## DESIGN AND FABRICATION OF PELTON WHEEL TURBINE

### A PROJECT REPORT

**Submitted by**

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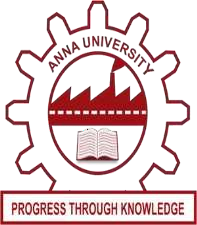
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***In partial fulfillment for the award of the degree of***

## BACHELOR OF ENGINEERING IN

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## MAY 2024

**BONAFIDE CERTIFICATE**

Certified that this report titled **DESIGN AND FABRICATION OF PELTON WHEEL TURBINE** is the bonafide work of **“SIVAMURUGAN S (8115U21ME045)”** who carried out the project work under my supervision.

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Submitted for the end semester examination held on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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## ABSTRACT

The present invention introduces a novel Pelton wheel turbine prototype that harnesses hydropower for electricity generation by utilizing a DC motor. This innovative system is comprised of several key components: the Pelton wheel itself, a nozzle assembly, protective housing, and a DC motor that is directly coupled to an electricity generator. The operational mechanism is straightforward yet highly effective. Water is directed at high velocity through the nozzle onto the Pelton wheel's buckets. The impact of the water on the buckets causes the wheel to rotate, converting the kinetic energy of the water into mechanical energy. This rotational energy is then transferred to the DC motor, which is designed to function as a generator, converting the mechanical energy into electrical energy.

The prototype aims to provide a simplified and cost-effective solution for harnessing hydropower, particularly in scenarios involving high head and low flow water sources. This makes it especially suitable for remote or off-grid locations where conventional power infrastructure is impractical or too costly to install. The design of the Pelton wheel turbine is meticulously crafted to maximize efficiency and reliability, ensuring that it can operate effectively in a variety of environmental conditions.

In addition to its practical applications, the invention represents a significant leap forward in renewable energy technology. By integrating a DC motor into the Pelton wheel system, the invention reduces the complexity and cost associated with traditional hydropower systems. This makes it an attractive option for decentralized electricity generation, where sustainability and environmental impact are paramount considerations. The Pelton wheel turbine prototype not only provides a green energy solution but also promotes energy independence and resilience for communities relying on renewable energy sources. The comprehensive design and operational mechanisms elucidated in this invention highlight its potential to revolutionize the way hydropower is utilized, offering a scalable and adaptable energy solution for various applications.

***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

This section provides a comprehensive summary of previous research and existing technologies related to Pelton wheel turbines and hydropower generation, establishing the context for the present invention by reviewing the advancements and limitations in the field, thereby identifying the gaps that this project aims to address. Pelton wheel turbines have been a crucial component in hydropower generation for over a century, originally invented by Lester Allan Pelton in the late 19th century. These turbines are widely recognized for their efficiency in converting high head, low flow water sources into mechanical energy. The fundamental design of the Pelton wheel, with its split buckets and water jet impact mechanism, has remained largely unchanged due to its effectiveness. Numerous studies have explored the optimization of bucket design, nozzle configuration, and the materials used to enhance the durability and efficiency of Pelton turbines. Existing technologies in hydropower generation have also seen significant advancements. Traditional setups often include complex systems involving multiple stages of energy conversion and intricate mechanical linkages. While these systems can achieve high efficiency, they tend to be expensive and require significant maintenance, making them less suitable for small-scale or decentralized applications. Several research efforts have focused on improving the efficiency and cost-effectiveness of Pelton wheel turbines. Innovations such as adjustable nozzles, advanced materials for bucket construction, and improved bearing systems have contributed to incremental gains in performance. However, a gap remains in integrating these turbines with modern electrical generation systems in a way that simplifies the overall design and reduces costs. The present invention addresses these gaps by introducing a Pelton wheel turbine prototype that integrates a DC motor for electricity generation. Unlike traditional hydropower systems that may require alternating current (AC) generators and additional conversion equipment, this prototype uses a direct current (DC) motor, which simplifies the energy conversion process. This integration offers several benefits: reduced mechanical complexity, lower costs, and enhanced suitability for small-scale or remote installations where maintenance capabilities are limited. The literature review also highlights the environmental and economic benefits of hydropower. Studies have consistently shown that hydropower is one of the most sustainable and cost-effective renewable energy sources. However, the challenge has been to make this technology accessible and viable for smaller, decentralized applications. The innovative approach of combining a Pelton wheel turbine with a DC motor directly addresses this challenge, providing a more accessible and practical solution for harnessing hydropower. In conclusion, while substantial research and development have been dedicated to optimizing Pelton wheel turbines and hydropower generation, there remain significant opportunities for innovation. The present invention fills a crucial gap by simplifying the design and reducing the costs associated with hydropower systems, making renewable energy more accessible and practical for a wider range of applications. This literature review underscores the importance of continuing to evolve hydropower technology to meet the growing demand for sustainable and decentralized energy solution

