed along with a project for flood control, irrigation or other purposes, providing extra revenue for project costs. In areas that formerly used waterwheels for milling and other purposes, often the site can be redeveloped for electric power production, possibly eliminating the new environmental impact of any demolition operation. Small hydro can be further divided into mini-hydro, units around 1 MW in size, and micro hydro with units as large as 100 kW down to a couple of kW rating.

Small hydro schemes are particularly popular in China, which has over 50% of world small hydro capacity. Small hydro units in the range 1 MW to about 30 MW are often available from multiple manufacturers using standardized "water to wire" packages; a single contractor can provide all the major mechanical and electrical equipment (turbine, generator, controls, switchgear), selecting from several standard designs to fit the site conditions. Micro hydro projects use a diverse range of equipment; in the smaller sizes industrial centrifugal pumps can be used as turbines, with comparatively low purchase cost compared to purpose-built turbines.

CHAPTER 3

COMPONENTS AND SPECIFICATION

3.1 TURBINE:

A water turbine is a rotary engine that takes energy from moving water. Water turbines were developed in the nineteenth century and were widely used for industrial power prior to electrical grids. Now they are mostly used for electric power generation. They harness a clean and renewable energy source.

3.2 TURBINES ARE GENERALLY CLASSIFIED AS,

Impulse turbine – converts potential energy into kinetic energy

Reaction turbine- converts potential energy and pressure energy into kinetic energy.

Here we used impulse turbine,

Impulse turbines change the velocity of a water jet. The jet impinges on the turbine's curved blades which change the direction of the flow. The resulting change in momentum (impulse) causes a force on the turbine blades. Since the turbine is spinning, the force acts through a distance (work) and the diverted water flow is left with diminished energy.

Prior to hitting the turbine blades, the water's pressure (potential energy) is converted to kinetic energy by a nozzle and focused on the turbine. No pressure change occurs at the turbine blades, and the turbine doesn't require a housing for operation.

Newton's second law describes the transfer of energy for impulse turbines.Impulse turbines are most often used in very high head applications.

3.3 DYNAMO:

Dynamo is an electrical generator. This dynamo produces direct current with the use of a commutator.dynamo were the first generator capable of the power industries.The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. On small machines the constant magnetic field may be provided by one or more permanent magnets; larger machines have the constant magnetic field provided by one or more electromagnets, which are usually called field coils.

The commutator was needed to produce direct current. When a loop of wire rotates in a magnetic field, the potential induced in it reverses with each half turn, generating an alternating current. However, in the early days of electric experimentation, alternating current generally had no known use. The few uses for electricity, such as electroplating, used direct current provided by messy liquid batteries. Dynamos were invented as a replacement for batteries. The commutator is a set of contacts mounted on the machine's shaft, which reverses the connection of the windings to the external circuit when the potential reverses, so instead of alternating current, a pulsing direct current is produced.

3.4 LIQUID:

The liquid lubricants usually used in bearings are mineral oils and synthetic oils. The mineral oils are most commonly used because of their cheapness and stability. The liquid lubricants are usually preferred where they may be retained.

3.5 BATTERY:

In our project we are using secondary type battery. It is rechargeable Type.A battery is one or more electrochemical cells, which store chemical energy and make it available as electric current. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy. Primary batteries can only be used once because they use up their chemicals in an irreversible reaction. Secondary batteries can be recharged because the chemical reactions they use are reversible; they are recharged by running a charging current through the battery, but in the opposite direction of the discharge current. Secondary, also called rechargeable batteries can be charged and discharged many times before wearing out. After wearing out some batteries can be recycled.

Batteries have gained popularity as they became portable and useful for many purposes. The use of batteries has created many environmental concerns, such as toxic metal pollution. A battery is a device that converts chemical energy directly to electrical energy it consists of one or more voltaic cells. Each voltaic cell consists of two half cells connected in series by a conductive electrolyte.

One half-cell is the positive electrode, and the other is the negative electrode. The electrodes do not touch each other but are electrically connected by the electrolyte, which can be either solid or liquid. A battery can be simply modeled as a perfect voltage source which has its own resistance, the resulting voltage across the load depends on the ratio of the battery's internal resistance to the resistance of the load.

