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Investment and exploitation of water flow to electricity with hydropower using in pumping stations

Defended in front of the jury composed of:

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Dedication

I dedicate this humble work
to my dear parents who have supported me throughout my life studies, may ALLAH preserve them.
To my dear brothers and sisters
For all my family and friends

Abstract

Using hydropower to generate electricity in pumping stations is a promising technology that can provide multiple benefits. In such a system, the potential energy of water flowing through the station can be harnessed to drive a turbine, which is connected to a generator that produces electricity. This electricity can then be used as a power to supply the pumping station's as well as a various electrical loads, including pumps and auxiliary motors. The main of our project is to improve and invest of the water fall to distribution in pumping system were using its energy to electricity, that can help to reduce the overall energy consumption and a reduction in gas emissions from electricity production.

مجرد

يعد استخدام الطاقة الكهرومائية لتوليد الكهرباء في محطات الضخ تقنية واعدة يمكن أن توفر فوائد متعددة. في مثل هذا النظام، يمكن تسخير الطاقة الكامنة للمياه المتدفقة عبر المحطة لتشغيل توربين متصل بمولد ينتج الكهرباء. يمكن بعد ذلك استخدام هذه الكهرباء كطاقة لتزويد محطة الضخ بالإضافة إلى الأحمال الكهربائية المختلفة، بما في ذلك المضخات والمحركات المساعدة. يتمثل الهدف الرئيسي لمشروعنا في تحسين واستثمار سقوط المياه في التوزيع في نظام الضخ الذي يستخدم طاقته في الكهرباء، مما يمكن أن يساعد في تقليل إجمالي استهلاك الطاقة وتقليل انبعاثات الغاز من إنتاج الكهرباء.

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List of symbols and abbreviations

➢ List of Abbreviations

PS : Power Stability

PSS : Power System Stabilizer

DC : Direct Current

AC : Alternatif Current

EM : Excitation Machine

GP : Principal Generator

SGS : Synchronous Generators

SSFR : Short-Circuit Tests, Standstill Frequency Response

OCFR : Open Circuit Frequency Response

PMSM : permanent magnet synchronous machine

➢ List of symbols

(d, q, 0) : Model Described in The Park's Coordinate System

Θ : An Electrical Angle

V : Voltage

Ω : The Angular Velocity Of The Rotor (Rad/S)

Vf : Excitation Voltage

Tm : Mechanical Torque

Rs : Stator resistance

Rf : Rotor resistance

$Vref$: Voltage Reference

R : Resistance

L : Leakage Induction

Fn : Frequency

General introduction

The production of electrical energy from the flow of water leaving the water tank is a common application of micro hydro power systems. In this type of system, water is extracted from a source, such as a river or stream, and stored in a tank or reservoir. [1]

The water is then released from the tank and flows through a penstock, which directs the water to a turbine. As the water flows through the turbine, it drives a generator to produce electricity. The electricity produced by the generator can be used to power a motor and pump to extract more water from the source and fill the tank. This creates a closed-loop system that can operate continuously as long as there is a sufficient flow of water.

The use of a moto pump in a micro hydro power system can help to optimize the system for efficiency and reliability. By using a moto pump to extract water from the source and fill the tank, the system can be designed to operate at maximum efficiency and to respond to changes in water flow rate and head height. The moto pump can also be controlled by a controller to ensure that the system operates safely and efficiently[2], [3].

This work is divided into three chapters, each focusing on different aspects of renewable energy and micro hydroelectricity. In first chapter, we provide an overview of the history of renewable energy and discuss the components of hydroelectric energy in general. We cover different types of turbines and generators, as well as the use of asynchronous motors in micro hydro power systems.

In second chapter, we focus specifically on micro hydroelectricity as a sustainable and reliable alternative to traditional forms of electricity generation. We discuss the components of a micro hydro power system, including turbines, generators, engines, pumps, and control systems. We also explore the advantages and limitations of micro hydro power systems, as well as factors that influence the selection of specific components.

For a last chapter, we present a modeling and simulation approach for micro hydro power systems using MATLAB SUMILINK tools. We discuss the steps involved in modeling each component of the system and showing the results of simulations performed on the system.

This work aims to provide a comprehensive overview of micro hydroelectricity and its components, as well as modeling and simulation for optimizing the performance and efficiency of micro hydro power systems.

Chapter 01

I. State of the Art of hydropower systems

I.1 Introduction

Energy sources that are continually replenished by nature the sun, the wind, water, the Earth's heat, and plants. Renewable energy technologies turn these fuels into usable forms of energy most often electricity, but also heat, chemicals, or mechanical power[4].

The most common types of renewable energy sources are solar, wind, hydro, and geothermal. Solar energy is derived from the sun, which is captured by photovoltaic cells or solar thermal collectors. Wind energy is generated by wind turbines that convert the kinetic energy of the wind into electrical energy. Hydro energy is obtained from flowing water, such as rivers, dams, and tidal movements. Geothermal energy is derived from the earth's natural heat, which is tapped into by drilling deep wells and using the heat to produce electricity.

Renewable energy is becoming increasingly important as a way to reduce greenhouse gas emissions and combat climate change. It is also an important tool for promoting energy independence, reducing energy costs, and creating jobs in the renewable energy sector.

I.2 Renewable energy

Renewable energy sources including biomass, geothermal, ocean, solar, and wind energy, as well as hydropower have a huge potential to provide energy services for the world. The renewable energy resource base is sufficient client to meet several times the present world energy demand and potentially even 10 to 100 times this demand. This chapter includes an in-depth examination of technologies to convert these renewable energy sources to energy carriers that can be used to fulfil all our energy needs, including their installed capacity, the amount of energy carriers they produced in 2009, the future, as well as major issues they may face relative to their sustainability or implementation. [5]

I.3 Types of renewable energy

I.3.1 Solar energy

Solar energy is one of the most abundant sources of renewable energy, and it is becoming increasingly affordable as technology advances. Solar panels use photovoltaic cells to convert sunlight into electricity, which can then be stored in batteries or fed into the power grid.

Figure I.1 Solar energy

I.3.2 Wind energy

Wind energy is another widely used source of renewable energy. Wind turbines convert the kinetic energy of wind into electricity through the use of rotating blades. Wind turbines can be installed on land or offshore, and they are most effective in areas with consistent wind patterns.

Figure I.2 Wind energy

I.3.3 Geothermal energy

Geothermal energy is a reliable and consistent source of renewable energy that uses the heat from the earth's core to generate electricity. Geothermal power plants can be found in areas with high levels of volcanic activity or hot springs.

Figure I.3 Geothermal energy

I.3.4 Biomass energy

Biomass energy is generated from organic matter, such as wood, crops, or waste. Biomass can be burned directly to generate heat, or it can be converted into biofuels, such as ethanol or biodiesel, for use in transportation.

Figure I.4 Biomass energy

I.3.5 Tidal energy

Tidal energy is a type of renewable energy that uses the rise and fall of tides to generate electricity. Tidal turbines are placed underwater in areas with strong tidal currents, and they generate electricity through the rotation of their blades.

Figure I.5 Tidal energy

I.3.6 Ocean thermal energy

Ocean thermal energy is a relatively new source of renewable energy that uses the temperature difference between warm surface water and cold deep water to generate electricity. This technology is still in the experimental phase, but it has the potential to provide a consistent source of renewable energy in areas with warm ocean currents.

Figure I.6 Ocean thermal energy

I.3.7 Hydropower

Hydropower is the most widely used source of renewable energy worldwide. Hydroelectric dams use the force of flowing water to turn turbines, which generate electricity. Hydropower is often used to supplement other sources of electricity during peak demand.

Figure I.7 Hydropower

I.4 History of hydro power

Hydroelectric power is a renewable energy source that uses the force of moving water to generate electricity. The history of hydroelectric power dates back to ancient times when water wheels were used to power mills and irrigation systems. However, the modern hydroelectric power industry began in the late 1800s and has continued to develop into the present day.

In 1878, the first hydroelectric power plant was built in Northumberland, England. The plant was small and produced only enough electricity to power a single arc lamp. However, it demonstrated the potential of hydroelectric power and sparked interest in the technology.

In 1882, the world's first hydroelectric power plant was built in Wisconsin, USA. The plant used the power of the Fox River to generate electricity for the nearby city of Appleton. This was a significant milestone in the development of hydroelectric power and paved the way for larger, more advanced power plants.

In 1891, the Niagara Falls Power Company built the first large-scale hydroelectric power plant at Niagara Falls, New York. The plant generated enough electricity to power the entire city of Buffalo, 20 miles away. This was a major breakthrough in the development of hydroelectric power, and the plant served as a model for future power plants around the world.[6]

Throughout the 20th century, hydroelectric power continued to develop and expand. Many large dams were built to harness the power of rivers and create hydroelectricity. One of the most famous examples is the Hoover Dam, which was built on the Colorado River between 1931 and 1936. The dam generated a massive amount of electricity and helped to power the growth of the western United States.

Figure I.8 1891, the Niagara Falls

I.5 Hydropower components

The components of a hydropower system listed as items based on wer statement:

I.5.1 Source of water

The source of water for a hydropower system is typically a river or other body of water with a significant flow of water. The flow of water is what provides the energy to turn the turbine and generate electricity.

A dam is often built on the river to create a reservoir, which can regulate the flow of water and store excess water for times of high demand.

I.5.2 Turbine

The turbine is the component of a hydropower system that converts the energy of moving water into mechanical energy.

The water flowing through the penstock (a large pipe) turns the blades of the turbine, which is connected to a shaft that rotates a generator.

There are different types of turbines used in hydropower systems, such as Pelton turbines, Francis turbines, and Kaplan turbines, which are selected based on the flow rate and head (the height difference between the water source and the turbine) of the water.

I.5.3 Generator

The generator is the component of a hydropower system that converts the mechanical energy from the turbine into electrical energy.

The generator contains a rotor and stator, which create a magnetic field that induces an electrical current in the wire coils of the stator. The electrical current is then transmitted through power lines to homes and businesses.

I.5.4 Motors and pump

Motors can be an effective and reliable solution for well water extraction systems, aslong as they are properly selected, installed, and maintained.

They offer a cost-effective and efficient way to extract water from wells for a variety of applications. Proper sizing of the motor and pump, along with proper maintenance and protection against overload and overheating, can help to ensure reliable and efficient operation of the system for the lifetime of the motor

I.6 Turbine

Hydraulic electric turbine, a device which can convert the hydraulic energy into the mechanical energy when the water falls on blades of turbine which again convert this mechanical energy into the electrical energy by connecting generator to the shaft of turbine. The hydroelectric turbine design consists of:

- Stator
- Rotor
- Shaft
- Wicket gate
- Blades

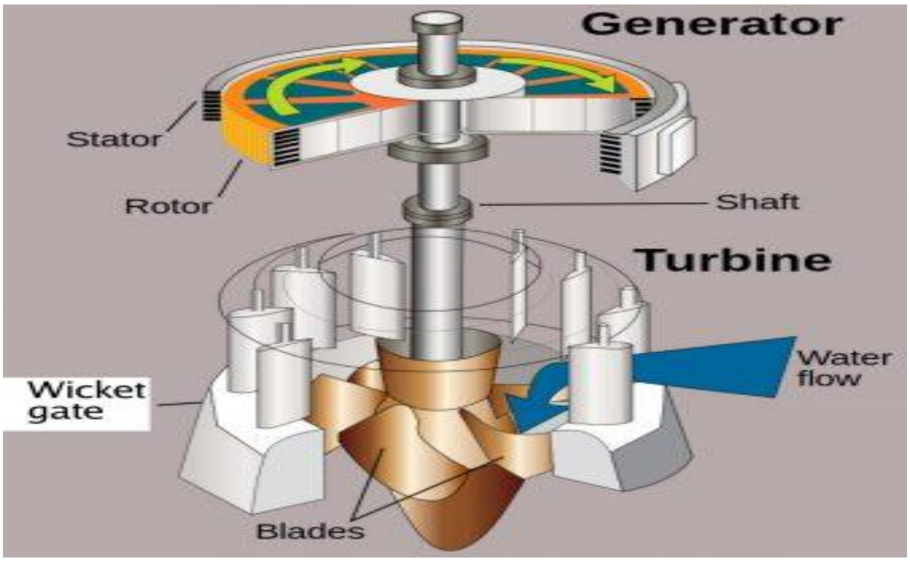


Figure I.9 Hydraulic electric turbine,

I.6.1 Power output factors

- Head of pressure which is the height of water from the turbine
- Flow rate of the turbine
- Efficiency

This work on the principal that when the circular blades will strike by the water coming from penstock with high pressure it will rotate the shaft that is connected with the propellers provided at the center and it causes generator to produce electrical power.[7]

I.6.2 There are several types of hydro power turbines, including

I.6.2.1 Pelton Turbine

Pelton turbines are used in high head applications. They have a single or multiple cups that are shaped like a spoon or bucket, which is driven by the high-pressure water stream. This type of turbine is best suited for high head and low flow rates. [2]

Figure I.10 Pelton turbines

I.6.2.2 Francis Turbine

Francis turbines are used in medium head applications. They are a reaction turbine and work by having water flow in and out of the turbine blades. The blades are curved and the water enters the blades radially, then moves along the blades, causing the turbine to spin.[2]

Figure I.11 Francis

I.6.2.3 Kaplan Turbine

Kaplan turbines are used in low head applications. They are axial flow turbines and have adjustable blades. They can be adjusted for different flow rates, making them efficient in varying water conditions.[2]

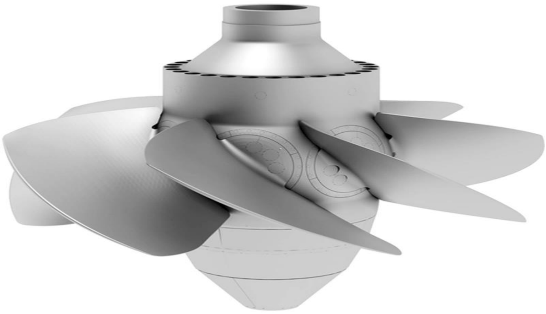


Figure I.12 Kaplan

I.6.2.4 Turgo Turbine

Turgo turbines are used in medium to high head applications. They have a single or multiple cups that are similar to Pelton turbines, but the water jet strikes the cups at an angle, causing the turbine to spin.[2]

Figure I.13 Turgo turbines

I.6.2.5 Crossflow Turbine

Crossflow turbines are used in low head applications. They have a vertical axis and are similar to a windmill in design. Water flows through the blades in a cross-flow pattern, causing the turbine to spin.[2]

Figure I.14 Crossflow turbines

I.7 Sizes of hydroelectric power plants

Hydroelectric power plants come in a wide range of sizes, from small-scale micro hydro systems to large-scale hydroelectric dams. The size of a hydroelectric power plant is typically determined by factors such as

Small-scale hydroelectric power plants, also known as micro hydro systems, typically have a power output of less than 100 kW. These systems are often used to provide electricity to remote communities or off-grid locations, and can be designed to operate at a constant or variable flow rate. Micro hydro systems can be relatively simple and inexpensive to install and maintain, making them an attractive option for small-scale

Medium-scale hydroelectric power plants typically have a power output of 100 kW to 10 MW. These systems are often used to provide electricity to small communities or industrial operations, and can be designed to operate at a constant or variable flow rate. Medium-scale hydroelectric power plants can be more complex and expensive to install and maintain than micro hydro systems, but can provide a reliable and cost-effective

Large-scale hydroelectric power plants typically have a power output of more than 10 MW, and are often associated with large dams and reservoirs. These systems are typically designed to operate at a constant flow rate and can provide a significant amount of electricity to the electrical grid. Large-scale hydroelectric power plants can be very expensive to construct and maintain, but can provide a reliable source of electricity over the long term and can have a significant impact on regional energy production and economic development.

