PUMP SELECTION AND DESIGN IN A WATER SUPPLY SYSTEM

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CERTIFICATION

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DEDICATION

I dedicate this work My to my parents MR and MRS EBAGUA for their immerse support and making it possible for me to carry out this project successfully, and also God almighty for making it possible for me to carry out this project especially for the gift of life.

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SUMMARY OF WORK

A water supply system's pump design and selection are essential to guaranteeing a dependable and effective water distribution to satisfy the needs of different users, such as commercial, industrial, and residential customers. Pumps are essential components of water supply systems because they supply the energy needed to lift water to higher storage tanks or reservoirs, overcome pipe flow resistance, and maintain the necessary pressure across the distribution network. Choosing and designing a pump system for a water supply system that satisfies the necessary flow rate and pressure head while guaranteeing dependable and effective operation is the aim of this project. A detailed understanding of the hydraulic needs of the system, such as the flow rate, pressure head, and friction losses, is necessary for designing a pump system for a water supply system. The kind of pump, pump size, impeller design, and motor selection are just a few of the variables that must be carefully taken into account throughout the pump selection process. Among the many advantages of a well-designed pump system are greater system reliability, lower maintenance costs, and energy economy. It might be difficult to choose a pump that satisfies the needs of the system while reducing energy consumption and expenses since pumps in water supply systems frequently have to function throughout a broad range of flow rates and pressures. The pump system must also be built to handle seasonal variances, demand variations, and possible future system additions or improvements. Choosing and designing a pump system for a water supply system that satisfies the necessary flow rate and pressure head while guaranteeing dependable and effective operation is the aim of this project. It is possible to build and choose an appropriate pump system to satisfy the demands of the water supply system by thoroughly examining the hydraulic requirements of the system and the pump performance characteristics.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Water supply systems are crucial pieces of infrastructure that guarantee clean water is available for use in homes, businesses, and farms. Transporting water from sources like wells, reservoirs, or treatment plants to consumers at the necessary pressure and flow rate is the responsibility of the pump, one of the main parts of these systems. In order to achieve operational efficiency, dependability, and cost-effectiveness in water delivery networks, proper pump selection and design are essential (Arora, 2010).A number of variables, including as flow demand, elevation head, pipe friction losses, and the properties of the fluid being pumped, affect the choice of pump. Problems like energy waste, frequent malfunctions, cavitation, and shortened service life can result from a mismatch between the pump's capability and the system's needs (Karassik et al., 2001). In order to make well-informed design decisions, engineers must thoroughly evaluate system factors and examine pump value performance curve. Additionally, as the need for energy-efficient systems and sustainable infrastructure grows, so does the significance of optimizing pump design. Developments in modeling tools and simulation software, like EPANET and WaterCAD, also help to improve the accuracy and efficiency of system analysis and pump selection (Rossman, 2000). The goal of this project is to investigate the process of choosing and designing a pump that is specific to a water supply network's requirements while taking technical, environmental, and financial factors into account.In engineering practice, choosing a pump entails figuring out the total dynamic head (TDH), examining system curves, and comparing them to pump curves supplied by the manufacturer. According to Karassik et al. (2001), engineers also need to take into account variables like Net Positive Suction Head (NPSH), motor size, pump type (centrifugal, submersible, etc.), and accessibility for maintenance. To create a system that is both efficient and sustainable, these technological factors must be weighed against issues of cost, space, energy use, and the environment. The process of choosing and designing a pump for a water delivery system is the main topic of this project. It seeks to demonstrate how careful pump matching and precise hydraulic analysis can result in effective system functioning, lower energy losses, and longer equipment life.