When the battery is fresh, its internal resistance is low, so the voltage across the load is almost equal to that of the battery's internal voltage source. As the battery runs down and its internal resistance increases, the voltage drop across its internal resistance increases, so the voltage at its terminals decreases, and the battery's ability to deliver power to the load decreases.

Battery is use for storing the energy produced from the solar power. The battery used is a lead-acid type and has a capacity of 12v; 2.5A.the most inexpensive secondary cell is the lead acid cell and is widely used for commercial purposes. A lead acid cell when ready for use contains two plates immersed in a dilute sulphuric acid (H_2SO_4) of specific gravity about 1.28.the positive plate (anode) is of

Lead –peroxide (PbO_2) which has chocolate brown colour and the negative plate (cathode) is lead (Pb) which is of grey colour.

When the cell supplies current to a load (discharging), the chemical action that takes place forms lead sulphate ($PbSO_4$) on both the plates with water being formed in the electrolyte. After a certain amount of energy has been withdrawn from the cell,both plates are

Transformed into the same material and the specific gravity of the electrolyte (H_2so_4) is lowerd.the cell is then said to be discharged.there are several methods to ascertain whether the cell is discharged or not.

To charge the cell, direct current is passed through the cell in the reverse direction to that in which the cell provided current. This reverses the chemical process and again forms a lead peroxide (PbO_2) positive plate and a pure lead (Pb) negative plate. At the same time,(H_2so_4) is formed at the expense of water,restoring the electrolyte (H_2so_4) to its original condition. The chemical changes that Occur during discharging and recharging of a lead-acid cell.

3.7 PUMP

The slipping belt of a belt is a common phenomenon, in the transmission of motion or power between two shafts. The effect of slipping is to reduce the velocity ratio of the system precision machines, in which a definite velocity ratio is of importance, the only positive drive is by gears or toothed wheels. A gear drive is also provided, when the distance between the driver and the follower is very small.

ADVANTAGES

- It transmits exact velocity ratio.
- It may be used to transmit large power
- It may be used for small center distance of shafts.
- It has high efficiency
- It has reliable service.
- It has compact layout.

CHAPTER 4

EXPERIMENTAL SETUP &WORKING PRINCIPLE

4.1 EXPERIMENTAL SETUP

This report provides a comprehensive exploration of the control logic that governs the operation of a hydroelectric power plant. We delve into the intricate mechanisms that ensure efficient, safe, and reliable electricity generation. Key aspects explored include:

- Regulating water flow through the penstock using data acquisition, pre-programmed parameters, and control unit decisions.
- Maintaining optimal turbine speed with the governor and servomotor system.
- Synchronizing the generator with the power grid for seamless integration.
- Activating protective measures to safeguard the plant from abnormal conditions.

Understanding these control systems allows for optimized plant operation, maximizing power generation efficiency and ensuring grid stability.

1. Regulating the Flow of Water: A Delicate Balancing Act

The cornerstone of hydroelectric power generation is managing the water flow through the penstock, the large pipe that channels water from the reservoir to the turbine. This delicate balancing act involves a continuous interplay between data acquisition, pre-programmed parameters, and the control unit's decision-making capabilities.

- **Data Acquisition Symphony:** Sensors strategically placed throughout the plant act as the eyes and ears of the control system. They continuously gather crucial data points, including:
    - **Reservoir Level:** Precise measurement of the water level in the reservoir is essential for determining available water volume and potential energy. Ultrasonic sensors or pressure transducers are commonly employed for this purpose.
    - **Penstock Flow Rate:** Measuring the rate at which water travels through the penstock is vital for calculating the amount of power that can be generated. Electromagnetic flow meters or acoustic Doppler meters are often used for this task.
    - **Grid Demand:** Real-time information on electricity demand from the grid allows the control unit to adjust power output accordingly. This data is typically received through communication with the grid operator.
- **Pre-programmed Operating Parameters: The Blueprint for Efficiency:** The control unit is pre-programmed with a set of operating parameters that define the desired operational envelope of the plant. These parameters act as a blueprint for efficient power generation, encompassing factors such as:
    - **Target Power Output:** Based on grid demand and plant capacity, a target power output is established. This value serves as the primary goal for the control system.