The size of a hydroelectric power plant is not only determined by the power output required, but also by the characteristics of the water source. The flow rate and head height of the water source can limit the size of the hydroelectric power plant that can be constructed. In addition, environmental considerations, such as the impact of the damage and reservoir on local ecosystems and communities, must also be taken into account.

In recent years, there has been growing interest in small-scale hydroelectric power plants, particularly micro hydro systems, as a sustainable and reliable source of electricity for remote communities and off-grid

Tableau 02: some of the most common types of small-scale hydroelectric power systems

Type of System	**Description**	**Power Output**
Pico hydro	Smallest type of hydro system, usually producing less than 5 kW	**< 5 kW**
Micro hydro	Larger than pico hydro, producing between 5 and 100 kW	**5-100 kW**
Mini hydro	Larger than micro hydro, producing between 100 kW and 1 MW	**100 kW - 1 MW**
Small hydro	Larger than mini hydro, producing between 1 MW and 10 MW	**1 MW - 10 MW**

Note: The power output ranges for these types of systems can vary depending on the source.

I.8 Electrical machines

Generators are used to convert mechanical energy into electrical energy. In a hydropower system, the spinning shaft of a turbine turns a rotor inside the generator, producing an electric current. Hydropower generators are usually synchronous generators, which produce alternating current (AC) electricity. The AC electricity produced by the generator is then stepped up in voltage using transformers and transmitted to the electrical grid for distribution to end-users.[8]

Asynchrones Motors are widely used in industrial and commercial applications due to their simplicity, robustness, and reliability. They are capable of delivering high torque at low speeds and can operate over a wide range of power outputs. Asynchronous motors are also less expensive and easier to maintain than synchronous motors, making them ideal for micro hydro power systems in remote or off-grid locations.

I.8.1 Synchronous Generators in hydropower

Synchronous generators are the most common type of generator used in hydropower plants. They work by using the principle of electromagnetic induction to convert mechanical energy from the turbine into electrical energy.[9]

In a synchronous generator, the rotor and the stator rotate at the same speed, which is called the synchronous speed. The rotor is connected to the turbine and rotates due to the force of the water. The stator is a stationary component with a set of windings that are arranged around the rotor. The windings are energized with an alternating current, which creates a rotating magnetic field that interacts with the magnetic field of the rotor. This interaction generates an electric current in the stator windings, which is then sent to the power grid.

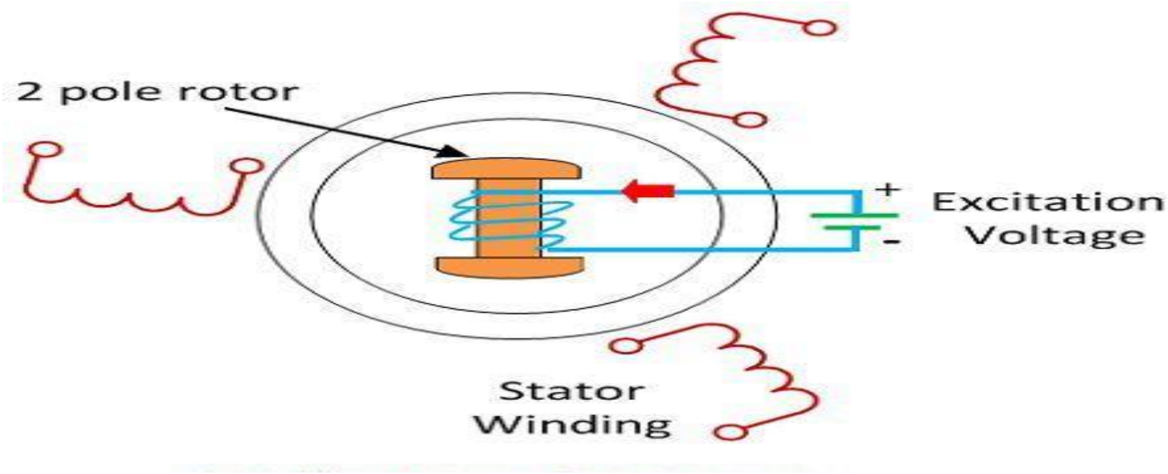


Figure I.15 Synchronous generator

I.8.1.1 Permanent magnet synchronous generator (PMSG)

Self excitation brings about various benefits. one is the elimination of the rotor copper losses. hence PMSG power supply is needed. the maintenance is eliminated since brushes and slip rings as well as the rotor windings are removed. the common issue with wrsg is the relation between the frequency induced and the mechanical speed of the rotor. when the wind speed changes,

The rotor speed and thereby the frequency of the induced voltage changes. however, in variable speed applications with PMSG this is usually not of concern since the generator is connected to the grid through a converter that will adapt the frequency of the induced voltage to the grid frequency. One other consideration is that, unlike WRSG, the field provided by magnets is not controllable. Thus, it is not possible to regulate the voltage and the reactive power. In variable speed wind systems, this is, usually, not an issue since the grid-side-converter regulates the output voltage and the power.[10]

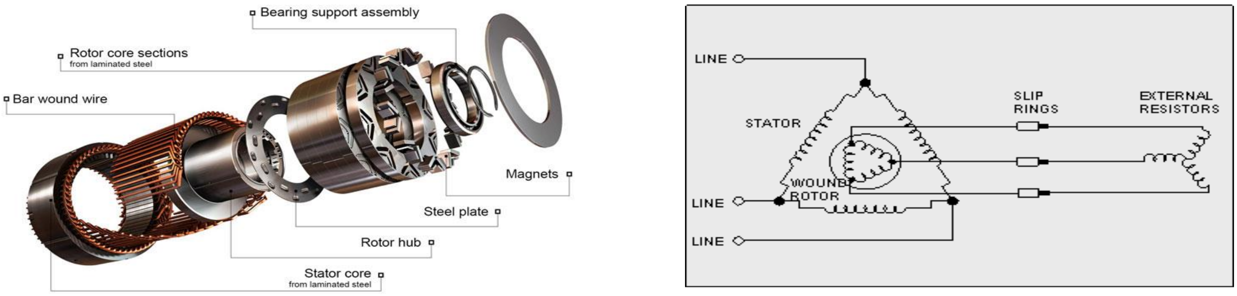


Figure I.16 Interior permanent magnet synchèronous

I.8.1.2 Wound rotor synchronous generator (WRSG)

In this type of generator, the rotor windings are connected to slip rings instead of being fixed. This allows for the rotor windings to be connected to an external circuit, which can be used to control the generator's power factor and speed. This type of generator is used in applications where precise speed control is required or where the load varies widely.[9]

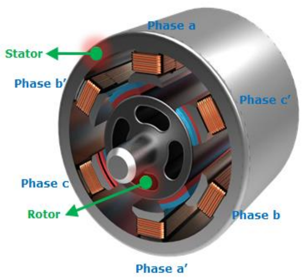


Figure I.18 staor Wound-rotor synchronous

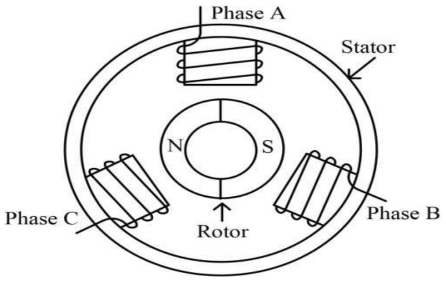


Figure I.17 Wound-rotor synchronous genertur

I.8.2 The asynchronous motor

An asynchronous motor, also known as an induction motor, is a type of AC electric motor that operates by electromagnetic induction. It's called "asynchronous" because the speed of the rotor is slightly lower than the speed of the rotating magnetic field in the stator. This speed difference, known as slip, is what allows the motor to produce torque.[11]

The construction of an asynchronous motor typically consists of a stator with a set of windings arranged in a specific pattern, and a rotor with a set of conductive bars or coils. When an AC voltage is applied to the stator windings, it produces a rotating magnetic field that induces a current in the rotor windings. The interaction between the rotating magnetic field and the rotor current creates a torque that drives the rotor to rotate.[11], [12]

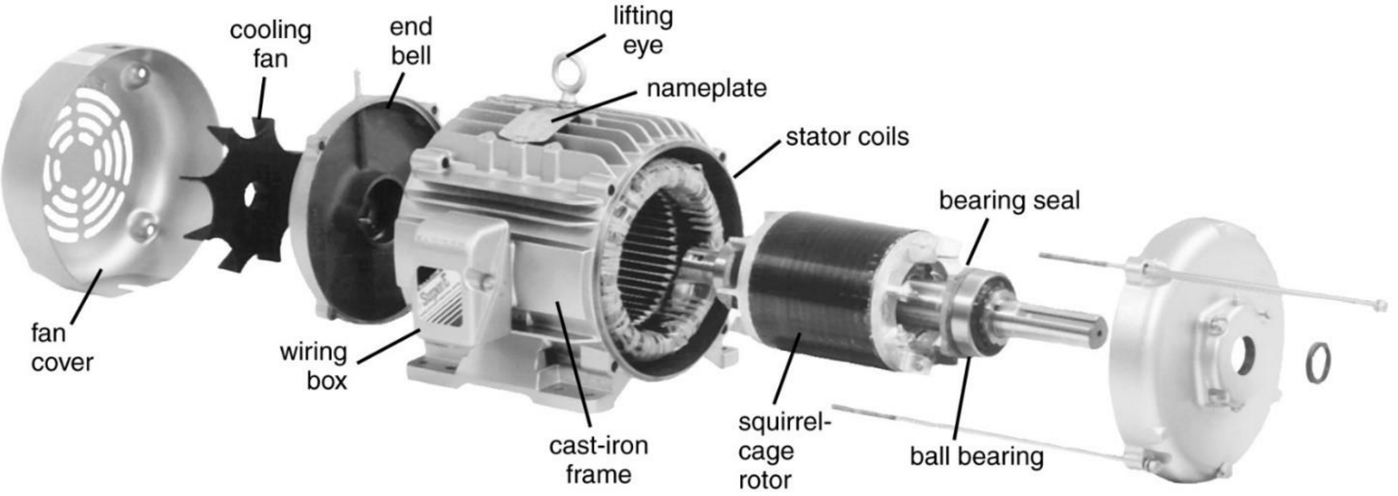


Figure I.19 The Asynchronous Motors

Asynchronous motors are widely used in industrial and commercial applications due to their simplicity, robustness, and reliability. They are capable of delivering high torque at low speeds and can operate over a wide range of power outputs. They are used in a variety of applications, including fans, pumps, compressors, conveyors, and machine tools.[12]

The performance of an asynchronous motor can be influenced by factors such as the design of the windings, the materials used in the construction of the rotor and stator, and the control method used to operate the motor. Proper selection and operation of an asynchronous motor can result in efficient, reliable, and cost-effective performance over the lifetime of the motor

I.8.2.1 Squirrel cage induction motor

This is the most widely used type of asynchronous motor. It features a rotor with conductive bars that are short-circuited at both ends by end rings, giving it a shape that resembles a squirrel cage. The stator has a set of windings that produce a rotating magnetic field, which induces a current in the rotor bars. The interaction between the magnetic field and the rotor current produces torque, which drives the rotor to rotate.[13]

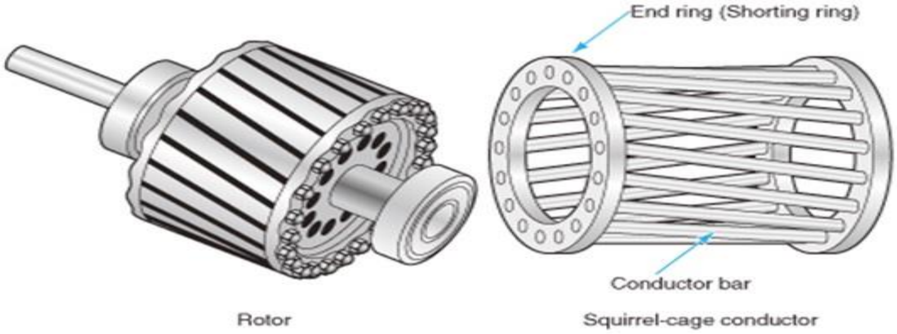


Figure I.20 Squirrel Cage Induction Motor:

I.8.2.2 Wound rotor induction motor

This type of asynchronous motor has a rotor with a set of windings that are connected to slip rings. The slip rings allow the rotor windings to be connected to an external resistance or a variable frequency power supply, which can be used to control the speed and torque of the motor. The stator windings produce a rotating magnetic field that induces a current in the rotor windings. The interaction between the magnetic field and the rotor current produces torque, which drives the rotor to rotate.[14]

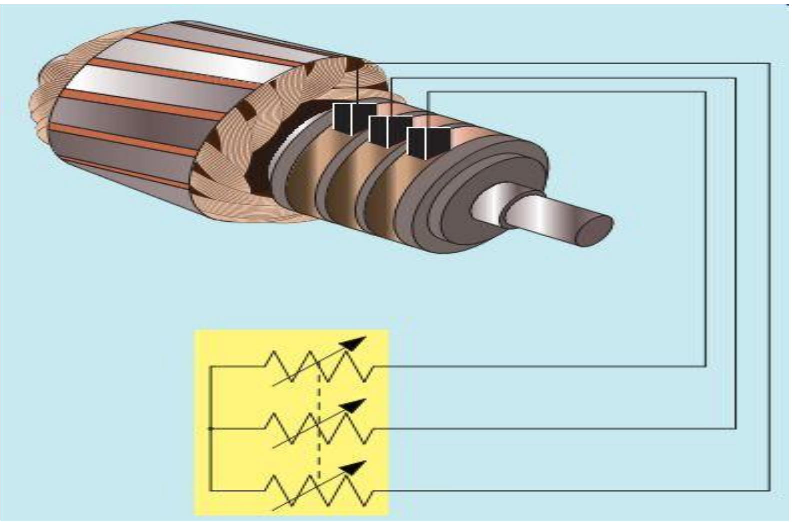


Figure I.21 Wound Rotor

I.9 Advantages and disadvantages for micro hydropower

Micro hydropower systems are smaller scale hydropower plants that are typically used to generate electricity for small communities, rural homes, or businesses. Some of the advantages and disadvantages of micro hydropower systems are:[3]

I.9.1 Advantages

- Renewable energy: Like large-scale hydropower systems, micro hydropower systems use a renewable source of energy - the power of flowing water - to generate electricity. This means they do not deplete natural resources and are considered a clean form of energy.
- Cost-effective: Micro hydropower systems can be cost-effective, especially for remote or off-grid locations where the cost of grid extension may be high. Once the system is installed, the cost of generating electricity is relatively low, with minimal fuel costs or transportation expenses.
- Reliable: Micro hydropower systems can be reliable sources of energy because water is constantly flowing, and electricity can be generated on demand. The system can operate 24/7 without interruption, as long as there is sufficient water flow.
- Environmental impact: Micro hydropower systems have a lower environmental impact than larger-scale hydropower systems, as they typically require smaller dams or diversion structures. This means there is less disruption to river ecosystems and fish populations.
- Multipurpose: Micro hydropower systems can be used for multiple purposes, such as irrigation, domestic water supply, and electricity generation. This makes them particularly useful for remote or off-grid communities that require access to multiple services.