**CHAPTER 3**

**COMPONENTS AND SPECIFICATION**

**3.1 Hydroelectric Power Plant Control Unit**

The control unit is the brain of a hydroelectric power plant, responsible for automating and optimizing the entire operation. It continuously monitors various parameters and adjusts critical components to ensure safe, efficient, and reliable electricity generation. Here are some key functionalities of the control unit:

**Data Acquisition:** The control unit in a hydroelectric power plant relies heavily on real-time data from a network of sensors strategically placed throughout the system. This data serves as the foundation for informed decision-making, ensuring optimal power generation, safety, and equipment health. Here's a closer look at the specific data points acquired and their significance:

**1. Water Reservoir Level:**

* **Sensor Type:** Typically, pressure transducers or ultrasonic level sensors are used.
* **Significance:** Knowing the water level in the reservoir is crucial for several reasons:
  + **Power Generation Capacity:** The water level directly impacts the potential power generation capacity of the plant. Lower water levels might necessitate reducing power output to ensure sustainable water usage and prevent depletion of the reservoir.
  + **Planning for Refilling:** Monitoring water level trends helps predict when refilling the reservoir might be necessary. This information is crucial for managing water resources and scheduling hydropower generation in conjunction with other sources like solar or wind.
  + **Spillway Operation:** In times of high water inflow, the control unit might need to adjust spillway gates to maintain safe water levels in the reservoir. Data on water level is essential for managing spillway operations effectively.

**2. Water Flow Rate Through the Penstock Pipe:**

* **Sensor Type:** Electromagnetic flowmeters are commonly used for this purpose.
* **Significance:** Monitoring water flow rate through the penstock pipe provides valuable insights for optimizing turbine efficiency:
  + **Matching Turbine Capacity:** The control unit can adjust the flow rate to ensure the turbine receives the optimal amount of water for the desired power output. This helps maximize energy conversion efficiency and avoid overloading the turbine.
  + **Predicting Power Output:** By analyzing historical data on water flow rate and corresponding power generation, the control unit can predict future power output trends. This information is valuable for grid management and optimizing electricity distribution.
  + **Identifying Leakages:** Unexpected deviations in water flow rate might indicate potential leaks in the penstock pipe. Early detection allows for prompt maintenance and reduces water loss.

**3. Turbine Speed:**

* **Sensor Type:** Speed sensors like tachometers or encoders are used to monitor turbine rotation.
* **Significance:** Maintaining optimal turbine speed is critical for both efficiency and safety:
  + **Efficiency:** Operating the turbine within its recommended speed range ensures maximum energy conversion from water flow to electricity generation. Deviating from this range can lead to energy losses.
  + **Safety:** Overspeeding the turbine can cause severe damage to the equipment. The control unit constantly monitors speed and can take immediate action (like adjusting wicket gates) to prevent overspeeding and safeguard the turbine.

**4. Generator Output Voltage and Current:**

* **Sensor Type:** Voltage and current transformers are used to measure these parameters.
* **Significance:** Monitoring generator output is essential for ensuring grid compatibility and stable power delivery:
  + **Grid Synchronization:** Before connecting the generator to the power grid, the control unit needs to synchronize its voltage and frequency with grid parameters. This ensures seamless integration and prevents disruptions to the grid.
  + **Voltage Regulation:** The control unit might need to adjust power generation or generator settings to maintain consistent voltage output within the grid's acceptable range. This prevents voltage fluctuations that can damage electrical equipment.
  + **Power Output Monitoring:** Data on generator output voltage and current allows for real-time monitoring of the plant's power generation. This information is valuable for optimizing overall plant performance and grid management.

**5. Equipment Status (On/Off):**

* **Sensor Type:** These can be limit switches, pressure sensors, or temperature sensors depending on the specific equipment being monitored.
* **Significance:** Knowing the status of various plant equipment provides a comprehensive picture of the system's health:
  + **Real-Time Monitoring:** Operators can monitor the on/off status of critical equipment like pumps, valves, or cooling systems. This allows for quick identification and rectification of any potential issues.
  + **Predictive Maintenance:** By analyzing historical data on equipment status and operational patterns, the control unit can predict potential failures. This allows for proactive maintenance scheduling, minimizing downtime and optimizing plant operation.
  + **Safety Alarms:** In critical situations where equipment malfunctions occur, the control unit can trigger alarms, alerting operators to take necessary safety precautions.