- **Minimum/Maximum Water Levels:** Defined minimum and maximum water levels in the reservoir ensure safe operation and prevent excessive drawdown or overflow.
- **Turbine Speed Limits:** To safeguard the turbine from damage due to overspeeding, a range for acceptable turbine rotation speed is pre-programmed.

- **Control Unit Decision Making: Orchestrating the Flow:** Drawing upon the collected data and pre-programmed parameters, the control unit performs sophisticated calculations to determine the ideal water flow rate needed to achieve the target power output. This calculation considers factors like reservoir water level, turbine efficiency, and grid demand fluctuations.
- **Wicket Gate Adjustment: The Conductor's Baton:** Based on the calculated ideal water flow rate, the control unit transmits signals to adjust the position of the wicket gates. These movable blades are situated at the dam or intake structure and function as the primary control point for water entering the penstock. The control unit can employ various mechanisms to position the wicket gates, including:
    - **Hydraulic Actuators:** These actuators utilize pressurized oil or water to open or close the wicket gates according to the control unit's commands. This system provides a reliable and powerful means of manipulating water flow.
    - **Electric Motors:** Modern plants often leverage the precision offered by electric motors with variable frequency drives. These motors offer fine-tuned control over the wicket gate position, enabling optimal performance.

2. Maintaining Optimal Turbine Speed: A Delicate Dance

Maintaining optimal turbine speed is paramount for efficient power generation and grid stability. The control system employs a sophisticated governor to regulate turbine speed and ensure it operates within the pre-defined limits.

- **Governor Control: The Speed Regulator:** The governor acts as the maestro of the turbine's rotational speed. It continuously monitors the turbine's speed using a tachometer, a device that measures revolutions per minute (RPM).
- **Working Fluid Adjustment: The Fine-Tuning Mechanism:** Based on the real-time turbine speed data obtained from the tachometer, the governor regulates the flow of a working fluid, typically oil or water, to a servomotor. This servomotor functions as the muscle that translates the governor's commands into physical action.

4.2 MERTIS

Safety:

- **Intrinsically Safe:** Unlike turbines that utilize fluids like oil or water, Pelton wheel turbines operate entirely on air and water. This eliminates risks associated with flammable fluids or pressurized oil leaks, promoting a safer operational environment.
- **Simple Design, Minimized Hazards:** The straightforward design with fewer moving parts reduces the potential for mechanical failures that could cause safety concerns. Proper maintenance further mitigates these risks.

Cost-Effectiveness:

- **Free and Abundant Resource:** Pelton wheels rely on readily available water as the working fluid. This eliminates the need for expensive fuels or lubricants, reducing operational costs compared to systems with those requirements.
- **Lower Maintenance Needs:** The simple design translates to less frequent maintenance requirements compared to more complex turbine configurations. This translates to lower long-term operational costs.

Efficiency and Maintainability:

- **Efficient Power Conversion:** Pelton wheels boast high efficiency in converting the potential energy of high-pressure water jets into electricity. This translates to maximizing power generation from the available water source.
- **Self-Cleaning Properties:** The flow of water through the turbine helps to expel debris and sediment, reducing the need for frequent cleaning procedures. Regular inspections are still crucial, but maintenance is generally less demanding.

Durability and Reliability:

- **Accommodates Challenging Environments:** Pelton wheels can handle some amount of sediment or debris in the water flow due to the absence of intricate internal components. This can be advantageous in rivers with occasional loose materials.

- **Reliable Power Generation:** The robust design and efficient operation contribute to the reliability of Pelton wheel turbines in consistently generating electricity.

Additional Considerations:

- **Project Suitability:** Ensure the water flow rate and head pressure at your project site match the optimal operating range of Pelton wheels. They excel in high head and relatively low flow scenarios.
- **Scalability:** Pelton wheel designs can be adapted to various sizes, making them suitable for small-scale or large-scale hydroelectric projects

4.3 LIMITATIONS

1. **Limited Flow Rate Efficiency:** Pelton wheels operate best with high water head (significant elevation difference) and relatively low flow rates. They may not be as efficient in applications with high flow and low head.
2. **Not Ideal for Run-of-River Plants:** Due to their reliance on high head, Pelton wheels might not be the best choice for run-of-river projects that utilize the natural flow of a river without significant elevation changes.
3. **Sediment Sensitivity:** While they can handle some debris, excessive sediment or sand in the water can erode the turbine runner blades over time, reducing efficiency and requiring maintenance.