I.9.2 Disadvantages

- Limited availability: Micro hydropower systems require a constant flow of water to generate electricity, which means they are not suitable for all locations.
- The available water flow may vary depending on the season or weather conditions, which can impact the system's output.
- Initial investment: The initial investment in a micro hydropower system can be high, as it requires capital for equipment, installation, and maintenance.
- The payback period may be longer for small-scale systems compared to larger ones.
- Maintenance costs: Micro hydropower systems require regular maintenance, such as sediment removal and turbine repairs, to ensure optimal performance. These maintenance costs can add up over time.

I.10 Conclusion

To conclude the first chapter, we discussed the components of a micro hydro power system, including turbines, generators, engines, pumps. There are different types of turbines and generators used in micro hydro systems, each with their own advantages and limitations. The choice of turbine, generator, and other components depends on factors such as the flow rate and head height of the water source, the desired power output, and the budget. Careful planning, installation, and ongoing maintenance are necessary to ensure that the micro hydro system operates efficiently and safely.

Overall, micro hydro power systems offer a sustainable and reliable alternative to traditional forms of electricity generation, especially in rural and remote areas where access to the grid is limited.

Chapter 02

II. Micro Hydroelectric Systems

II.1 Introduction

Micro hydroelectric is a type of hydro power system that generates electricity from small water sources,

With a capacity of less than 100 kW. It is a renewable energy technology that utilizes the kinetic energy of flowing water to generate electricity, without producing greenhouse gas emissions or pollution.[3]

Micro hydroelectric systems typically consist of a turbine, generator, control system, and transmission equipment. The turbine is typically a small, water-powered wheel or propeller that is turned by the flowing water.

This mechanical energy is then converted into electrical energy by a generator, which produces a current that can be transmitted and distributed to power electrical devices and appliances.

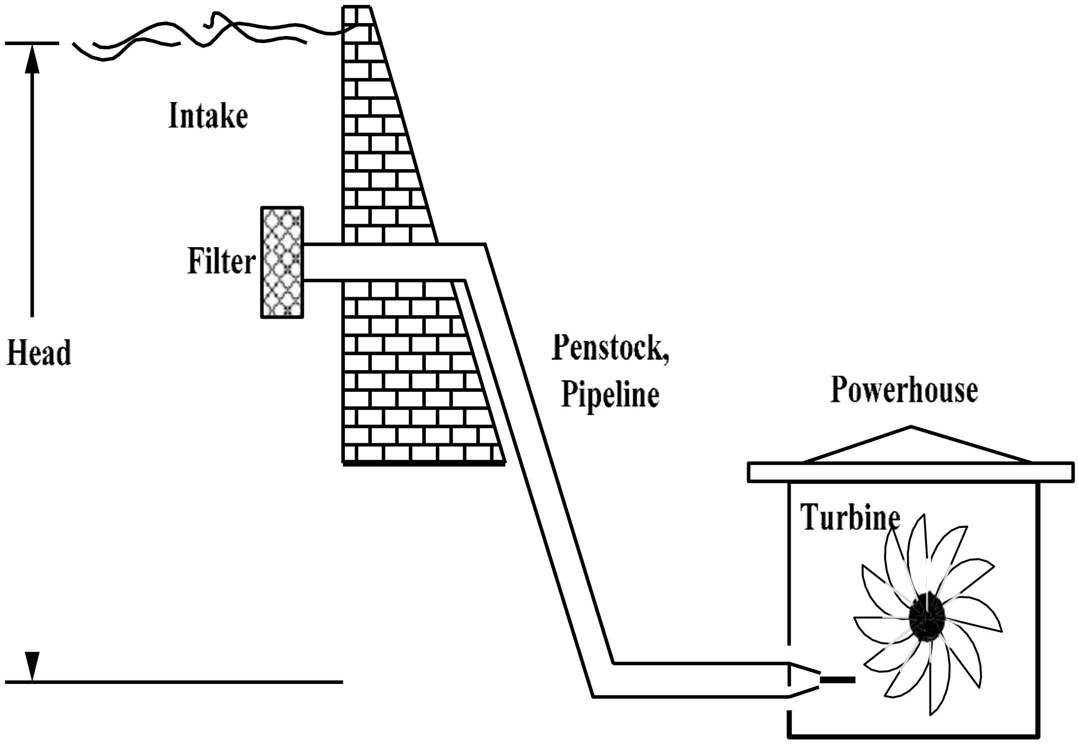


Figure II.1 Micro hydroelectric is a type of hydro power system

II.2 Proposal idea

II.2.1 Micro-hydroelectricity generation

the world continues to grapple with the issue of climate change, more and more people are looking for ways to reduce their carbon footprint and move towards sustainable living. One of the ways to achieve this is by harnessing the power of flowing water, [15]which is often overlooked as a potential energy source. Many homes and businesses have water tanks that are connected to pipes, and the water flowing through these pipes can be harnessed to generate electricity. In this article, we will explore the benefits of placing a generator under the water tank to exploit the water flowing through the pipes as micro-hydroelectricity. We'll also discuss the different components required for this type of setup and how it can be installed. By taking advantage of this often-overlooked resource, we can move closer to a sustainable future and reduce our reliance on non-renewable energy sources.

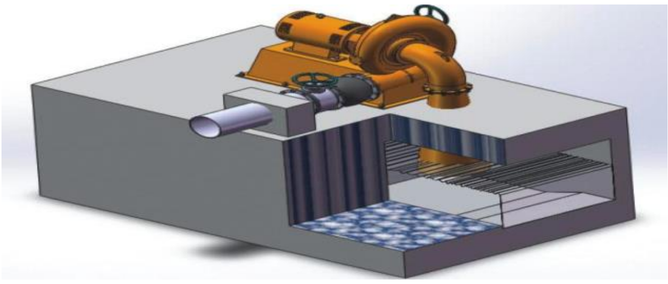


Figure II.2 Micro-hydroelectricity Generation

II.2.1.1 Components of Step

The picture shows the components of a micro-hydropower station, including a turbine and generator with a capacity of 32 kW and a storage tank with a capacity of 5000 $m^3\ /s$ This system utilizes water flow to generate electrical energy and is a renewable energy solution that can potentially save money on energy bills, offer a reliable source of backup power, and reduce carbon footprint. It's important to consult with a professional to ensure proper installation, testing, and maintenance of the system..

Figure II.3 Micro-hydroelectricity Generation 32kw

II.2.2 Areas of use micro-hydropower

Micro-hydropower systems can be used in a variety of settings, including:

II.2.2.1 Rural electrification

Micro-hydropower systems can be installed in remote or rural areas where there is no access to grid electricity. These systems can provide power for lighting, heating, and small appliances, improving the quality of life for people living in these areas.[7]

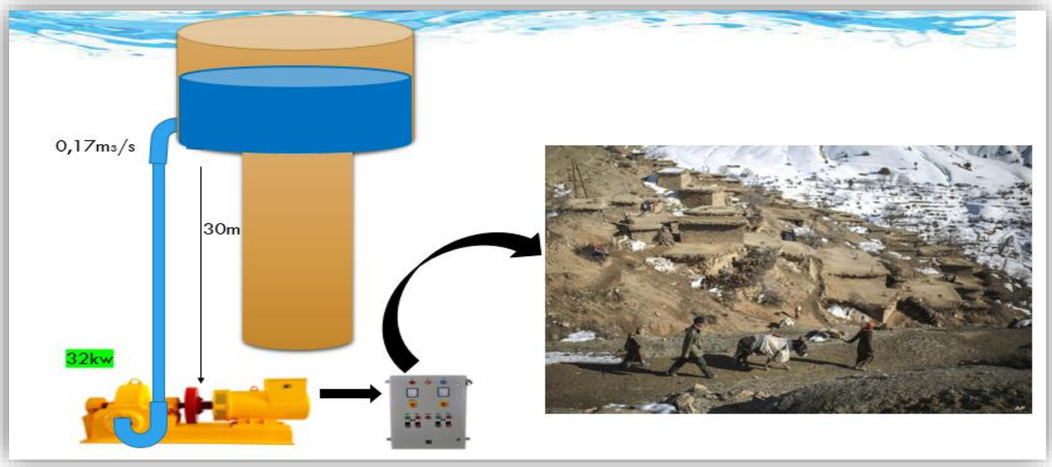


Figure II.4 Micro-hydropower systems can be installed in remote or rural

II.2.2.2 Agricultural applications

Micro-hydropower systems can be used to power irrigation pumps, agricultural machinery, and other equipment on farms, providing a reliable source of power for these applications.

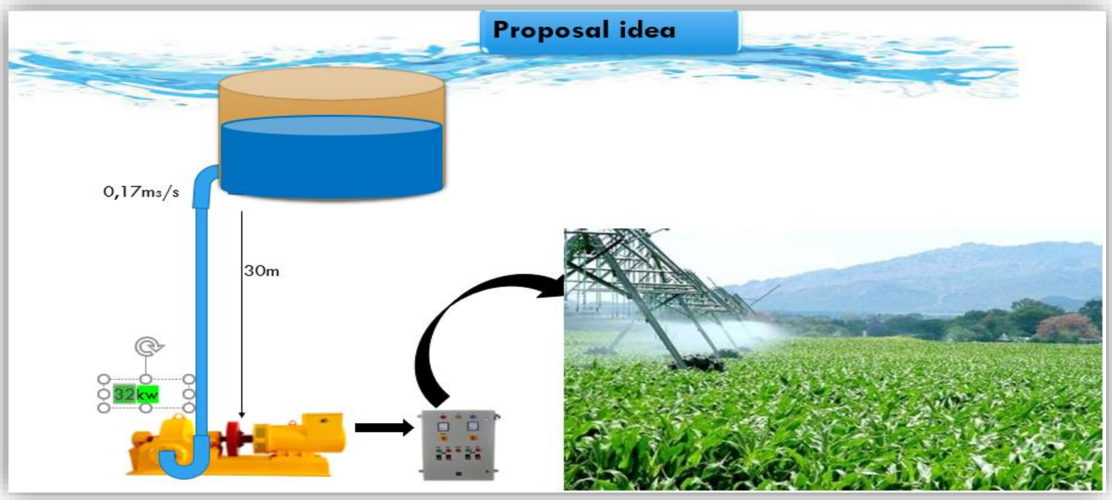


Figure II.5 Micro-hydropower systems can be used to power irrigation

II.2.2.3 Environmental and conservation applications

Micro-hydropower systems can be used to power water treatment plants, monitoring equipment, and other environmental applications that require a reliable source of power.

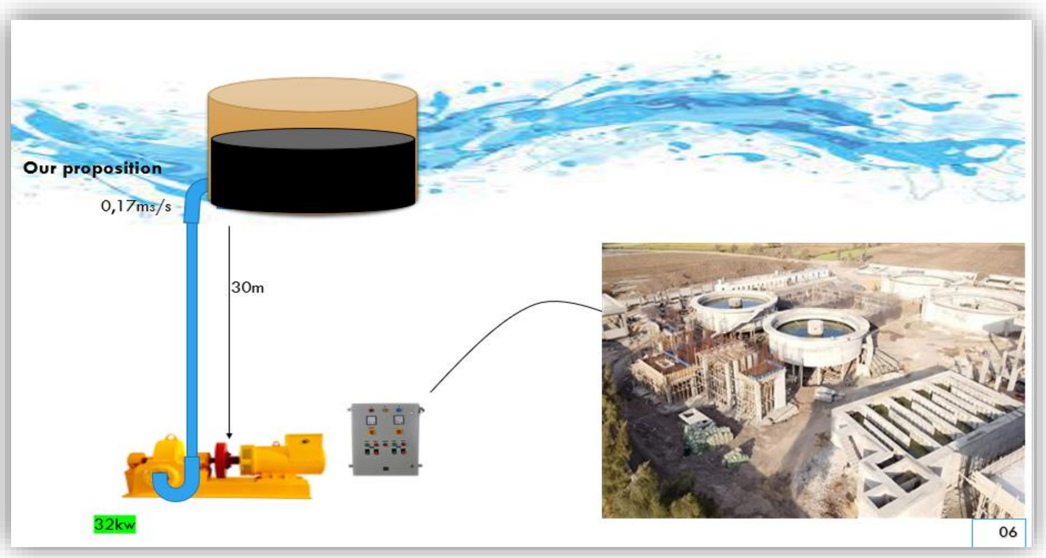


Figure II.6 Micro-hydropower systems can be used to power water treatment plants

II.3 Theoretical study

Theoretical study involves the installation of a turbine and generator with a capacity of 32 kilowatts under a water tank that carries 5000 m^3 $/s$ with a water flow of 0.17 cubic meters per second. The purpose of this installation is to produce electric power equivalent to 32 kw per second by harnessing the energy of the flowing water. This system can potentially provide a renewable energy solution, reduce energy bills, and offer a reliable source of backup power. However, it's important to note that a professional should be consulted to ensure proper installation, testing, and maintenance of the system.

Table03: of data for the proposed study

Property	Value
Water Flow Rate	0.17 cubic meters per second
Height Of Water Column	30 meters
Tank Capacity	5000 m^3 $/s$
Power Output	32 kW
Efficiency	0.8

II.3.1 The source of water for this proposal

Using water tanks as a source of water for the production of electric energy Is a Common practice in hydro power generation. Hydro power Is a renewable source of energy That generates electricity by converting the energy of falling or flowing water into mechanical energy, which is then used to turn a generator to produce electricity.

In a hydropower system that uses water tanks, water is stored in the tank, typically at a higher elevation than the power generation site.

When electricity is needed, the water is released from the tank, and gravity pulls it down through a penstock (a pipe or channel) to the turbine at the power generation site. The force of the flowing water turns the turbine, which drives a generator to produce electricity.[16]

Figure II.7 Water tanks of 5000 m^(3)/s in Ouled sidi Ibrahim

Water tanks of 5000 $m^3\ /s$ can provide a significant amount of water for power generation. However, the actual amount of energy that can be generated Wil depend on virions factor,

such as the height difference between the water tank and the power generation site, the flow rate of the water, and the efficiency of the hydro power system.

II.3.2 Pelton turbine

The Pelton turbine is a type of water turbine that is well-suited for high head, low flow applications such as the one described in the theoretical study. It is designed to convert the energy of a high velocity jet of water into rotational mechanical energy that can be used to drive a generator to produce electricity.

In this system, the Pelton turbine would be positioned under the water tank, and water would be directed through a penstock or pipeline to the turbine. [10]

The high velocity jet of water would strike the Pelton wheel, causing it to spin and drive the generator to produce electricity.

The control system would regulate the flow of water through the turbine to optimize electricity production and ensure safety.