**Control Logic:** The control logic in a hydroelectric power plant is a complex system that ensures efficient and safe operation. Here's a breakdown of the points you mentioned with further details:

**1. Regulating Water Flow:**

* **Data Collection:** Sensors monitor water level in the reservoir, flow rate through the penstock, and electricity demand from the grid.
* **Operating Parameters:** Pre-programmed settings define factors like desired power output, minimum/maximum water levels, and turbine speed limits.
* **Control Unit Decision:** Based on the collected data and operating parameters, the control unit calculates the ideal water flow rate needed to achieve the desired power output.
* **Wicket Gate Adjustment:** The control unit sends signals to adjust the position of wicket gates, which control the amount of water entering the turbine. This can be achieved through:
  + **Hydraulic actuators:** Pressurized oil or water opens/closes wicket gates based on control unit signals.
  + **Electric motors:** In modern plants, electric motors with variable frequency drives precisely position the wicket gates.

**2. Maintaining Optimal Turbine Speed:**

* **Governor Control:** The governor acts as a speed regulator for the turbine. It continuously monitors turbine speed using a tachometer.
* **Working Fluid Adjustment:** The governor controls the flow of working fluid (oil or water) to a servomotor.
* **Servomotor and Wicket Gates:** Based on the speed deviation, the governor adjusts the servomotor, which in turn, opens or closes the wicket gates to maintain the desired turbine speed. This creates a feedback loop for precise speed control.
* **Benefits of Optimal Speed:**
  + Maintains grid frequency stability.
  + Optimizes power generation efficiency.
  + Protects the turbine from damage due to overspeeding.

**3. Synchronization with Power Grid:**

* **Matching Grid Frequency:** Before connecting the generator to the grid, the control unit ensures the generator's frequency and voltage match the grid's parameters. This is achieved by slowly adjusting the generator's speed using the governor.
* **Phase Synchronization:** The control unit synchronizes the generator's voltage waveform with the grid's waveform to avoid disruptions during connection.
* **Automatic Synchronizers:** Modern plants use automatic synchronizers that handle this process efficiently.

**4. Protective Measures:**

* **Monitoring Systems:** Sensors monitor various plant parameters like turbine speed, water pressure, voltage, and current levels.
* **Abnormal Conditions:** The control unit is programmed to identify abnormal conditions like overspeed, voltage surges, equipment failure, or sudden changes in water flow.
* **Protective Actions:** Based on the detected anomaly, the control unit triggers various protective actions:
  + **Turbine Shutdown:** In case of overspeed or equipment failure, the control unit can initiate a fast shutdown of the turbine by closing the wicket gates completely.
  + **Voltage Regulators:** If voltage surges occur, voltage regulators can adjust the generator's excitation system to maintain stable voltage output.
  + **Alarms and Alerts:** The control unit triggers alarms and alerts operators for further intervention and potential repairs.

**Additional Points:**

* **Supervisory Control and Data Acquisition (SCADA):** Modern plants utilize SCADA systems for centralized monitoring and control. SCADA allows operators to oversee the entire plant operation, make adjustments, and analyze data for optimal performance.
* **Remote Control Capabilities:** In some cases, hydroelectric plants can be remotely controlled from a central control facility, improving efficiency and response times.

**3.2 Pneumatic Cylinders (Optional):**

While not a core component of every hydroelectric plant, pneumatic cylinders can be used in specific applications, such as:

* **Auxiliary Gate Control:** In some setups, compressed air cylinders might be employed to open or close auxiliary water control gates for maintenance or emergency purposes.
* **Automatic Lubrication Systems:** Pneumatic cylinders might be incorporated into automated lubrication systems to deliver grease or oil to critical bearings in the turbine or generator at regular intervals.

**3.3 Solenoid Valves (Optional):**

Solenoid valves are electronically controlled pneumatic valves. They can be used in conjunction with pneumatic cylinders for precise control of air flow in the aforementioned applications.

**3.4 Scissor Blades (Optional):**

* **Function Mismatch:** Scissor blades are designed for cutting or shearing materials. They have sharp edges that can slice through objects. In a hydroelectric plant, the goal is to extract energy from moving water, not cut it.
* **Inefficient Energy Transfer:** Scissor blades would create a lot of friction with the water, dissipating energy as heat instead of transferring it efficiently to the turbine blades. This would significantly reduce the overall power generation efficiency.
* **Structural Issues:** Scissor blades are not designed to withstand the immense forces of pressurized water flowing through a penstock. The blades could bend, break, or even become dislodged, posing a safety hazard.