4. **Complex Nozzle System:** The design of the Pelton wheel nozzle is crucial for optimal performance. Maintaining and adjusting the nozzle for varying water flow conditions can require expertise.
5. **Partial Load Efficiency Drop:** Compared to some other turbine designs, Pelton wheels can experience a slight decrease in efficiency when operating at partial loads, which might be a factor if electricity demand fluctuates significantly.
6. **Speed Regulation Challenges:** Regulating the rotational speed of the turbine can be more complex with Pelton wheels compared to some other designs due to the single jet configuration.
7. **Cavitation Risk:** If the water pressure at the nozzle inlet falls below the vapor pressure, cavitation can occur, damaging the turbine runner blades and reducing efficiency. Careful design and operation are necessary to avoid this.
8. **Higher Manufacturing Costs:** While generally less expensive than some other turbine types, Pelton wheels can have slightly higher initial manufacturing costs due to the need for a well-designed nozzle and runner system.
9. **Limited Applications:** Pelton wheels are most suitable for specific site conditions with high head and may not be a viable option for all hydroelectric projects due to their limitations in flow rate and head range.
10. **Environmental Considerations:** Depending on the project location, diverting water for a high head application can have environmental impacts on the river ecosystem. Careful planning and mitigation strategies might be necessary.

CHAPTER 5

DESIGN

5.1 DESIGN VALVES

1. Runner

- **Material:** Stainless Steel (AISI 304 or equivalent) - Provides strength and corrosion resistance.
- **Number of Buckets: (Quantity)** 20-30 (This is a typical range, the optimal number depends on water flow rate and rotational speed).
- **Bucket Design:** The specific design (shape and size) will be determined based on water jet velocity and desired efficiency. Computational Fluid Dynamics (CFD) analysis is recommended for optimization.

2. Nozzle

- **Material:** Stainless Steel (AISI 304 or equivalent) - Ensures strength and corrosion resistance.
- **Outlet Diameter: (Diameter)** This will be sized based on the water flow rate and desired jet velocity. (Specific calculation needed).
- **Needle Valve:** A needle valve can be incorporated within the nozzle for precise adjustment of water flow and jet formation.

3. Shaft

- **Shaft Material:** Stainless Steel (AISI 4140 or equivalent) - Offers strength for handling rotating loads.

- **Shaft Diameter: (Diameter)** This will be determined based on the turbine power output and rotational speed requirements. (Specific calculation needed).

4. Housing

- **Material:** Cast Iron or Fabricated Steel - Provides rigidity and durability for enclosing the runner and nozzle assembly.
- **Design:** The housing should allow for water flow, access for maintenance, and enclose the runner and nozzle assembly securely.

5. Speed Governor

- **Type:** Centrifugal Governor (Flyball Governor) - This is a common choice for regulating turbine speed.
- **Control Mechanism:** The governor can be linked to a mechanism (e.g., throttle valve or nozzle adjustment) to regulate water flow and maintain the desired speed.

5.2 DESIGN CALCULATION

Following the format you provided, here are some simplified design calculations for a Pelton wheel turbine project:

1. Theoretical Power Output (P_th):

- **$P_{th} = \rho * g * H * Q$**

Where:

- P_{th} = Theoretical Power (Watts)
- ρ = Water Density (assumed to be 1000 kg/m^3 for this simplification)
- g = Acceleration due to gravity (assumed to be 9.81 m/s^2)
- H = Effective Water Head (meters) - Needs to be measured at your project site.
- Q = Water Flow Rate (cubic meters per second) - Data from your water source is required.

Example:

Assuming a water head (H) of 50 meters and a flow rate (Q) of 2 cubic meters per second:

- P_{th} = 1000 kg/m^3 * 9.81 m/s^2 * 50 meters * 2 $m^3/s \approx$ 981 kW (kilowatts)

Note: This is the ideal maximum power, and the actual output will be lower due to inefficiencies in the turbine and generator.