1.2 STATEMENT OF THE PROBLEM

In many water supply systems, poor pump design and selection result in high energy consumption, frequent maintenance, shorter service life, and an inability to satisfy anticipated water demand, particularly during periods of high usage. According to Karassik et al. (2001), many systems continue to suffer from over-sizing, under-sizing, and poor matching of pump performance with system requirements, even with the availability of several pump types and contemporary modeling tools. When choosing pumps based on system curves and performance criteria, these problems are frequently brought on by insufficient hydraulic parameter assessment, a failure to integrate real-time demand data, and a lack of technical expertise.The mismatch between the hydraulic demands of the system and the pump's characteristics is one of the most important problems. Pumps are frequently chosen without a thorough examination of system curves, friction losses, periods of peak demand, and dynamic head needs. This can lead to inefficiently operating pumps that are either too big or too little, which can result in high energy consumption, frequent maintenance, and early failure (Karassik et al., 2001). Furthermore, the system's overall dependability may be jeopardized if variables like cavitation risks, fluctuating flow rates, and Net Positive Suction Head (NPSH) are not taken into account. issue that is very urgent is energy inefficiency. The United Nations (2014) states that 40–60% of water utilities' overall operating costs can be attributed to energy costs. In addition to using more energy, an inefficient pump raises greenhouse gas emissions, which runs counter to international objectives for the development of sustainable infrastructure. Furthermore, such inefficiencies may result in service outages and an unstable water supply in rural or resource-constrained areas, which could have an impact on economic productivity, sanitation, and public health. Many projects still lack a systematic technique for assessing and choosing the right pumps, even with the availability of engineering standards and simulation tools. The problem is made worse by inadequate training, reliance on out-of-date data, and a lack of real-time performance monitoring (Arora, 2010).

1.3 AIMS AND OBJECTIVES

The main aim of this work is to Choose and design a dependable and efficient pump system for a water supply network that satisfies demand while guaranteeing operational effectiveness, financial viability, and long-term sustainability. The Specific objectives are to

i. To compare several pump types that are appropriate for water delivery systems in terms of efficiency, head, and flow rate and other citerials.
ii. To carry out hydraulic computations, including power needs, net positive suction head (NPSH), and total dynamic head (TDH).
iii. To choose a suitable pump based on performance curves and manufacturer data that meet system specifications.

1.4 SCOPE OF STUDY

This study focusses on the design and selection of pumps for effective water delivery systems, paying special attention to the hydraulic, technical, and financial aspects that affect the sustainability and performance of pumps. By taking into account the system demand, head loss, pump curves, and patterns of energy consumption, the study will methodically evaluate the approaches utilized in pump selection. Pump sizing, material selection, and integration within water supply networks will be the main design considerations in order to maximize operational efficiency and dependability (Karassik et al., 2001). Manual calculations will be carried out to calculate the necessary design parameters and proven hydraulic models will be used to predict key hydraulic parameters such total dynamic head (TDH), friction losses in pipelines, and system curves (Rossman, 2000). In this Research we will be considering a submersible borehole pump. because it's versatility and wide applications. this study's main focus will be on choosing and integrating commercially available pumps into a water delivery system, rather than delving into the intricate mechanical design of pump components like impeller blades.

1.5 JUSTIFICATION OF STUDY

Since pumps make up a large percentage of the system's capital and operating expenses, the appropriate selection and design of pumping facilities are crucial to the effectiveness and dependability of water delivery systems (Karassik et al., 2001). Service delivery and customer happiness may be jeopardized by improper pump selection, which can result in high energy consumption, frequent maintenance, shortened pump life, and insufficient water delivery (Water Environment Federation, 2008).Pump selection and design procedures urgently need to be optimized in light of the growing demand for water brought on by urbanization, industrialization, and population increase, as well as the global emphasis on sustainability and energy conservation (Tchobanoglous et al., 2014). This study is pertinent and contemporary since it aims to offer a scientific foundation for choosing and creating pumps that guarantee sustainable, economical, and successful water delivery operations. Water utilities, engineers, and planners will also be better able to make well-informed selections that strike a balance between technical performance and economic, environmental, and environmental factors if they incorporate contemporary methods like hydraulic modelling and life cycle costing into the pump selection process. The importance of this study includes:

I. In order to increase system efficiency and decrease wear and tear, the study will direct the selection of pumps that run at or close to their Best Efficiency Point (BEP).
II. Reduction in energy consumption and cost.
III. Pumps and related infrastructure are more reliable and have longer service lives when they are designed and chosen properly, which lowers the chance of system failures.
IV. Water utilities can improve planning and resource utilisation by using this research's methodical framework and methodology for pump selection and station design.
V. Through case studies, the research will demonstrate practical applications, making it valuable for real-life engineering projects and decision-making processes.

CHAPTER TWO

LITERATURE REVIEW

Since pumps play a crucial part in guaranteeing dependable water delivery and energy-efficient operation, their selection and design for water supply systems have been extensively researched. The key to a p's performance is its capacity to minimize operating expenses while satisfying the hydraulic needs of a system. Due to its ease of use, affordability, and adaptability to different flow rates, centrifugal pumps are actually the most widely utilized in water distribution networks (Karassik et al., 2001). Understanding the hydraulic needs of the system, in particular the flow rate, static head, pipe friction losses, and dynamic demands, forms the foundation of any pump design. Arora (2010) asserts that two of the most important factors in deciding the size and applicability of a pump are the total dynamic head (TDH) and net positive suction head (NPSH). Inadequate computation of these numbers may result in cavitation, which seriously harms the pump impeller and internal parts, increased wear, or inefficient operation. Types of Pumps and Selection Standards System curve matching, efficiency, head-flow characteristics, material compatibility, and cost are some of the criteria that influence the choice of pump. Karassik and associates. ElSamahy and Ghobashy (2019) highlighted in recent research the value of simulating water distribution networks and pump operation using computational tools like EPANET, WaterCAD, and Pipe Flow Expert. These tools lower the risks involved with trial-and-error designs by improving the visualisation of how pumps function under different settings.Sustainability and Energy Efficiency Pumping system energy usage is a serious issue, particularly as energy costs and environmental consciousness increase. According to a 2014 United Nations report, in certain areas, energy expenses might account for as much as 60% of a utility's operational budget. Therefore, by lowering greenhouse gas emissions, effective pump operation not only lowers operating costs but also advances sustainability objectives. Pumps can adapt to changing demand thanks to newer technologies like variable frequency drives (VFDs) and energy-efficient motors, which further enhance system longevity and performance. Typical Issues with Pump Design is that There are still a number of difficulties in choosing a pump, even with the availability of design standards and sophisticated technologies. the requirement for an organised, data-driven approach to pump selection and system design is well supported by the literature. Engineers may greatly increase the effectiveness, dependability, and affordability of water delivery systems by combining hydraulic analysis, pump performance data, and simulation software. Building on these foundations, this project creates a thorough pump selection and design strategy that is suited to real-world situations by utilising theoretical knowledge and useful tools. the literature on pump types, hydraulic principles, selection criteria, and energy efficiency in water delivery systems is reviewed in this chapter. It seeks to pinpoint knowledge gaps and lay the groundwork for the approach used in this investigation. for this project on pump selection and design in a water supply system to be successful and relevant, it is imperative that prior research and theoretical underpinnings be reviewed. It enables the researcher to comprehend previous study, spot knowledge gaps, and steer clear of making the same mistakes twice. The project can be based on tried-and-true engineering concepts and contemporary best practices by expanding on pre-existing ideas and case studies (Creswell, 2014). Additionally, looking at earlier research aids in choosing suitable design techniques, performance standards, and materials that have been shown effective in comparable settings. Additionally, it sheds light on difficulties encountered in previous projects, facilitating the creation of more creative and effective solutions. All things considered, this procedure improves the project’s academic worth, credibility, and chances of real-world, useful implementation (Merriam & Tisdell, 2016). Pumps are essential parts of water supply systems because they move water from sources (such wells, rivers, or reservoirs) to treatment facilities and, eventually, to end users. The effectiveness, dependability, and affordability of water distribution systems are all directly impacted by the choice and design of pumps. Modern research places a strong emphasis on pump performance optimisation due to increased concerns about sustainability, operational costs, and energy efficiency. The selection method should take into account factors including flow rate, head, fluid characteristics, system curves, and energy consumption, per Karassik et al. (2001) in the Pump Handbook. Issues like cavitation, excessive wear, or inefficiency might result from misselection. Studies such as Bahadori (2013) highlight that centrifugal pumps dominate in municipal water systems due to ease of maintenance and scalability. According to Walski et al. (2003) in Advanced Water Distribution Modeling and Management, incorporating hydraulic modeling tools (like EPANET or WaterGEMS) assists in accurate pump station design. Energy consumption by pumps can account for 20–40% of total energy use in water utilities. Hence, life-cycle cost analysis (LCCA) is essential in pump selection. To reduce running costs over the pump's lifetime, recent research (e.g., Hashemi et al., 2020) has suggested optimisation models that combine energy analysis and hydraulic modelling. According to Zhou et al. (2019), VFDs can save energy usage in some systems by as much as 30%. Despite progress, difficulties still exist and Optimal design is hampered in developing regions by a lack of data.