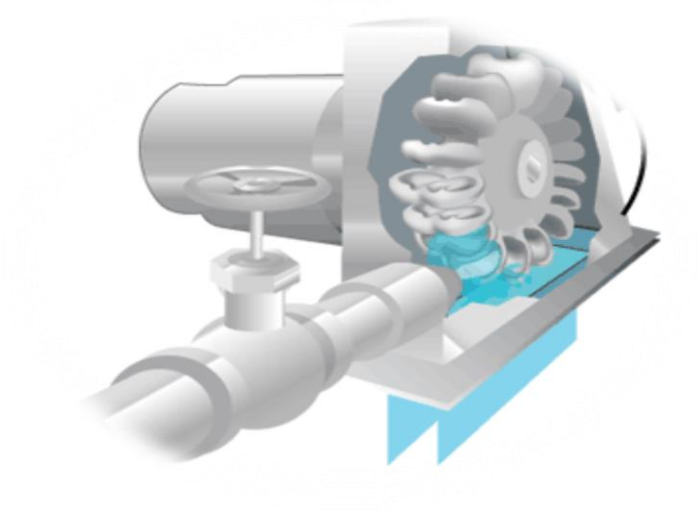


Figure II.8 Pelton Turbines Configuration

Assuming an efficiency of 90%, the 32-kw turbine and generator could produce 28.8 kw of electricity. With a water flow of 0.17 m^3/s cubic meters per second, the system could potentially produce 2476 kw/h of electricity per month (assuming 720 h in a month).

This amount of electricity could provide a significant portion of the energy needs for a Micro community or business.

II.3.3 Generator

Generators transform mechanical energy into electrical energy. Although most early hydroelectric systems were of the direct current variety to match early commercial electrical systems, nowadays only three-phase alternating current generators are used in normal practice Depending on the characteristics of the network supplied, we can choose[17]

II.3.3.1 Synchronous generators

are commonly used in small hydropower systems because they can operate at a constant speed, making them well-suited to work with the frequency of the electrical grid.

They can also be designed to operate at high efficiencies and provide high-quality electrical power with low levels of harmonic distortion.[9]

Control systems are often used with synchronous generators to regulate the voltage, frequency, and power output of the generator, ensuring stable operation and protection against overloading or other faults.

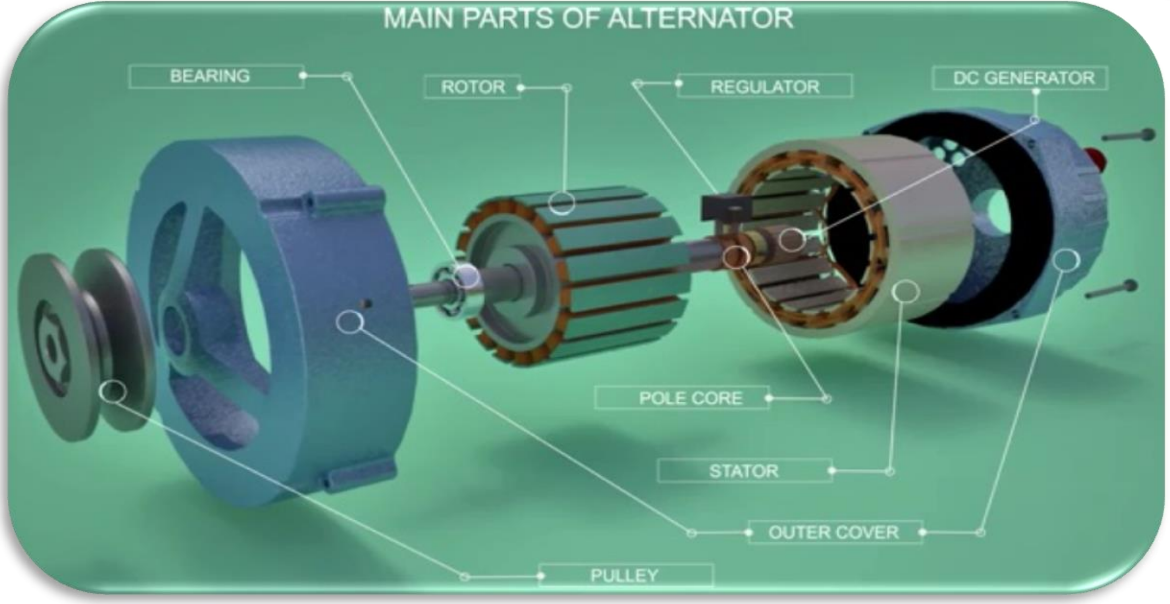
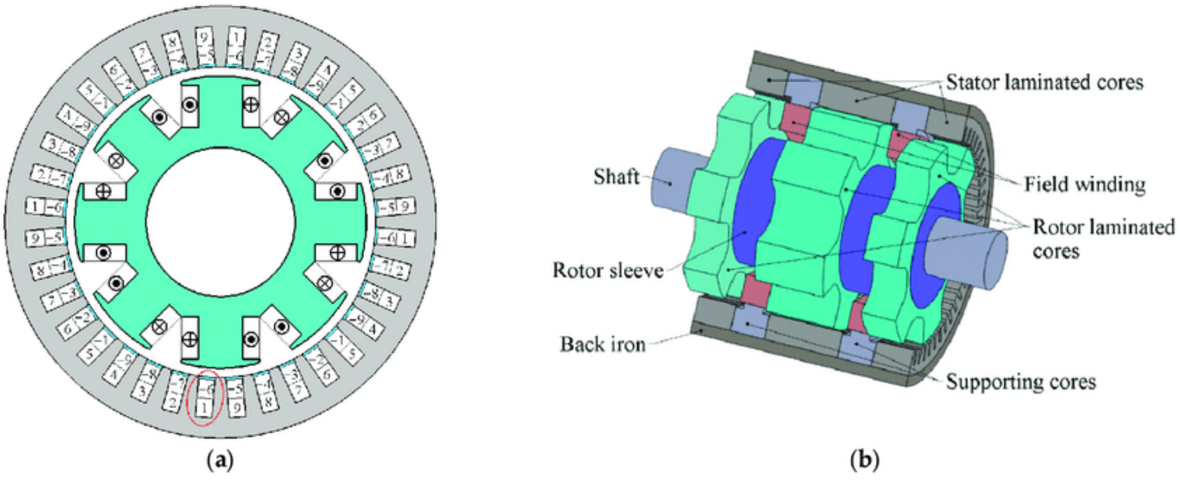


Figure II.9 The main parts of Alternator are rotor, stator bearing, slip-ring.

II.3.3.2 Wound rotor synchronous machine (WRSM)

wound rotor synchronous machine (WRSM) is a type of synchronous electric motor where the rotor is made up of a set of wound coils rather than a set of permanent magnets or a squirrel-cage winding. The stator in a WRSM is similar to that of a conventional synchronous machine, consisting of a set of three-phase windings that produce a rotating magnetic field. The rotor windings, on the other hand, are connected to slip rings rather than short-circuited, solid conductors.[9]



(a) (b)

Figure II.10 wound rotor synchronous machine (WRSM)

WRSMs are also commonly used in micro-hydropower applications, where they can be used to convert the mechanical energy from the flowing water into electrical energy. In micro-hydropower systems, the WRSM is typically coupled to a turbine or other mechanical device that is driven by the flowing water. The rotor of the WRSM is then used to generate an electrical current, which can be fed into a power grid or used to power local loads.[9]

The use of a WRSM in micro-hydropower applications offers several advantages over other types of electric generators. For example, the wound rotor design allows for greater control over the machine's performance characteristics, which can be important in micro-hydropower systems where the available water flow and head may vary over time. Additionally,

WRSMs can provide high starting torque and precise speed control, which can be important for maintaining stable power output in variable flow conditions.

II.3.3.3 The synchronous generator

The synchronous generator in our proposal is rated at a capacity of 20 kW and has a voltage output of 400V at a power factor of 0.8. It is designed to operate at a constant speed of 1500 rpm under continuous load. Additionally, it is equipped with a suitable bearing, excitation system, and all necessary auxiliary equipment required for coupling it to a horizontal shaft peltone turbine.

This configuration ensures the synchronous generator is able to operate efficiently and reliably, meeting the demands of our micro-hydropower system.

Figure II.11 wound rotor synchronous machine (WRSM)

Table 03: wound rotor synchronous Generator 20 kW

Parameter	Value
Power	20 kW
Voltage Output	400V
Power Factor	0.8
Speed	157rd/s
Load Type	Alternating AC
Coupling	Horizontal Shaft Peltton Turbine
Efficiency and Reliability	90% 85%
Numbers of Phases	3

II.3.3.4 The asynchronous motor and water pump

An asynchronous motor with a power output of 18 kW can be used to drive a water pump in a variety of applications. The selection of the motor and pump would depend on the specific requirements of the application, such as flow rate, head, and fluid properties.[18]

A Water Pump driven by a 18 kW asynchronous motor would be capable of delivering a substantial amount of water flow and pressure. For example, a typical centrifugal pump with a 18 kW motor might be able to deliver a flow rate of several hundred cubic meters per hour and a head of several tens of metres.[19]

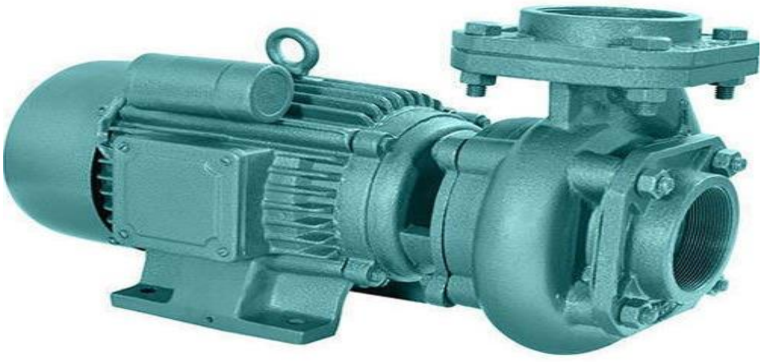


Figure II.12 Asynchronous Motors 18 KW

There are many factors to consider when selecting a motor and pump for a water pumping application, including the type of pump (e.g., centrifugal or positive displacement), the desired flow rate and pressure, the

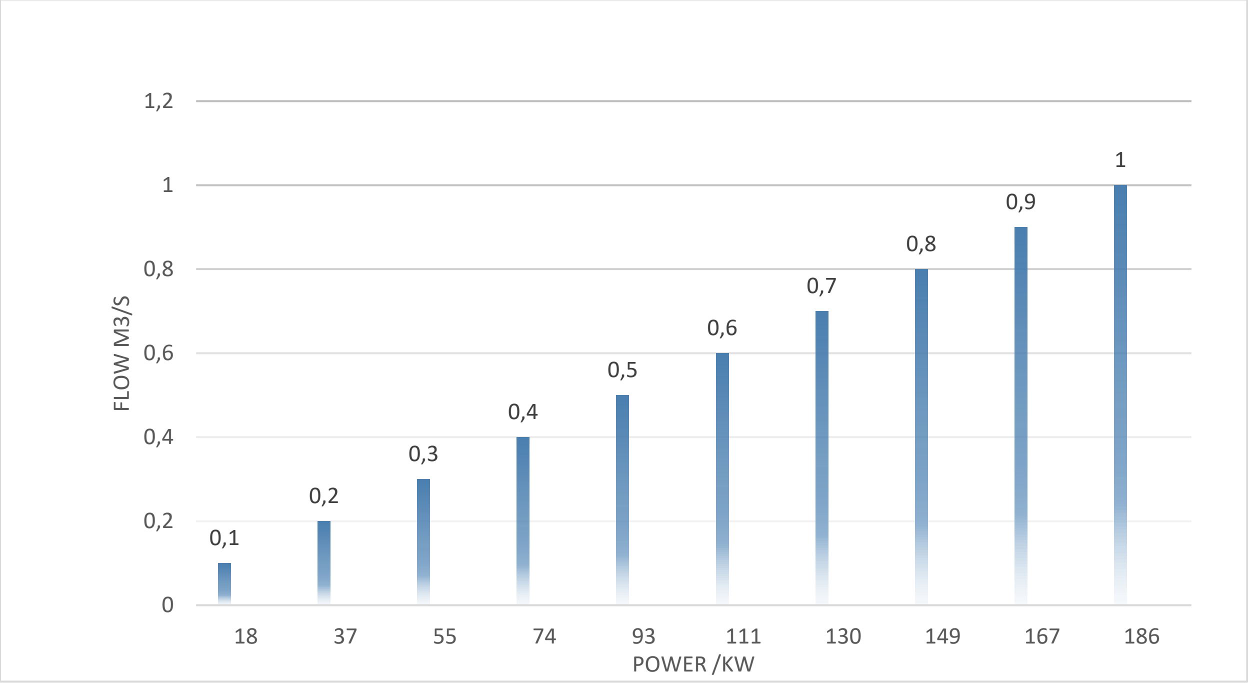
type of fluid being pumped, and the operating environment (e.g., temperature, humidity, and altitude). It's important to select equipment that is well-matched to the specific application to ensure reliable and efficient operation[12].

Table 03 : Asynchronous Motor 18 KW

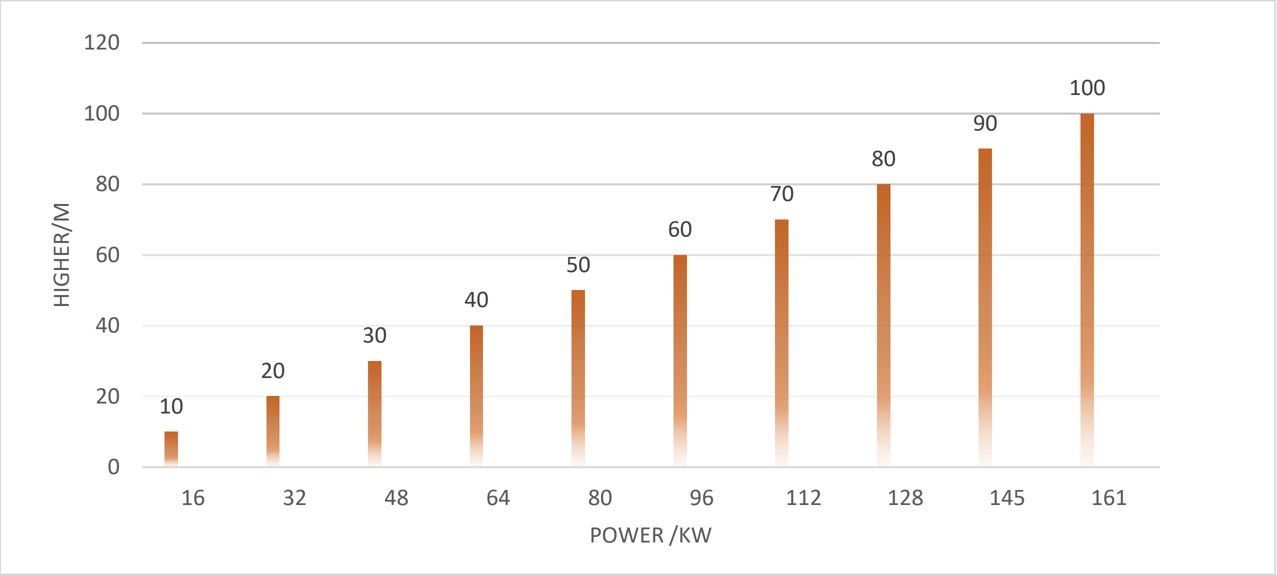
Parameter	Value
Power	18 kW
Voltage Output	400V
Power Factor	0.8
Speed	157 rd/s
Load Type	Alternating AC
Hz	50
Efficiency and Reliability	90% 85%
Hp	21

II.4 Conclusion

the specific design and capacity of the micro-hydropower system will indeed depend on the characteristics of the water source at the installation site. The height of the water source, or "head," and the flow rate of the water will both play important roles in determining the optimal size and type of turbine and generator for the system. In general, higher heads and greater flow rates will allow for larger and more powerful turbines and generators to be used. It's important to carefully evaluate the site and the available water resources to ensure that the system is designed to maximize efficiency and generate the desired amount of electrical energy.