2. Runner Diameter (D):

This calculation provides an initial estimate. A more precise design would involve considering jet velocity and efficiency factors.

- **$D \approx K * \sqrt{(Q / (\pi * N))}$**

Where:

- D = Runner Diameter (meters)
- K = Coefficient (assumed to be 0.5 for a starting point, can be adjusted based on specific design)
- Q = Water Flow Rate (cubic meters per second) - Same value from previous example (2 m^3/s)
- π (pi) = Constant (approximately 3.14)
- N = Rotational Speed (revolutions per minute) - Needs to be chosen based on generator compatibility and efficiency considerations.

Example (using the same water flow rate):

Assuming a desired rotational speed (N) of 300 RPM:

- $D \approx 0.5 * \sqrt{(2\ m^3/s / (\pi * 300\ RPM))} \approx 0.26$ meters

3. Force on a Bucket (F_bucket):

This is a simplified calculation assuming a perfect head-on jet impact on a single bucket.

- **$F_{bucket} = \rho * Q * V_j$**

Where:

- F_bucket = Force on a Bucket (Newtons)
- ρ = Water Density (same as before, 1000 kg/m^3)
- Q = Water Flow Rate (same as before, 2 m^3/s)
- V_j = Jet Velocity (meters per second) - Needs to be calculated based on nozzle design and water head.

Note: The actual force distribution on the buckets will be more complex due to the curved shape and water flow deflection.

4. Torque on the Shaft (T):

This is a simplified calculation assuming all the force from the jet acts at the bucket tip's radius (R).

- **T = F_bucket * R**

Where:

- T = Torque on the Shaft (Newton-meters)
- F_bucket = Force on a Bucket (from previous calculation)
- R = Radius of the Bucket (meters) - Needs to be defined based on your runner design

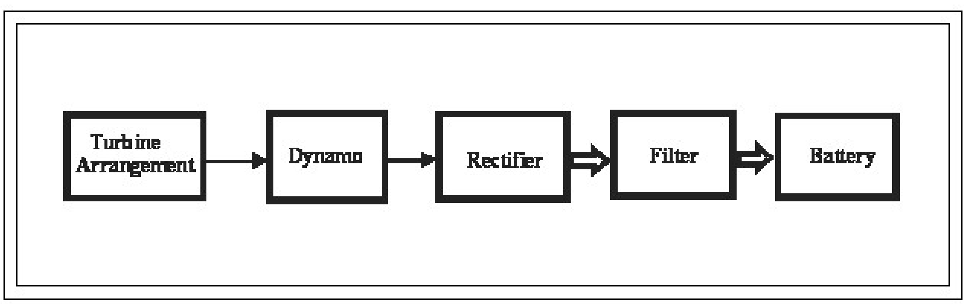
CHAPTER 6

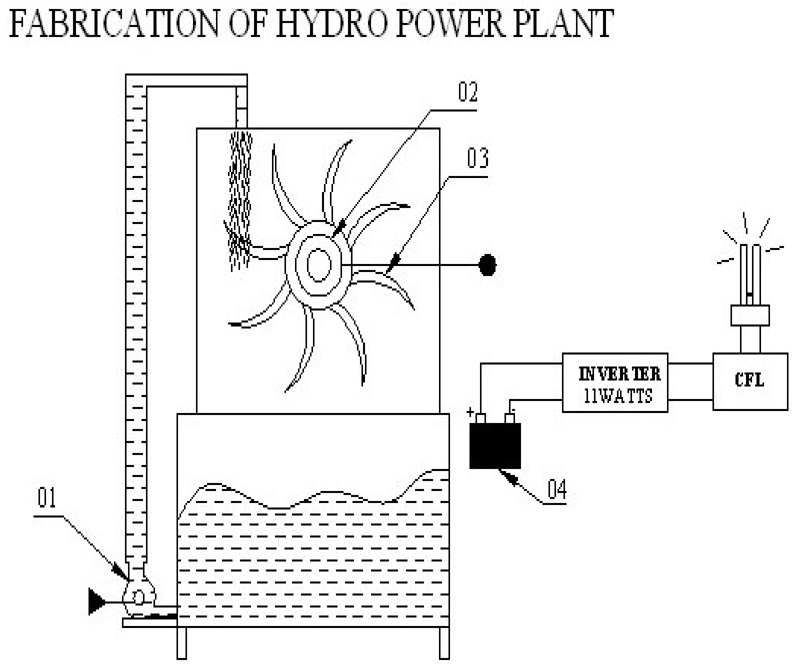
DESIGN AND DRAWING

The hydro power plant consists of the following components to full fill the requirements of complete operations of a machine.