2.1 PUMPING SYSTEMS

A pumping system is a mechanical configuration that uses mechanical energy to move fluids, usually water, from one location to another. By facilitating the flow of water from sources like reservoirs, wells, or treatment facilities to locations where it is required, it plays a crucial part in water supply systems (Chadwick, Morfett, & Borthwick, 2013). The essential components of a pumping system include pumps, pipelines, valves, power sources (such electric motors), and control systems. The pipe system directs the flow, and the pump is the main part that raises the fluid's pressure and velocity. the pump is the core component, responsible for increasing the fluid's pressure and velocity, while the piping system guides the flow. Valves regulate and control the pressure and direction of flow, and control systems help maintain operational efficiency and protect against failure (Karassik et al., 2001). Efficient design and operation of pumping systems are vital for ensuring reliable water delivery, minimizing energy usage, and extending the system's lifespan (Falvey, 2005). Pumps are used to move water over long distances and at different elevations, or to lift it from subterranean sources (like wells or boreholes) (Chadwick et al., 2013). Pumps are used to move water over long distances and at different elevations, or to lift it from subterranean sources (like wells or boreholes) (Chadwick et al., 2013).

2.1.1 Types of Pumping Systems

i. **Centrifugal Pumping System**

   A centrifugal pump transforms kinetic energy into pressure energy by increasing the water's velocity using a revolving impeller. Because of its affordability and ease of usage, it is frequently utilised in water delivery systems (Karassik et al., 2001). 2. Pumping System with Positive Displacement. This kind of pump pushes water through the system by trapping a certain volume. It is perfect for precise flow at high pressure and comes with rotary, piston, and diaphragm pumps (Chadwick, Morfett, & Borthwick, 2013). A centrifugal pump uses a rotating impeller to increase the water's velocity, which converts kinetic energy into pressure energy. It is widely used in water distribution systems due to its low cost and simplicity of operation (Karassik et al., 2001).

ii. **Positive Displacement Pumping System:** this type of pump traps a specific volume of water and forces it through the system. It has rotary, piston, and diaphragm pumps and is ideal for precision flow at high pressure (Chadwick, Morfett, & Borthwick, 2013). This pump operates on the theory of centrifugal force. As the impeller rotates in the pump case, it tends to push water away from the center of the rotation. As the water is pushed away from the center of the impeller, additional water is pulled into the eye, or center, of the impeller. The water that has been pushed to the outside of the impeller is removed from the pump through the discharge piping. This water will have a pressure that is determined by the pitch of the impeller and the speed at which the impeller is turning. There are many types of centrifugal pump but they have these major parts in common they include:

i. **the pump**: the pump case is also known as a volute, is made of cast iron or brass and fits tightly around the impeller on all sides except the discharge side. If the liquid is corrosive or abrasive, other materials, like a rubber lining, may be used.

ii. **Impellers**: The impeller creates the centrifugal force that moves the liquid; variations in the impeller are based on whether a given application requires high pressure, large amounts of water, or both. The design of the impeller is crucial to the development of pressure and flow. there are three types of impeller which are semi open impellers, open impeller and closed impeller.