Note the value of the Higher is constant 20m



Note the value of the flow is constant 0,17m3/

Chapter 03

III. Modeling the proposal system

III.1 Introduction

In the third chapter of wer work, we model and simulate all the components of a micro hydro power system using MATLAB. This involves creating mathematical models of the turbine, generator, asynchronous motor, and other components, and simulating their performance under various conditions.[19], [20]

III.2 Modeling of the conversion chain of proposal system

The modeling and simulation process allows we to optimize the performance and efficiency of the micro hydro power system by testing different scenarios and identifying areas for improvement. For example, we can simulate the impact of changes in flow rate or head height on the performance of the system, and adjust the design and configuration of the components to improve efficiency and reliability.[10]

By modeling and simulating all the components of the micro hydro power system, we can also identify potential problems or limitations before construction, which can help to avoid costly mistakes or delays. The simulation results can also be used to guide the selection of specific components and to optimize the overall design of the system.

To model this water tank system with a 22 kW turbine, a 20 kW generator, and a 18 kW motor with a water pump using MATLAB, we would create mathematical models for each component and simulate their performance under various conditions. Here's an overview of how we might approach each component:

Water tank: The water tank has a capacity of 5000 cubic meters. To model the water tank, we would use a simple mass balance equation to track the amount of water in the tank over time. This equation would take into account the inflow of water from the turbine, as well as the outflow of water to the motor and pump.

Turbine: The turbine is designed to produce 22 kW of power. To model the turbine, we would use a set of equations to describe the flow of water through the turbine, as well as the torque and power output of the turbine. These equations would take into account factors such as the flow rate of water, the head height of the water source, and the design of the turbine blades.

Generator: The generator is designed to produce 20 kW of electrical power. To model the generator, we would use a set of equations to describe the electrical output of the generator, as well as the efficiency of the generator in converting mechanical power from the turbine into electrical power.

Motor used in the system has a power rating of 18 kW, then we would include this power rating in wer mathematical model for the motor component. The equations used to model the motor's electrical power input and mechanical power output would need to take into account this power rating, along with other factors such as the efficiency of the motor and the flow rate of water required to drive the motor.

the modeling and simulation of this water tank system with a pump that extracts water from a well and pumps it into a reservoir using MATLAB provides a powerful tool for designing and optimizing micro hydro power systems. By simulating the performance of each component and the system as a whole, we can make informed decisions about the design and configuration of the system, and ensure that it operates safely, efficiently, and reliably over its lifetime

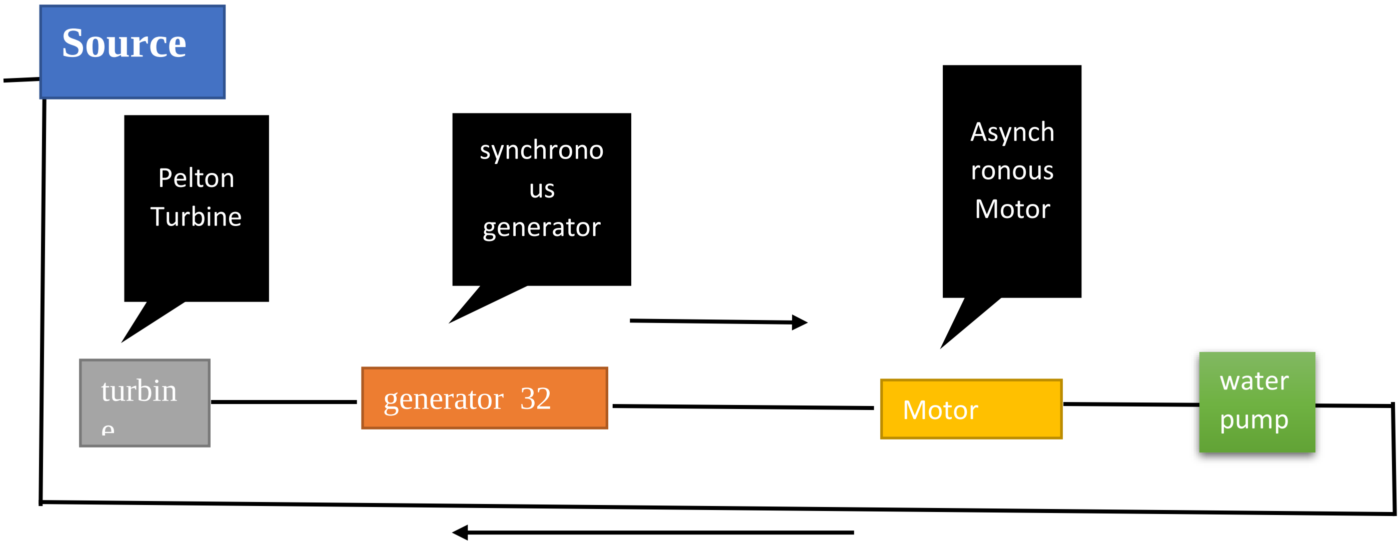


Figure III.1 hydropower system

III.3 Modeling of source water

Modeling a water source for a micro-hydropower system, there are several factors that need to be considered, such as the flow rate and head of the water, the shape and size of the intake structure, and the hydraulic characteristics of the pipeline or penstock that carries the water to the turbine.

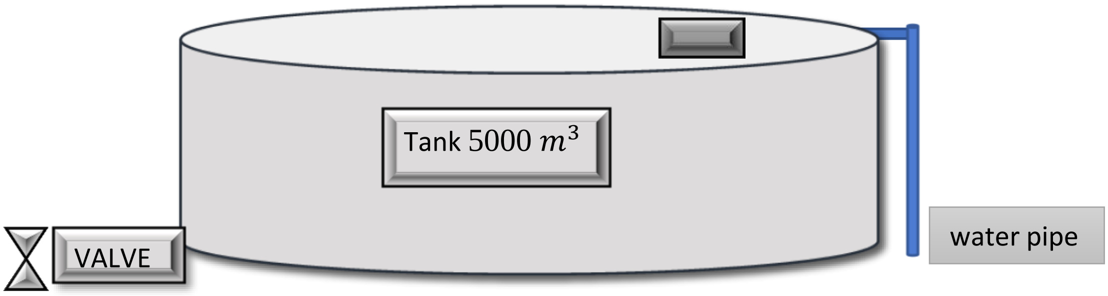


Figure III.2 Tank 5000 m^ (3)

III.3.1 Bernoulli equation

The Bernoulli equation is a fundamental principle in fluid dynamics that relates the pressure, velocity, and height of a fluid along a streamline. It is based on the conservation of energy principle and can be used to predict the behavior of fluids in a wide range of applications, including pipes and other fluid flow systems.

According to the Bernoulli equation, the pressure difference between two points in a fluid flow system is related to the difference in velocity and height between those points. Specifically, the equation states that the total energy per unit mass of a fluid is conserved along a streamline, which can be expressed as:[21]

$$\mathbf{P + (1/2)\ \rho v^{2} + \rho g h = constant}$$

Where:

P : is the pressure,

P : is the density of the fluid,

V : is the velocity of the fluid,

G : is the acceleration due to gravity,

H : is the height above a reference point,

and the constant is the total energy per unit mass of the fluid.

From this equation, we can see that as the velocity of the fluid increases, the pressure decreases. This is because the total energy per unit mass of the fluid must remain constant, so an increase in kinetic energy (represented by the velocity term) must be balanced by a decrease in potential energy (represented by the pressure term).

In the context of a pipe system, the Bernoulli equation can be used to calculate the velocity of fluid exiting the pipe based on the pressure difference between the inlet and outlet. This can be useful for designing and optimizing pipe systems for various applications, such as in hydraulic systems or fluid transport systems

III.3.2 Mathematical equations

In practice, the power input equation may need to be modified to take into account factors such as losses due to friction in the pipeline or penstock, variations in water flow rate, and changes in the head due to changes in the water level or topography.

However, the basic form of the equation provides a useful starting point for modeling the power input to a micro-hydropower system that uses a water source.

This equation that the power input to the system is directly proportional to the flow rate of water, the head of the water source, and the overall efficiency of the system.[21]

III.3.3 Water flow rate equation

$Q = A * V$

Q : is the flow rate of water,

A : is the cross-sectional area of the turbine inlet,

V : is the velocity of water.

III.4 Modeling water turbine

Water turbine modeling can be a complex and challenging task due to the complex interactions between the fluid flow, mechanical components, and control systems. However, it is essential for designing and optimizing efficient and reliable water turbines for renewable energy generation.[2]

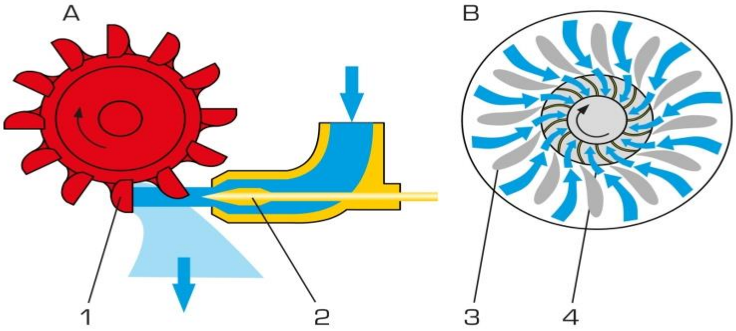


Figure III.3 A Pelton turbine working principle: 1 Pelton wheel with vanes, 2 adjustable nozzle needle; B Francis turbine working principle: 3 guide vanes, 4 rotor

III.4.1 Power equation of turbine water

The power input equation for a micro-hydropower system that uses a water source can be expressed as:

$$\mathbf{P = \eta \rho g Q H}$$

Where:

P : is the power input to the system in watts (W)

ρ : is the density of water in kilograms per cubic meter (kg/m^3)

g : is the acceleration due to gravity in meters per second squared (m/s^2)

Q : is the flow rate of water in cubic meters per second (m^3/s)

H : is the head, which is the difference in elevation between the water source and the turbine intake, in meters (m)

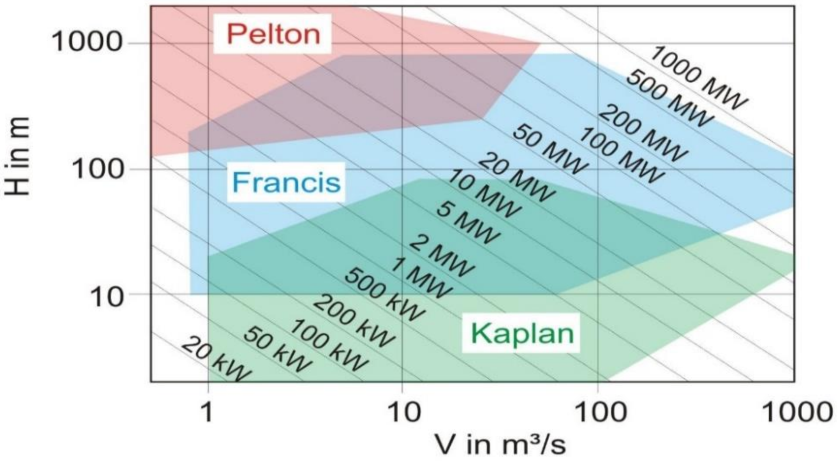


Figure III.4 Pelage utilisation des turbines Pelton

III.5 Modeling synchronous generators

Modeling Synchronous Generators refers to the process of creating mathematical models to simulate the behavior and performance of synchronous generators. Synchronous generators are widely used in power systems to convert mechanical energy into electrical energy.

They operate at a constant speed that is synchronized with the frequency of the AC power system, hence the name synchronous.[10]

To model a synchronous generator, various parameters such as the stator resistance, reactance, rotor resistance, and reactance are considered.

The model can be used to simulate the generator's response to changes in the electrical and mechanical inputs, including variations in load, excitation, and speed.[22]

These models can help power system engineers to analyze and optimize the performance of the synchronous generator in a power system, ensuring reliable and stable power generation.

Figure III.5 synchronous magnet machine.

III.5.1 General structure of wound rotor synchronous (WRSM)

The general structure of a permanent magnet synchronous machine is shown in the following figure:[23]

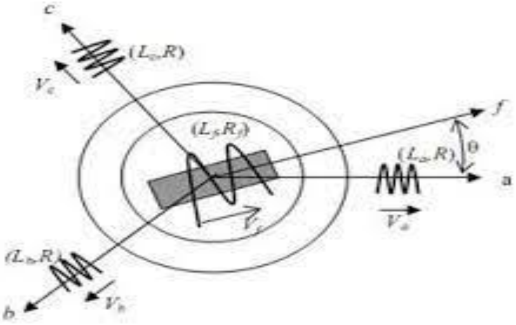


Figure III.6 Diagram of the MSAP

The stator has three identical phases, a, b, and c, which are shifted from each other by an electrical angle of **$(\frac{2\pi}{3})$.** On the other hand, the rotor has two axes characterized by:

- A longitudinal magnetization axis (d);
- A quadrature interpolar axis (q), phase-shifted by (2/π) with respect to the (d) axis;
- The position of the rotor is identified by the electrical

$\theta = \theta + \omega t$

where

θ_0 is the initial electrical angle,

ω is the electrical angular frequency

III.5.2 Electrical equations

$$\left\{ \begin{array}{l} [v] = [Rs].[i] + \frac{d[\varphi]}{[dt]} \\ [\varphi] = [Ls]\ [i] + \varphi f \end{array} \right\} \qquad \text{(III.1)}$$

V : stator voltage vector;

I : stator current vector;

RS : Stator phase resistance;

LS : Stator inductance matrix (self and mutual inductance)

So the system [1] becomes:

$$\begin{Bmatrix} [va] = [Rs].[ia] + \frac{d[\varphi a]}{[dt]} \\ [vb] = [Rs].[ib] + \frac{d[\varphi b]}{[dt]} \\ [vc] = [Rs].[ic] + \frac{d[\varphi c]}{[dt]} \end{Bmatrix} \qquad (III.2)$$

III.5.3 Mechanical equation

Translation: The equation of the dynamics of the WRSM is given as follows:

$$C_m - C_{em} - C_f = J \frac{d\Omega}{dt} \qquad (III.3)$$

$$C_f = f_c \, \Omega$$

With:

Ω : machine rotation speed ($\Omega = \frac{\omega r}{p}$)

Cm : motor torque;

Cem : electromagnetic torque;

Cf : friction torque;

J : moment of inertia of the rotating machine;

p : number of pole pairs;

ωr : rotor electrical speed;

fc : friction coefficient

III.5.4 Park transformation

In order to eliminate the nonlinearity of the system of differential equations, variable transformations are performed to reduce the complexity of the system.[10]

In three-phase electrical machines, this variable transformation involves converting the three windings corresponding to the three phases into orthogonal windings (d, q) rotating at a speed of ωr.