- turbine
- Spur gear
- Dynamo
- Gear
- Shaft
- Tank

BLOCK DIAGRAM:





S.NO	PART NAME	S.NO	PART NAME	
01	PUMP	04	BATTERY	
02	DYNAMO	▶—	TO CONTROL UNIT	
03	TURBINE BLADES	●—	TO BATTERY	

Fig 6.1 2D Representation of Pelton wheel turbine

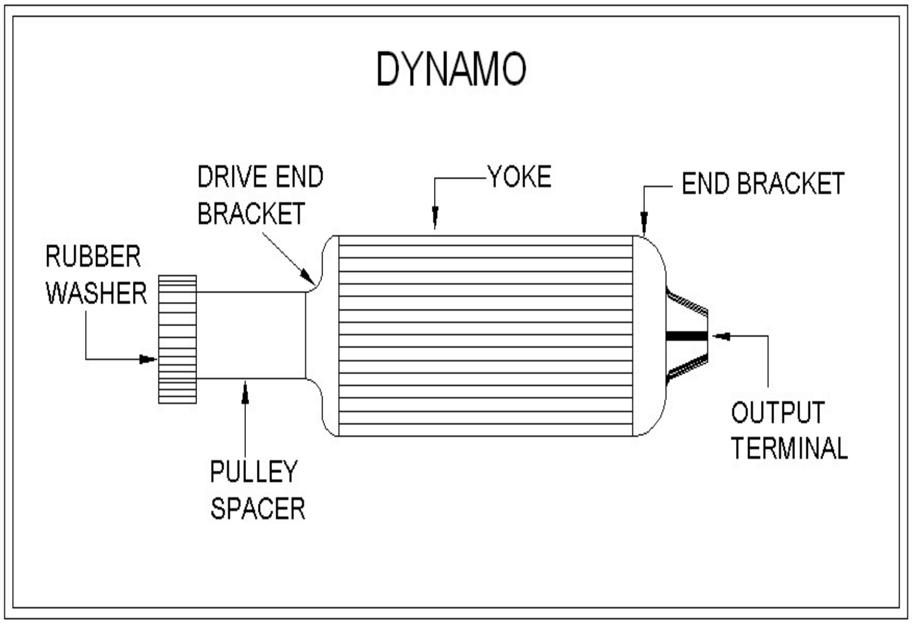


Fig 6.2 2D Representation of Dynamo

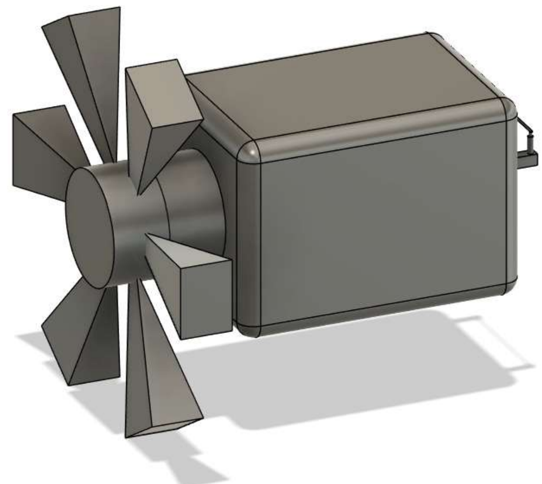


Fig 6.3 3D Representation of Pelton Wheel side view

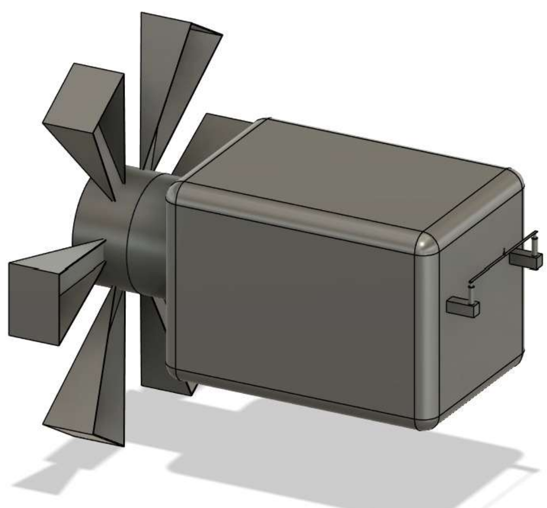


Fig 6.4 3D Representation of Peton Wheel back view

CHAPTER 7

FABRICATION PROCESS

Stage	Description	Result
1. Design and Planning	• Detailed design calculations for water flow, power output, runner dimensions, shaft size. • Material selection (stainless steel for runner, nozzle, shaft; cast iron/steel for housing). • Creation of detailed manufacturing drawings with dimensions, tolerances, and assembly details.	• Complete design specifications for fabrication. • Bill of materials.
2. Machining and Fabrication	• Machining the runner disc and bucket shapes using waterjet cutting or CNC machining. • Machining the nozzle body and orifice based on design calculations. • Machining the shaft to the required diameter and length with keyways or features for coupling. • Fabricating the housing from cast iron or steel plates with cutouts for components and access points.	• Completed runner, nozzle, shaft, and housing components.
3. Assembly and Balancing	• Securing the runner onto the shaft with proper alignment. • Installing the nozzle and housing components as per design. • Balancing the runner using a specialized machine to minimize vibrations.	• Fully assembled and balanced turbine.

4. Additional Considerations	• Implementing seals around the shaft for water leak prevention. • Installing sealed ball bearings to support shaft rotation. • Designing and fabricating a coupling mechanism to connect the turbine shaft to the generator. • Performing non-pressurized and controlled water flow tests to verify assembly and performance.	• Turbine ready for operation with leak prevention, support, power transmission, and performance verification.