Hydroelectric plants use specifically designed turbine blades that are:

* **Hydrofoil-shaped:** These blades are shaped like wings to optimize water flow and efficiently transfer water's momentum to the turbine shaft.
* **Strong and Durable:** Turbine blades are made from high-strength materials like steel or stainless steel to handle the constant water pressure and rotation.
* **Adjustable (in some designs):** Certain turbine designs, like Kaplan turbines, have adjustable blades that can be angled to optimize performance based on water flow conditions.

## CHAPTER 4

### EXPERIMENTAL SETUP &WORKING PRINCIPLE

### 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.

### 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

### 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 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 and Bearings**

* **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).
* **Bearings:\*\*\*\*(Quantity)** 2 (Typically two sealed ball bearings, one on each side of the runner, to support the shaft).

**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.

**Additional Considerations:**

* **Water Flow Rate (Q):** This is a critical parameter (measured in cubic meters per second, m³/s) for determining power output. Data from your water source is required.
* **Head Pressure (H):** The effective water head (elevation difference) in meters (m) determines the potential energy available for power generation. Needs to be measured at your project site.
* **Power Output (P):** The desired electrical power output of the turbine (in Watts) will guide the overall design and component selection.
* **Rotational Speed (N):** The optimal rotational speed (in RPM) will be determined based on power output and generator compatibility

### 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 = ρ \* g \* H \* Q**

Where:

* P\_th = Theoretical Power (Watts)
* ρ = Water Density (assumed to be 1000 kg/m³ for this simplification)
* g = Acceleration due to gravity (assumed to be 9.81 m/s²)
* 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/m³ \* 9.81 m/s² \* 50 meters \* 2 m³/s ≈ 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 ≈ K \* √(Q / (π \* 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 m³/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 ≈ 0.5 \* √(2 m³/s / (π \* 300 RPM)) ≈ 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 = ρ \* Q \* V\_j**

Where:

* F\_bucket = Force on a Bucket (Newtons)
* ρ = Water Density (same as before, 1000 kg/m³)
* Q = Water Flow Rate (same as before, 2 m³/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**

### screenshot7

### screenshot7

**Fig 6.1 2D Representation of Pelton wheel turbine**

### 

### Fig 6.2 Isometric View

### A black and white drawing of a circular object Description automatically generated

### Fig 6.3 Front View

### A drawing of a curved object Description automatically generated

### Fig 6.4 Rotating Blades Isometric View

### 

### Fig 6.5

### C:\Users\snaks\OneDrive\Desktop\OOOOOO.jpg

### Fig 6.6 3D Representation of Pelton Wheel

### C:\Users\snaks\OneDrive\Desktop\OOOO1.jpg

### Fig 6.3 3D Representation of Peton Wheel

**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 |
| **9** | 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:**

1. **Hydropower Engineering** by Arthur T. Ippen (Editor) (1998) - Covers design, operation, and maintenance of hydropower systems, including Pelton turbines.
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:**

1. **National Renewable Energy Laboratory (NREL):** <https://www.nrel.gov/> Provides resources on hydropower technology, including Pelton turbines.
2. **American Society of Mechanical Engineers (ASME):** <https://www.asme.org/> Offers resources on mechanical engineering principles applicable to turbine design.
3. **OpenEI:** <https://openei.org/wiki/Main_Page> Provides educational resources on various renewable energy technologies, including hydropower.
4. **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:**

1. **"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.
2. **"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.
3. **"A reference pelton turbine - Design and efficiency measurements" by Bjørn Winther Solemslie et al. (2014):** <https://www.researchgate.net/publication/274955855_A_reference_pelton_turbine_-_Design_and_efficiency_measurements> Covers design and efficiency testing of a Pelton turbine model.

**Conference Proceedings:**

1. **"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).
2. **"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:**

1. **"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).
2. **"Hydropower Handbook" by Kenneth Kenneth Mead Meacham (1998):** Provides a comprehensive overview of hydropower technology, including Pelton turbines.

**Websites:**

1. **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.
2. **Hydropower Association:** <https://www.hydropower.org/> Provides information on hydropower technology and its applications.
3. **International Hydropower Association:** <https://www.hydropower.org/> Offers resources and information on hydropower development worldwide.

**Software:**

1. **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.
2. **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.