The Park equation represents the transition from the three-phase system to the two-phase (d, q) system, given by

$$[\mathrm{Fabc}] = [\mathrm{P}(\theta)][\mathrm{Fdqo}]$$

$$[\mathrm{Fdqo}] = [\mathrm{P}(\theta)]^{-1}[\mathrm{Fabc}]$$

With :

d : Axe direct (ou axe de flux) dans le système d'enroulements orthogonaux (d, q).

q : Axe en quadrature (ou axe de couple) dans le système d'enroulements orthogonaux (d, q). ωr : Vitesse de rotation du système d'enroulements orthogonaux (d, q)

With:

$$[\mathrm{P}(\theta)]=\sqrt{\frac{2}{3}}\begin{bmatrix} \frac{1}{\sqrt{2}} & \cos(\theta) & \sin(\theta) \\ \frac{1}{\sqrt{2}} & \cos\left(\theta-\frac{2\pi}{3}\right) & \sin\left(\theta-\frac{2\pi}{3}\right) \\ \frac{1}{\sqrt{2}} & \cos\left(\theta+\frac{2\pi}{3}\right) & \sin\left(\theta+\frac{2\pi}{3}\right) \end{bmatrix}$$

Then P^{-1} becomes as follows:

$$[\mathrm{P}(\theta)]^{-1}=\sqrt{\frac{2}{3}}\begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \cos & -\frac{2\pi}{3} & -\frac{4\pi}{3} \\ -\sin & -\frac{2\pi}{3} & -\frac{4\pi}{3} \end{bmatrix}$$

The angle θ Is defined as follows

$$\omega = \frac{d\theta}{dt}$$

Where:

θ: : Angle between the Magnetic axis (a) and the longitudinal axis (d).

ω : Rotational speed of the chosen reference frame

Depending on the choice of ω, we distinguish:

III.5.5 Stator-linked reference frame

When the stator is fixed, the speed of the Park reference frame is:

$$\omega\theta = \omega S = 0$$

III.5.6 Rotor-Linked Reference Frame

This case, the speed of the (d, q) reference frame is the rotor speed, that is, ωr:

$$\omega\theta = \omega r$$

III.5.7 Field-Oriented Reference Frame

The speed of the park reference frame is the speed of the field-oriented reference frame:

$$\omega\theta = \omega$$

ω: Angular frequency of the power supply

the equations for the fluxes in the park transformation:

Flux d-axis (direct axis):

$$\psi d = Lmd * id + \psi pm * \cos(\theta) + Ls * iq * \sin(\theta)$$

Flux q-axis (quadrature axis) :

$$\psi q = Lmq * iq - \psi pm * \sin(\theta) + Ls * iq * \cos(\theta)$$

Where:

ψd : Flux in the d-axis (direct axis).

ψq : Flux in the q-axis (quadrature axis).

Lmd : d-axis mutual inductance.

Lmq : q-axis mutual inductance.

Ls : stator self-inductance.

id : current in the d-axis (direct axis).

iq : current in the q-axis (quadrature axis).

ψpm : permanent magnet flux.

θ : Angle between the magnetic axis (a) and the longitudinal axis (d).

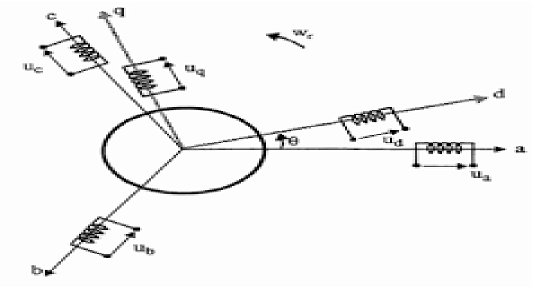


Figure III.7 Repository a,b,c and Repository d,q

III.5.8 State equations of the WRSM

We seek to obtain a system of equations in the form of state equations:

$$[\mathrm{x}] = [\mathrm{i\ d} \quad \mathrm{iq}]^T \text{and } [\mathrm{x}] = [0 \quad \varphi\ ]^T$$

The equations can be written in matrix form:

$$\begin{bmatrix} \frac{d}{dt}\ idc \\ \frac{d}{dt}\ iqc \end{bmatrix} = \begin{bmatrix} -\frac{Rs+Rs}{Ld+Lch} & \omega r\frac{Lq+Lch}{Ld+Lch} \\ -\omega r\frac{Ld+Lch}{Lq+Lch} & -\frac{Rs+Rs}{Ld+Lch} \end{bmatrix} = \begin{bmatrix} id \\ iq \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{\omega\varphi f}{Ld+Lch} \end{bmatrix}$$

We can write the matrices [A] and [B] in the form:

$$[A]=.\begin{bmatrix}\frac{d}{dt}\ idc\\ \frac{d}{dt}\ iqc\end{bmatrix}=\begin{bmatrix}-\frac{Rs+Rch}{Ld+Lch} & 0\\ 0 & -\frac{Rs+Rch}{Lq+Lch}\end{bmatrix}+\omega\begin{bmatrix}0 & \frac{Lq+Lch}{Ld+Lch}\\ -\frac{Ld+Lch}{Lq+Lch} & 0\end{bmatrix}$$

$$[\,B] = \frac{\omega}{Lq + Lch}\begin{bmatrix}0\\ \varphi f\end{bmatrix}$$

III.6 Modelling of the asynchronous motor

Modelling an asynchronous motor is an important task in the field of electrical engineering, as it allows engineers to analyze the behavior of the motor under different operating conditions and design control strategies to regulate its speed and torque. An asynchronous motor, also known as an induction motor, is a type of AC motor that operates based on the principle of electromagnetic induction. It consists of a stator, which contains a set of stationary windings, and a rotor, which contains a set of conductive bars arranged in a cylindrical shape.[18]

In this context, modelling a motor asynchronous 25kW involves determining the various parameters that describe the motor's electrical and mechanical characteristics, such as its rated voltage, current, power factor, efficiency, synchronous speed, number of poles, and torque. [18]These parameters are used to create a mathematical model of the motor, which can then be simulated using as MATLAB/Simulink . The simulation allows engineers to analyze the motor's performance under different operating conditions, such as different load torques and speeds, and design control strategies to regulate its speed and torque.

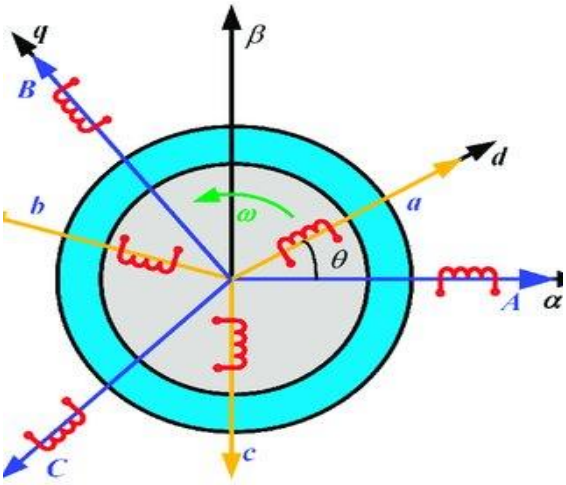


Figure III.8 motor asynchronous

III.6.1 Some of the most common ones

The asynchronous machine is represented by 6 windings 3 in the stator and 3 in the rotor as follows:

$$\begin{array}{ll} Vsa = Vm*Cos\,(2\pi Ft) & Vra = Vm*Cos\,(2\pi Ft) \\ Vsb = Vm*Cos\,(2\pi Ft\frac{2\pi}{3}) & Vrb = Vm*Cos\,(2\pi Ft\frac{2\pi}{3}) \\ Vsc = Vm*Cos\,(2\pi Ft\frac{-4\pi}{3}) & Vrc = Vm*Cos\,(2\pi Ft\frac{-4\pi}{3}) \end{array} \quad (III.4)$$

Vsa, Vsb and Vsc (V): a-axis, b-axis and c-axis components of the stator voltage vector Vs.

Vra, Vrb and Vrc (V): a-axis, b-axis and c-axis components of the stator voltage vector Vr.

III.6.2 Electrical equations

There are many electrical equations that are used in electrical engineering. Here are

$$[v\,s] = [Rs\,].[is\,] + \frac{d[\varphi\,s]}{[\,dt]} \qquad [(III.5)$$

$$[v\,r] = [Rr\,].[ir\,] + \frac{d[\varphi\,r]}{[\,dt]}$$

The appropriate subscripts as, bs, cs, ar, br, and cr, the voltage equations of the magnetically coupled stator and rotor circuits can be written as follows:

$$\begin{Bmatrix} [vas] = [Rs\,].[ias\,] + \frac{d[\,\varphi as]}{[\,dt]} \\ [vbs] = [Rs\,].[ibs] + \frac{d[\varphi bs\,]}{[\,dt]} \\ [vcs\,] = [Rs\,].[ics\,] + \frac{d[\varphi c\,s]}{[\,dt]} \end{Bmatrix} \qquad \begin{Bmatrix} [var] = [Rr\,].[iar\,] + \frac{d[\,\varphi ar]}{[\,dt]} \\ [vbr] = [Rr\,].[ibr] + \frac{d[\varphi br\,]}{[\,dt]} \\ [vcr] = [Rr\,].[icr] + \frac{d[\varphi c\,r]}{[\,dt]} \end{Bmatrix} \qquad (III.6)$$

The mathematical model in question comprises a complex system of six differential equations with coefficients that vary periodically over time. Even with the aid of numerical tools, solving this system can be challenging. However, a solution to this problem is to employ the three-phase to two-axis voltage transformation technique. This technique converts a three-phase system (a, b, c) to a two-phase system (d, q),

$$[vsd] = \sqrt{\frac{2}{3}}(vsa - \frac{1}{2}vsb - \frac{1}{2}vsc \qquad (III.7)$$

$$[vsq] = \sqrt{\frac{2}{3}}(vsa - \frac{\sqrt{3}}{2}vsb - \frac{\sqrt{3}}{2}vsc$$

In the electrical model, the two-phase voltage [Vds, Vqs, Vdr, Vqr] is the input and the current vector [ids, iqs, idr, iqr] is the output vector. The rotor voltage vector is normally zero because of the shortcircuited cage rotor winding, Vdr=0 and Vqr=0

$$\begin{aligned}
[\mathrm{vds}] &= [\mathrm{Rs}].[\mathrm{ids}] - \omega s\varphi ds + \frac{d[\varphi ds]}{[dt]} \\
[\mathrm{vqs}] &= [\mathrm{Rs}].[\mathrm{iqs}] + \omega s\varphi qs + \frac{d[\varphi qs]}{[dt]} \\
[\mathrm{vdr}] &= [\mathrm{Rr}].[\mathrm{idr}] - \omega r\varphi dr + \frac{d[\varphi dr]}{[dt]} = 0 \\
[\mathrm{vqr}] &= [\mathrm{Rr}].[\mathrm{iqr}] + \omega r\varphi dr + \frac{d[\varphi dr]}{[dt]} = 0
\end{aligned} \tag{III.8}$$

- Ids, Iqs : D-Axis And Q-Axis Components of The Stator Current Vectors Is (A).
- Idr, Iqr : D-Axis And Q-Axis Components of The Rotor Current Vectors Ir (A).
- Rr : Rotor Resistance (Ω).
- Rs : Rotor Resistance (Ω).
- ωS, ωR : Stator and Rotor Electrical Heartbeat (rad /s).
- ϕS, ϕR : Stator and Rotor Fluxes Linkage.

III.6.3 Magnetic equation

In matrix notation, the flux linkages of the stator and rotor windings may be written in terms of the winding inductances and the current in the reference

$$[\Phi s] = [\mathrm{Ls}].[\mathrm{Is}] - [\mathrm{Msr}].[\mathrm{Is}] \tag{III.9}$$

$$[\Phi r] = [\mathrm{Lr}].[\mathrm{Ir}] + [\mathrm{Msr}].[\mathrm{Ir}]$$

- Ls (H) : stator inductance.
- Lr (H) : rotor inductance.
- M (H) : Mutual Inductance between the stator and the rotor
- Is, Ir : Stator and rotor currents.

III.6.4 Equations of power and torque

The conversions keep instantaneous power. The last power will be written:

$$[\mathrm{Pi}] = [\mathrm{Rs}] + [\mathrm{Rs}].[\mathrm{Is}q^2] + \frac{d[\varphi sd]}{[dt]} * \mathrm{Isd} + \frac{d[\varphi sq]}{[dt]} * \mathrm{Isq} + \omega s(\varphi sd * \mathrm{Isq} * \mathrm{Isd} \tag{III.10}$$

The first term is easily identifiable in joule losses; the second term corresponds to electromagnetic power; the third term represents therefore the electrical power transformed into mechanical power.In the twoaxis stator reference frame, the electromagnetic torque Ce is given by:

$$Pe = Ce * \Omega s = \omega s(\phi sd * isq - \phi sq * isd)$$

$$Ce = \frac{Pe}{\Omega s} = \frac{\omega s}{\Omega s} * (\phi sd * isq - \phi sq * isd) \qquad \text{(III.11)}$$

$$Ce = P * (\phi sd * isq - \phi sq * isd)$$

$$Ce = P * M(isq * ird - isd * isq)$$

- Ωs : stator angular electrical frequency (rad /s)
- Ce : Electromagnetic torque (Nm)
- P : Pole Numbers

III.6.5 Mechanical equation

part of induction motor can be described by (9), where is angular rotor velocity, J- moment of inertia, Cr - mechanical torque, Ce electromagnetic torque

$$J\,.\frac{d\Omega r}{dt} = Ce - Cr \qquad \text{(III.12)}$$

III.6.6 Induction motor slip and efficiency of asynchronous motor

The motor slip between the swivel field and the rotor is spelt as follows:

$$g = \frac{\Omega s - \Omega}{\Omega s} \qquad \text{(III.13)}$$

The efficiency of the machine varies according to their power is given by:

$$\eta = \frac{Pa}{Pu} \qquad \text{(III.14)}$$

- Pa : Absorbed power

- Pu : Output Power

III.7 Modelling of the water pump

Modelling and simulation of a water pump is an important task in the field of mechanical and electrical engineering, as it allows engineers to analyze the behavior of the pump under different operating conditions and design control strategies to regulate its flow rate and pressure.

A water pump is a mechanical device that is used to transport water from one location to another, such as from a well to a storage tank.[19]

$$Q(L/min) = \frac{\left(\frac{\mathrm{p} * \eta}{1000}\right) * 3600 * 106}{\mathrm{p} * H * g * 60}$$

Where:

- Q : Pump discharge in L/min
- P : Power available at motor shaft in W
- p : Density of water = 1000 kg / m3
- H : Lifting head in meter
- g : Gravitational acceleration = 9.8 m/ s2
- η : Pump Efficiency = 75%

The pump receives input mechanical power from the motor and gives the output as water flow ‘Q’ in L/min.

The water flow ‘Q’ of the pump is calculated using the equation

Chapter 04

IV. Simulation and Results of the system

IV.1 Simulation of proposal system

To simulate the performance of the micro hydropower system, the global conversion chain simulation solves the equations for each component of the system and calculates the overall efficiency and power output of the system.