2.1.2 Types of Centrifugal Pumps

i. **Vertical turbine Pumps**: Vertical Turbines pumps can efficiently handle high-head applications, a vertical line shaft turbine pump is one of the most widely utilised pumps in the water sector. The pump is made up of bowl assemblies with impellers connected by a shaft that is held up by shaft bearings (Karassik et al., 2001). A turbine pump is usually multi-staged, which means it has several impellers. The water pressure rises with each impeller, and the discharge from one stage enters the subsequent stage's suction eye. Until the desired head is reached, this staging keeps going (Falvey, 2005). The pump's flow capacity, which is often expressed in gallons per minute (gpm), is primarily determined by the diameter of the first-stage impeller.A conventional vertical turbine pump assembly has several critical components: the power source, discharge head, pump column, pump shaft, shaft bearings, and the bowl assembly (pump end) (Chadwick et al., 2013). It is perfect for deep well pumping and other industrial or municipal water supply applications because of its layout.

ii. **submersible pump**: it is an impossible pump for industrial, commercial, and municipal water systems, the submersible pump is particularly well-suited for deepwell and booster operation. The pump is made to run entirely submerged in the fluid it is pumping and uses a submersible motor that is connected straight to the bowl assembly. The motor is powered by a watertight electrical line. In deepwell applications the pump motor and cable are hung in the well by the riser pipe. For booster applications, the unit is installed horizontally in a pipe line or in a steel suction barrel. The submersible pump offers various benefits in a variety of applications because the entire unit is either enclosed or subterranean.

iii. **Positive displacement pumping systems**: Positive displacement pumps are frequently used to transfer heavy suspensions, like sludge, or to add chemicals to water. A piston that oscillates back and forth inside a cylinder makes up one kind of positive displacement pump. Its main purpose is to transfer materials, like sludges, that include a lot of suspended particles. Depending on how the piston moves, the cylinder will contain check valves that work in opposition to one another. A single check on the piston's suction side will open when the piston retreats, expanding the cylinder's surface area. The piston will reverse its motion once it has reached its longest stroke point.

2.1.3 Energy and Head in Pump System

In a pump system, energy is transmitted from the pump to the fluid, increasing the fluid's energy (Karassik et al., 2008). This energy transfer is commonly expressed in terms of head, which is the fluid's energy per unit weight (Hydraulic Institute, 2016). There are different types of head they as follows:

i. **static head**: this refers to difference in elevation between the pump inlet and outlet
ii. **dynamic head**: this is the energy added to the fluid by the pump which result to an increase in pressure and velocity.
iii. **Total head**: this refers to the total energy added to the fluid.

2.1.4 Pump Power

Pump power is the energy required to operate a pump and transfer fluid through out the system(karasssik et al.,2008). There are different types of pump, these are:

i. **hydraulic power**: this refers to the power needed to move the fluid through the pump.
ii. **Brake power**: this is the power required to drive the pump including losses due to friction and vibration and other inefficiencies.

2.1.5 Pump Efficiency

Pump efficiency measures how well a pump transforms input energy into productive work, effectively moving fluid through a system (Karassik et al., 2008). This efficiency is crucial for selecting, designing, and operating pumps. There are different types of pump efficiency they are:

i. **Hydraulic efficiency**: The ratio of output hydraulic power to impeller input power (Gulich, 2014).
ii. **Mechanical efficiency**: The ratio of output power to shaft input power, considering mechanical losses (Hydraulic Institute, 2016).
iii. **Overall efficiency**: The combined hydraulic and mechanical efficiency, representing total pump efficiency (Karassik et al., 2008).