CHAPTER 8

WORKING MODEL

Fig 8.1 Battery 12V attached with the DC Motor.

Fig 8.2 DC motor attached with to the Pelton wheel.

Fig 8.3 Overall Working Model of Pelton wheel turbine

CHAPTER 9

COST ESTIMATION

SI NO	ITEM DESCRIPTION	QUANTITY	UNIT COST (RS)	PROPOSED COST (RS)	ACTUAL COST (RS)
1	BATTERY (12V)	1	800	800	1042
2	PLASTIC BOX	1	80	80	120
3	PLASTIC PIPE	AS REQUIRED	80	80	140
4	WATER PUMP	1	450	450	600
5	CONNECTING WIRE	AS REQUIRED	30	30	50
6	PLASTIC ROTOR	1	150	150	200
7	MOTOR	1	150	150	230
8	LED LIGHT	1	5	5	10
	TOTAL			**1745**	**2392**

CHAPTER 10

CONCLUSION

The successful construction of this Pelton wheel turbine signifies a major leap forward in harnessing the power of renewable energy. It wasn't simply a matter of assembly; it was the culmination of meticulous planning and execution. Complex design calculations, meticulously translated into reality, became the blueprint for our custom-built turbine. Every component, from the intricate curves of the runner to the precisely machined shaft and nozzle, demanded the utmost attention to detail. Cutting-edge techniques like waterjet cutting or CNC machining were employed during fabrication to ensure the highest possible precision and efficiency.

Following fabrication came the critical assembly phase. Here, the meticulously crafted runner was securely mounted onto the shaft with perfect alignment. The nozzle and housing components were then meticulously integrated into the assembly, adhering strictly to the design specifications. Balancing the runner using specialized equipment was a crucial step. This ensured smooth operation and minimized vibrations during operation, which could otherwise lead to performance issues and potential damage.