The simulation can also be used to predict the performance of different turbine and generator configurations, as well as to analyze the impact of different operating conditions (such as changes in flow rate or load demand) on the performance of the system[20]

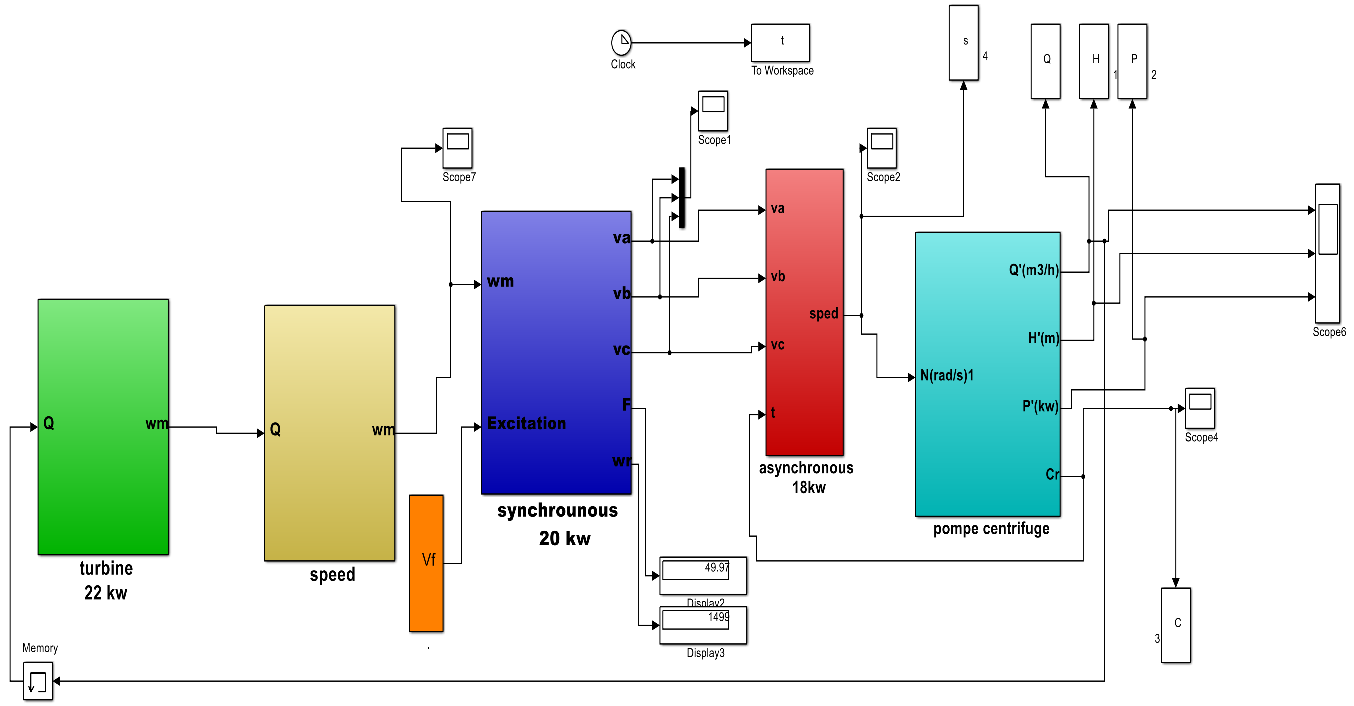


Figure IV.1 Block diagram of proposal system

IV.1.1 Turbine simulation results

The figures IV.2 below represent the results of the block diagram simulation for Turbines

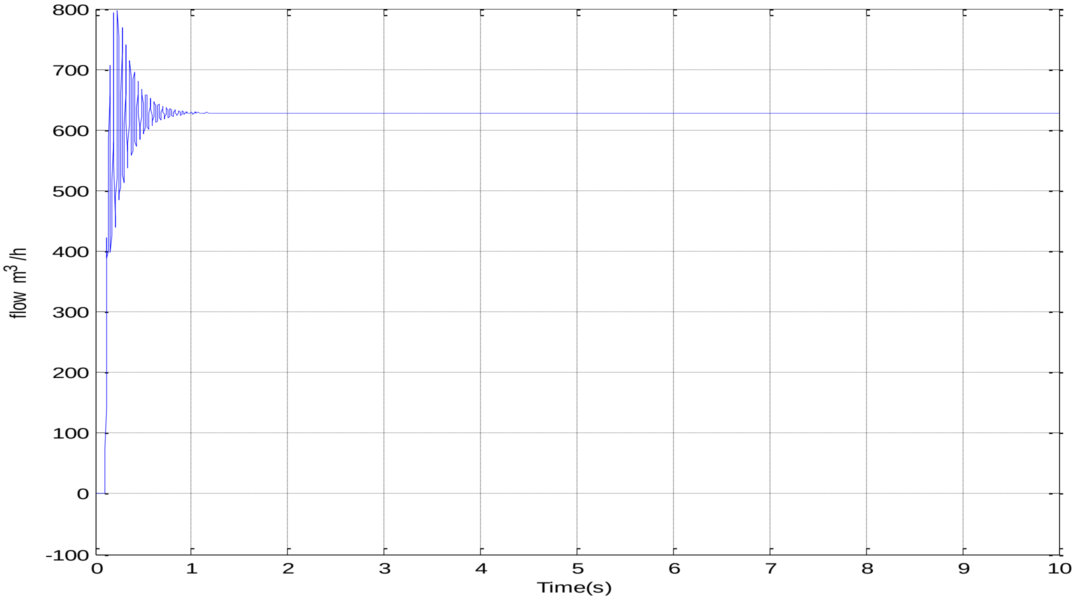


Figure IV.2 The water flow is constant at 630m^ (3)/h

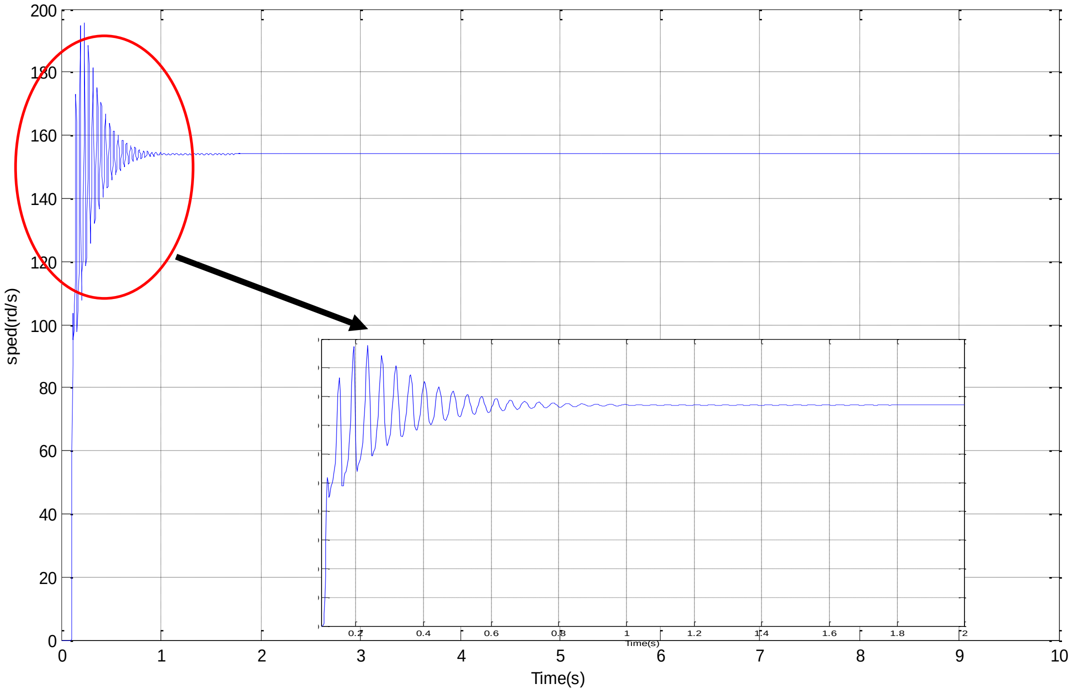


Figure IV.3 The speed of the water flow profile (constant speed)

IV.2 Simulation of the alternator results

The simulation a wound rotor. The wound rotor is a type of electric motor that has a winding on the rotor. This winding can be used to control the speed and torque of the motor.

We Presented The different types of wound rotor and the structure synchronous machine, as well as its mathematical modeling using the Park transformation.

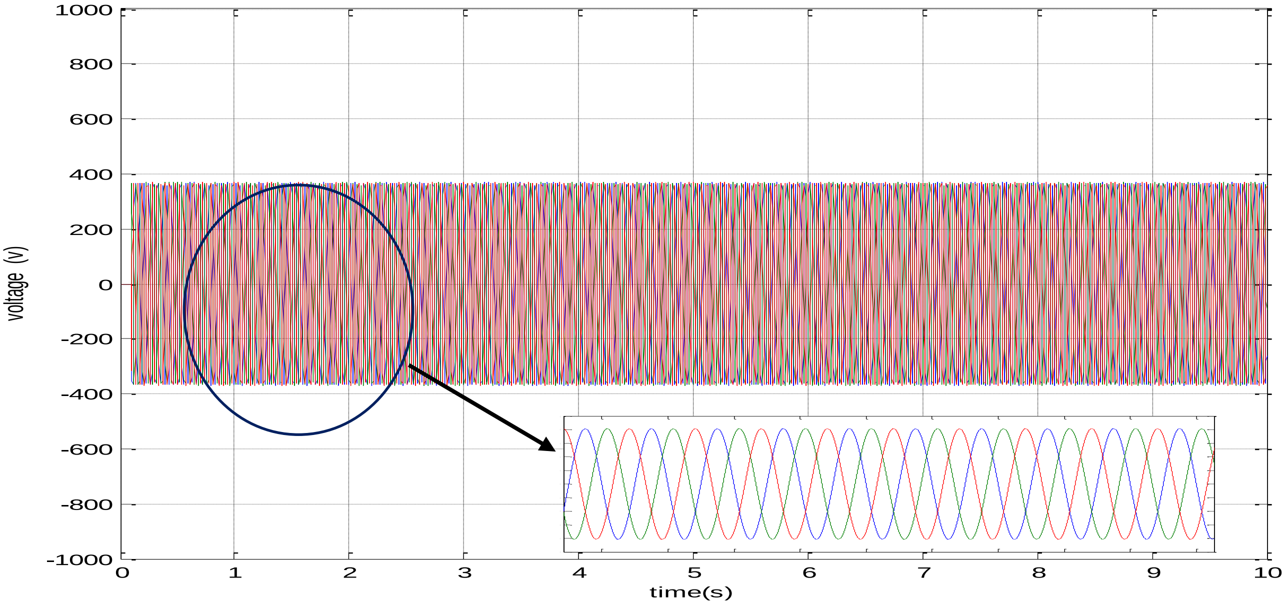


Figure IV.4 stator voltages

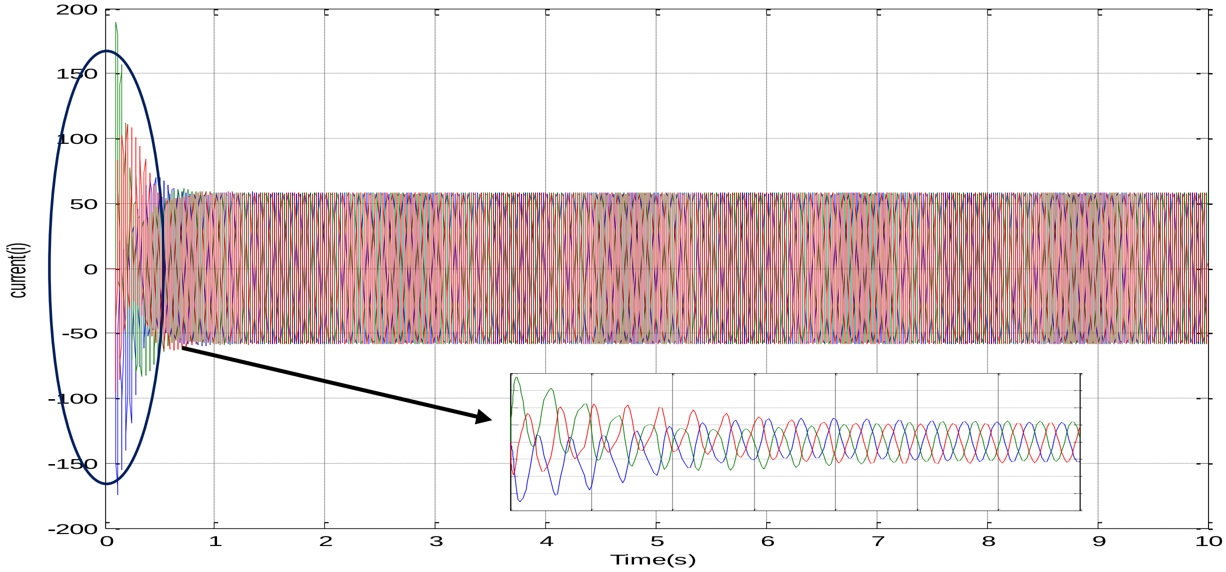


Figure IV.5 Stator current Is

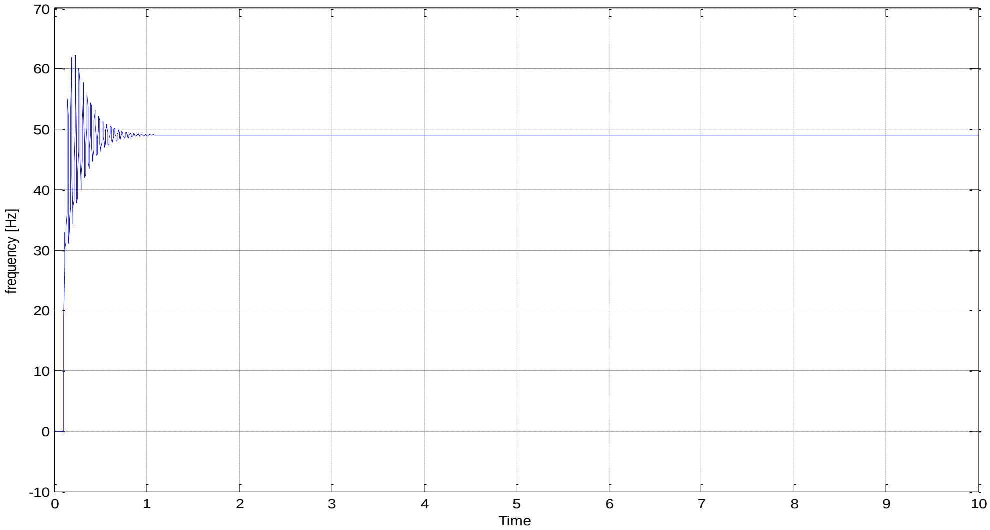


Figure IV.6 Alternator frequency

IV.3 Simulation of an asynchronous machine results

The simulation of an asynchronous machine is an important aspect control strategies to regulate its speed and torque. Asynchronous machines, also known as induction machines, are widely used in industrial applications, such as pumps, compressors, and fans, due to their robustness, reliability, and low cost. [18]

The induction motor was the motor of 22 KW power and electrical parameters: nominal current, in 50 A = stator resistance Rs= 0.22 Ω, stator inductance Ls=0.0425 H, rotor resistance, Rr= 0.28 Ω, rotor inductance, Lr = 0.043 H, mutual inductance M= 0.04, the simulation results are given for the induction motor system at different reference speed and load torque: NS = 1500 tr/min and Cr =130 Nm

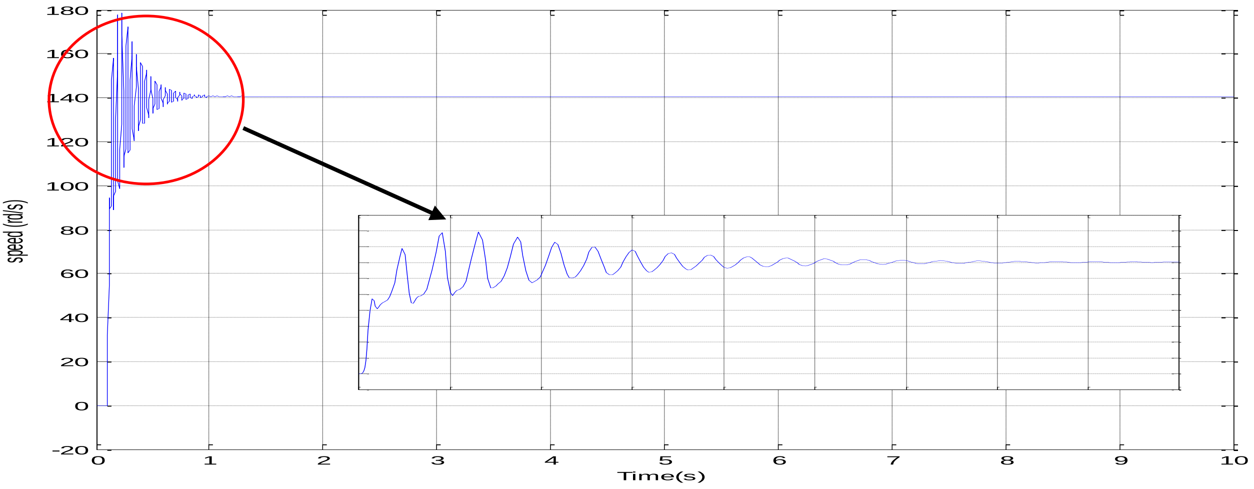


Figure IV.7 Evolution of the mechanical speed during simulation

Figure IV.7 shows the evolution of the mechanical speed during the no-load and coupled load simulation. The speed shows oscillations in the first moments of starting, then stabilizes at a value close to 140 rad/s.