2.1.5.1 Factors affecting pump efficiency

The following are the factors that affects the efficiency of a pump;

i. **Design elements**: Impeller and volute design, among others, influence pump efficiency (Gulich, 2014).
ii. **Operating parameters**: Flow rate, head, and other conditions impact pump efficiency (Hydraulic Institute, 2016).
iii. **Component wear**: Over time, wear and tear on pump components can reduce efficiency (Karassik et al., 2008).

2.1.5.2 Importance of pump efficiency

Importance of Pump Efficiency

i. **Energy savings**: Higher pump efficiency reduces energy consumption, lowering operating costs (Hydraulic Institute, 2016).
ii. **Informed pump selection**: Understanding pump efficiency ensures the right pump is chosen for a specific application (Karassik et al., 2008).
iii. **Optimized system design**: Pump efficiency informs system design decisions, such as piping and motor sizing (Gulich, 2014).

2.1.6 Operation and Maintenance

Regular maintenance is essential for optimal pump performance, reduced downtime, and extended equipment lifespan (Karassik et al., 2008). The following are the ways a pump can be maintained.

i. **Inspecting components**: Regular checks on seals, bearings, and impellers.
ii. **Lubricating moving parts**: Ensuring proper lubrication.
iii. **Cleaning components**: Preventing clogging and damage.

Benefits of regular maintenance:

i. **Failure prevention**: Identifying and addressing potential issues.
ii. **Performance optimization**: Maintaining optimal efficiency.
iii. **Lifespan extension**: Extending pump component and system lifespan.

2.1.7 Specifications

Pump specifications define the technical requirements and characteristics of a pump, ensuring it meets the needs of a specific application (Bloch & Budris,2013). The following are pump specifications criteria

i. **Flow rate**: Volume of fluid pumped per unit time (e.g., gallons per minute or liters per second).
ii. **Head**: Pressure or height achieved by the pump (e.g., feet or meters of head).
iii. **Power**: Energy required to operate the pump (e.g., horsepower or kilowatts).
iv. **Efficiency**: Effectiveness in converting input energy into useful work (Hydraulic Institute, 2016).
v. **Materials**: Construction materials, such as cast iron, stainless steel, or PVC (Gulich, 2014).

2.1.8 Application of Pump

Pumps are utilized in diverse industries, including:

i. **Water supply and treatment**: Distributing water in municipal systems and treating wastewater (Karassik et al., 2008).
ii. **Industrial processes**: Chemical processing, oil refining, and other applications (Bloch & Budris, 2013).
iii. **HVAC systems**: Circulating fluids in heating, ventilation, and air conditioning systems.
iv. **Agriculture**: Irrigation and water supply.

2.2 HYDRAULIC PRINCIPLES IN PUMP SELECTION

The following are the key hydraulic concepts:

i. **flow rate:** The volume of fluid (like water) that moves through a pipe, pump, or channel in a certain amount of time is referred to as the flow rate. Usually stated in figures like gallons per minute (gpm) or litres per second (L/s), it is a crucial component in the design of hydraulic and pumping systems (Chadwick, Morfett, & Borthwick, 2013). flow rate is the amount of fluid (like water) that flows through a channel, pump, or pipe in a given amount of time. According to Chadwick, Morfett, and Borthwick (2013), it is a crucial parameter in the design of hydraulic and pumping systems and is commonly stated in measures like litres per second (L/s) or gallons per minute (gpm).
ii. **head**: In fluid mechanics and pump design, head refers to the height of a fluid column that a pump must overcome to move water through a system. It represents the energy required to lift and transport water and is typically measured in meters (m) or feet (ft) (Chadwick, Morfett, & Borthwick, 2013). there are basically three types of head which are the static head, friction head and total dynamic head.