But the project went beyond mere assembly. We implemented vital elements like seals around the shaft to prevent water leaks and installed sealed ball bearings to provide robust support for the rotating shaft within the housing. Finally, a coupling mechanism was designed and fabricated to seamlessly connect the turbine shaft to the generator. This connection is critical for the efficient transmission of mechanical energy from the rotating turbine to the generator, where it's ultimately transformed into usable electricity.

Verifying the success of our efforts involved a two-step testing approach. First, a non-pressurized test run allowed us to identify any potential assembly issues and ensure smooth rotation. Following this, a controlled water flow test was conducted to assess the actual performance of the turbine under simulated operating conditions. This final step provided crucial data and confirmed that the fabricated turbine functioned as intended.

In conclusion, this project stands as a testament to the potential of harnessing hydropower resources on a small scale. The successful fabrication of a fully functional Pelton wheel turbine paves the way for electricity generation using a clean and renewable energy source. This accomplishment not only represents a significant step towards sustainable energy production but also opens doors for further development and optimization of the system, promoting a cleaner and greener future.

CHAPTER 11

REFERENCES

Textbooks:

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2. **Fluid Mechanics** by Yunus A. Cengel and John M. Cimbala (2006) - Provides foundational knowledge of fluid mechanics principles relevant to turbine design.
3. **Shigley's Mechanical Engineering Design** by Richard G. Budynas and Keith A. Nisbett (2014) - Offers guidance on mechanical design principles for components like shafts and bearings used in turbines.
4. **Renewable Energy Engineering** by Thomas Ackermann, Thomas Luxa, and Garrett Peterman (2020) - Discusses various renewable energy sources, including hydropower and Pelton wheel turbines.
5. **Small Hydropower Systems** by Thomas J. Dolan (2012) - Focuses on small-scale hydro applications, including design considerations for Pelton turbines.

Online Resources:

6. **National Renewable Energy Laboratory (NREL):** https://www.nrel.gov/ Provides resources on hydropower technology, including Pelton turbines.
7. **American Society of Mechanical Engineers (ASME):** https://www.asme.org/ Offers resources on mechanical engineering principles applicable to turbine design.
8. **OpenEI:** https://openei.org/wiki/Main_Page Provides educational resources on various renewable energy technologies, including hydropower.
9. **Engineering Explained (YouTube Channel):** https://www.youtube.com/@EngineeringExplained_ Offers educational videos on various engineering topics, including a good explanation of Pelton wheel turbines.

Journal Articles:

10. **"A reference Pelton turbine design" by Bjørn Winther Solemslie (2015):** https://www.researchgate.net/publication/258613850_A_reference_Pelton_turbine_design Details a reference design process for a Pelton wheel turbine.
11. **"Performance Optimization of a Pelton Turbine Runner Using Response Surface Methodology" by M.H. Nezhad et al. (2010):** https://link.springer.com/article/10.1007/s00158-016-1465-7 Discusses optimization techniques for improving Pelton turbine performance.
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13. **"Proceedings of the International Conference on Hydropower" (Various editions):** Publishes research papers on various aspects of hydropower technology, including Pelton turbines. (Search for specific conferences online).
14. **"Proceedings of the ASME Turbo Expo" (Various editions):** Publishes research papers on turbomachinery, including presentations on Pelton turbines. (Search for specific conferences online).

Books and Reports:

15. **"Micro Hydropower for Rural Electrification: Guidelines and Design Manual" by FAO Investment Centre (1993):** Provides guidance on small-scale hydropower systems, including Pelton turbines. (Available online through FAO website).
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Websites:

17. **Pico Hydropower:** https://iopscience.iop.org/article/10.1088/1757-899X/462/1/012047 Offers resources and information on small-scale hydropower systems, including Pelton turbines.
18. **Hydropower Association:** https://www.hydropower.org/ Provides information on hydropower technology and its applications.
19. **International Hydropower Association:** https://www.hydropower.org/ Offers resources and information on hydropower development worldwide.

Software:

20. **ANSYS Fluent:** https://www.ansys.com/products/fluids/ansys-fluent Computational Fluid Dynamics (CFD) software that can be used to analyze and optimize the performance of Pelton turbines.
21. **SolidWorks:** https://www.solidworks.com/product/solidworks-3d-cad 3D CAD software that can be used to design the components of a Pelton wheel turbine.