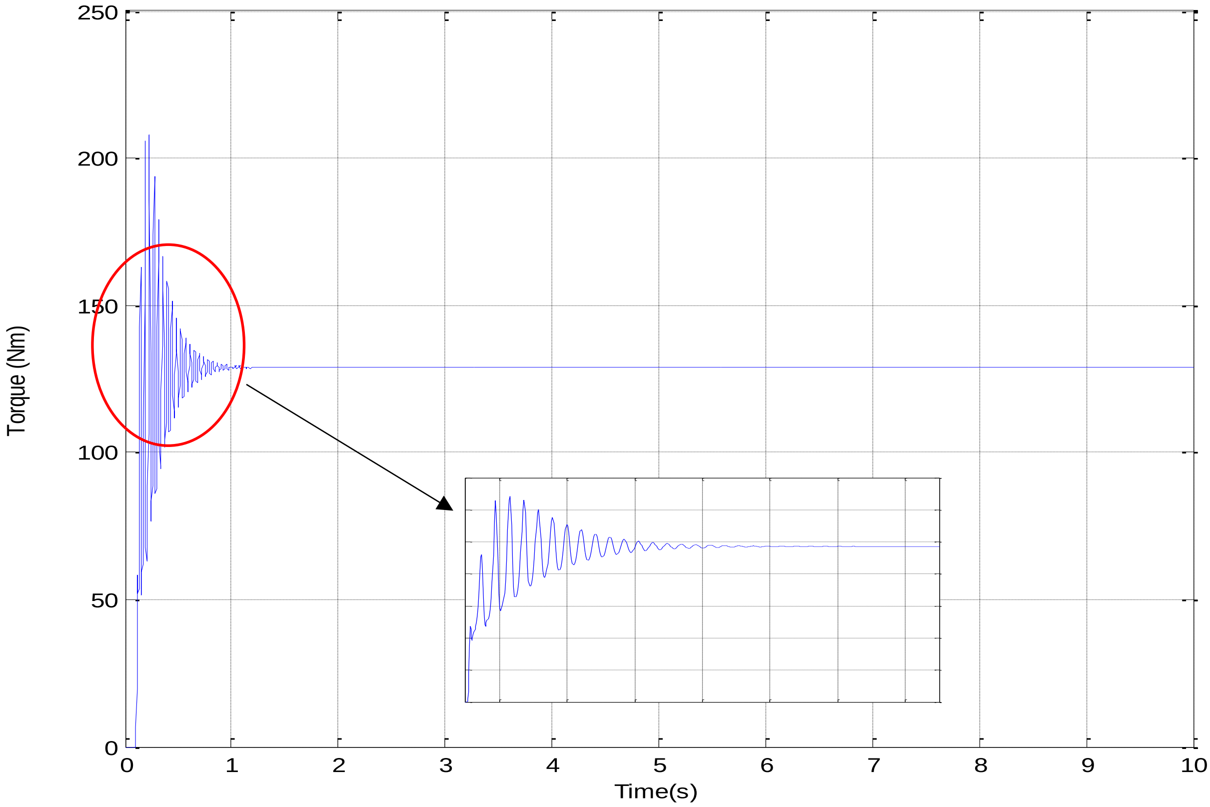


Figure IV.8. Torque characteristic

Figure IV.08. shows the torque is a measure of the rotational force that is applied to an object, such as a pump end motor.

IV.4 Simulation of the water pump

The complete Simulink model water pumping system is developed as illustrated

In Simulink, we can create a simulation model of a water pumping system by using various blocks that represent different components of the system.

These components typically include a water source, a pump, pipes, valves, and a water tank or reservoir.

IV.4.1 Results of a simulation of the pump

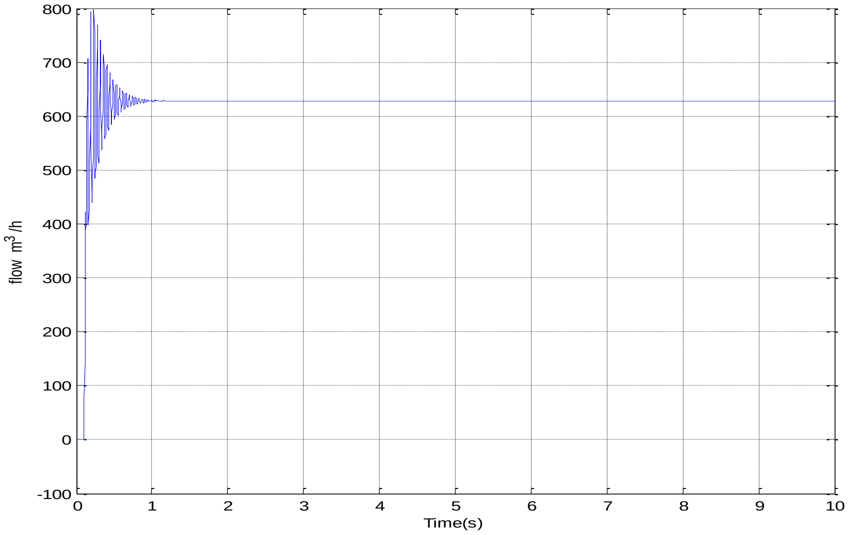


Figure IV.9 total Flow water in pump 630m^3/h

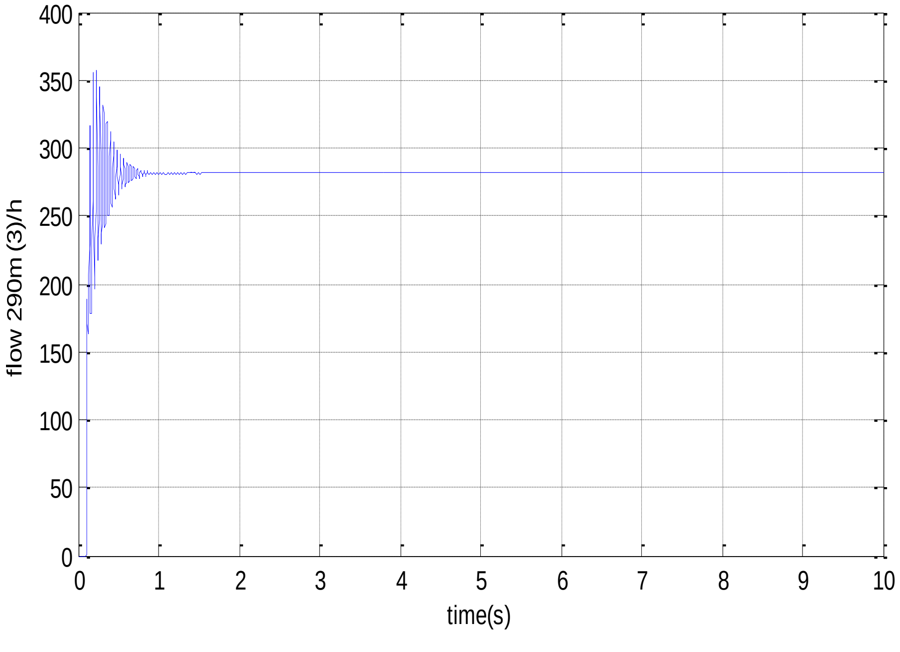


Figure IV.10 Flow water in pump centrifugal 290m^3/h

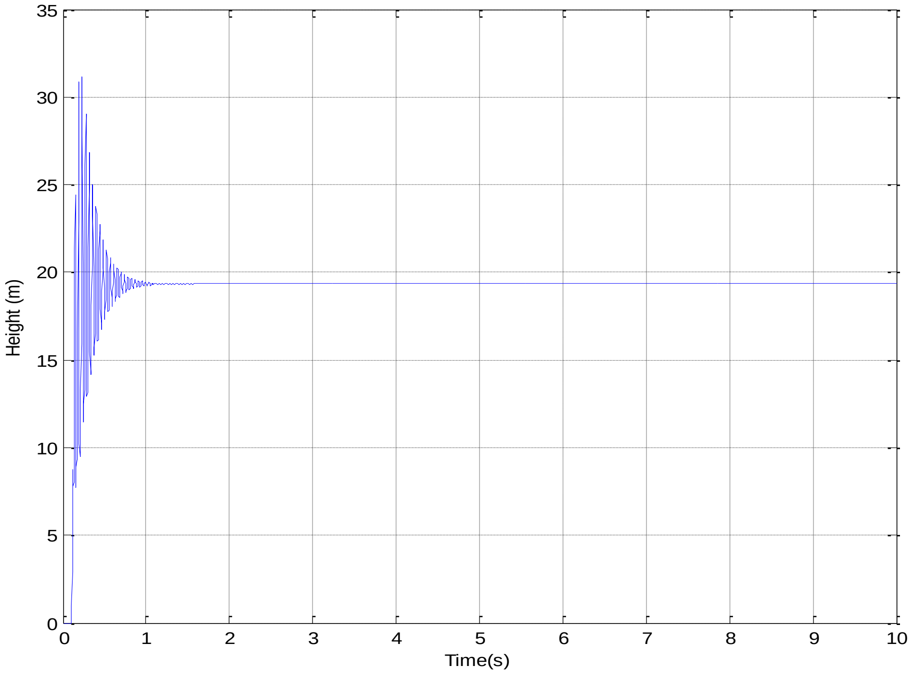


Figure IV.11 height of the water in a pump typically centrifugal

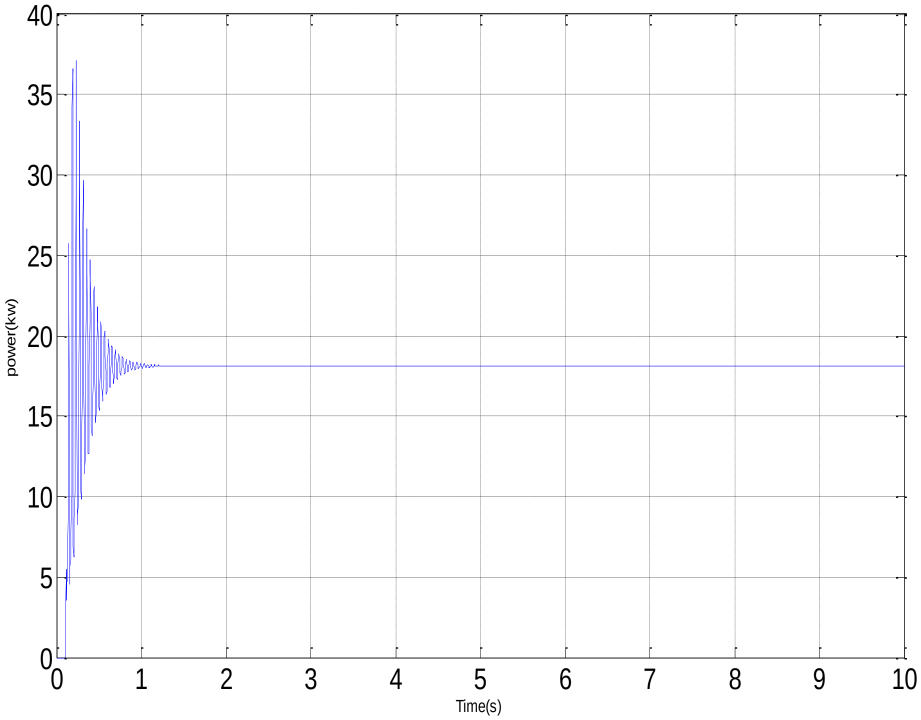


Figure IV.12 The curve represents the power consumed by a pump Centrifugal

IV.5 Conclusion

In conclusion, this chapter provides a comprehensive discussion on simulations and their outcomes. The results obtained from these simulations clearly demonstrate the effectiveness and credibility of our system. By evaluating its performance against established criteria, we have shown that our system not only meets the desired outcomes but also outperforms existing solutions in the field. Moreover, we have established the system's credibility by comparing simulation outputs with real observations, showcasing its consistency and reliability.

Furthermore, the chapter highlights the practical applicability of our system in real-world scenarios. Through simulations, we have gained valuable insights into how the system behaves and performs under different conditions. This has allowed us to identify potential challenges and practical considerations for its successful implementation. By considering factors such as scalability, efficiency, and compatibility with existing infrastructure, we can confidently assert that our system is ready to be deployed in real-world applications.

In summary, the simulations and results presented in this chapter provide compelling evidence of the effectiveness, credibility, and practical applicability of our system. These findings solidify our confidence in the system's capabilities and pave the way for its successful integration into real-world contexts

General conclusion

The exploitation the flow of water leaving the water station to generate electricity using a turbine and then transferring the energy to moto pump from the well and storing it in a tank is a great example of using renewable energy to optimize the efficiency of water management systems. By harnessing the energy of the flowing water leaving the water station, we are able to generate electricity without the need for additional fuel sources or energy inputs. This can help reduce the overall energy consumption of the water management system and promote sustainable energy practices.

Using the same energy to pump water from the well and store it in a tank creates a closed loop system that maximizes the efficiency of the available energy. This can help reduce waste and improve the overall effectiveness of the water management system. Our project also discusses the modeling and simulation of micro hydropower systems using MATLAB software. A result is concluded, which indicate the potential for using this model effectively in the production of electric power.

We discussed in our project about all the components of a micro hydro power system, including turbines, generators, engines, pumps, and control systems. We also explore the advantages and limitations of micro hydro power systems, as well as factors that influence the selection of specific components. This work has provided a comprehensive overview of the potential of micro hydropower systems to generate electricity from flowing water and optimize the efficiency of water management systems. Through our study and simulation, we have shown that this technology has promising results that are applicable in the real world.

However, our project is subject to develop and improve in reality. We recognize the importance of continued research and development in this area, it has highlighted the importance of sustainable energy practices and the potential of micro hydropower systems to contribute to this goal. We hope that our work will provide a foundation for future research and development in this field and contribute to a more sustainable and resilient future.

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