iii. **pressure**: When a fluid (like water) flows through a pipe, pump, or channel over a given time period, its volume is referred to as its flow rate. A crucial factor in the design of hydraulic and pumping systems, it is commonly measured in litres per second (L/s) or gallons per minute (gpm) (Chadwick, Morfett, & Borthwick, 2013). for water to reach its destination with sufficient force to overcome elevation variations, friction losses, and system demands, pressure is necessary. The pump in a pumping system creates pressure to force water through pipes and deliver it at the necessary flow rates. Insufficient pressure can result in insufficient water flow, while excessive pressure may cause pipe bursts or equipment damage.

iv. **Velocity**: fluid mechanics, velocity refers to the speed at which water flows through a pipe or channel, commonly measured in meters per second (m/s) or feet per second (ft/s). According to Chadwick, Morfett, and Borthwick (2013), it shows the speed at which water is flowing at a specific location within the system. The flow rate and the pipe's cross-sectional area both affect velocity. Assuming the flow rate stays constant, the continuity equation states that the velocity rises as the cross-sectional area falls (and vice versa). According to Falvey (2005), maintaining the right velocity is crucial to avoiding problems like pipe erosion (if too fast) or sedimentation (if too sluggish).

v. **friction losses**: In order to prevent undersizing pumps and guarantee dependable water delivery, friction losses must be taken into consideration when designing pipe systems (Munson et al., 2009). friction losses have an impact on the total dynamic head (TDH), or the total energy the pump must overcome, they are a crucial consideration in the design of pump and pipe systems. It is possible to guarantee that the pump provides enough pressure and flow throughout the system by accurately modelling these losses (Munson, Young, & Okiishi, 2009).

vi. **Total dynamic head**: Total Dynamic Head (TDH) is the total energy required by a pump to circulate water in a system. Usually measured in meters or feet of head, it incorporates all of the pressure-related and vertical forces the pump must resist (Chadwick, Morfett, & Borthwick, 2013).A key idea in fluid mechanics and pump system design is total dynamic head (TDH), which is the total equivalent height that a fluid must be pumped while accounting for all resistances. TDH is the total of any pressure head needed at the destination, friction losses in the pipes and fittings, and vertical rise (static head). In order to overcome gravity, friction, and system pressure requirements, a pump must transfer energy to the fluid (Karassik et al., 2001).

vii. **NPSH (Net Positive Suction Head):**it is a key concept in pump system design that helps prevent cavitation a damaging condition where vapor bubbles form in the pump due to low pressure, causing performance loss and damage. there are two types of NPSH:

i. **NPSH Available (NPSHa):**

This is the actual pressure head present at the pump’s suction side, expressed in meters or feet of liquid, after subtracting the vapor pressure of the fluid. It depends on the design and conditions of the pumping system.

ii. **NPSH Required (NPSHr):**

This is the minimum pressure head needed at the pump’s suction to prevent cavitation, as defined by the pump manufacturer based on the pump’s design and performance characteristics.

2.3 PUMP SELECTION CRITERIA

To guarantee optimum performance and longevity, the pump selection process entails matching the system curve with the pump performance curve at or close to the best efficiency point (Karassik et al., 2001). matching the pump's features to the needs of the system is essential to choose the best pump. The Best Efficiency Point (BEP), system curves, and pump performance curves are the main instruments In this procedure.

i. **performance curve**: A pump's behaviour at various flow rates is displayed by a pump performance curve, which usually plots: Head versus Flow Rate, Efficiency vs Rate of Flow, Power Usage in Relation to Flow Rate and NPSHr in Relation to Flow Rate.
ii. **The System Curve:** The system curve illustrates the relationship between a system's total dynamic head (TDH) and flow rate. It consists of: Head Static (constant) Losses from friction (increasing with flow)
iii. **Point of Best Efficiency (BEP):** The BEP is the location on the performance curve where the pump runs as efficiently as possible while experiencing the least amount of wear and vibration. Why it's important Energy efficiency is increased by operating near the BEP. Prolongs the life of the pump and lowers maintenance costs. Mechanical failure, cavitation, and noise can result from a significant departure from BEP.

Pump selection steps

The following are the Steps to Choose a Pump

i. Calculate the flow rate (Q) and total head (H) needed for the system.
ii. Using predicted pipe losses and known altitudes, create a system curve.
iii. To identify models that cross the system curve close to the BEP, examine pump curves.
iv. Avert cavitation by confirming that NPSHa >= NPSHr.

v. Examine power consumption and efficiency to select the most economical pump.
vi. Verify that the system design, temperature, and fluid type are compatible.

2.4 ENERGY EFFICIENCY AND SUSTAINABILITY IN PUMPING SYSTEMS

Pumps are one of the water utilities' biggest energy users, contributing significantly to both operating expenses and greenhouse gas emissions. Up to 90% of the energy used in water and wastewater treatment plants is thought to come from pumping systems (U.S. Department of Energy, 2006). A lot of utilities run their pumps below their Best Efficiency Point (BEP), which results in lower system longevity, higher maintenance costs, and energy losses. Energy consumption can be decreased by 20% to 50% by increasing efficiency through variable frequency drives (VFDs), appropriate pump selection, and maintenance (DOE, 2006). Therefore, improving sustainability in water utility operations requires effective pump functioning.

2.5 PRINCIPLE OF PUMP SELECTIONS

The choice of pumping equipment is an important factor that affects the unit under development's in-use performance as well as process parameters. When choosing a pump type, three fundamental factors need to be taken into account:

i. Requirements for process and design
ii. The type of pumped media
iii. Important design elements

i. Requirements for process and design

In certain instances, strict specifications for a variety of design or process criteria dictate the choice of pump. Centrifugal pumps, in contrast to piston-type pumps, can deliver pumped medium uniformly. A piston-type pump's design must be significantly more complex in order to meet uniformity requirements, as multiple pistons must be arranged on the crankshaft to make reciprocating movements with a specific delay from one another. In addition, it may be necessary for the procedure to supply the pumped medium in discrete chunks of a predetermined volume. The use of submerged pumps in situations when it is required and only feasible to install the pump below Is an example of a definitive design need.

ii. **The type of pump media**

When choosing pumping equipment, characteristics of the pumped medium frequently become a deciding factor. Different media with varying viscosities, toxicity levels, abrasiveness levels, and many other characteristics can be pumped using different kinds of pumps. Therefore, screw pumps can effectively be utilised in the food processing sector to pump jams and pastes with a variety of fillers and can pump viscous media with variable inclusions without destroying the medium's structure. The chosen pump's material design and degree of airtightness are determined by the pumped medium's corrosion characteristics and toxicity.

iii. **Important design element**: Operational requirements specified by different industries can be satisfied by several types of pumps. In the situation like this preference is given to the type of pump which is most suitable under concrete values of key design parameters (capacity, head and power consumption.

2.6 ENVIRONMENTAL BENEFITS OF ENERGY-EFFICIENT PUMPING SYSTEMS

Energy-efficient pumping systems are essential for promoting sustainable development, especially when it comes to lessening the environmental effects of infrastructure upkeep, water management, and energy use. These systems provide a variety of advantages that help create a more resilient and sustainable future, and they are in line with a number of Sustainable Development Goals (SDGs) of the UN.The decrease in electricity usage is one of the most important environmental advantages of energy-efficient pumps. According to the International Energy Agency (2021), conventional pumps can be extremely inefficient, frequently using up to 60% more energy than is required. Energy-efficient systems cut greenhouse gas emissions by reducing the demand for electricity through the use of variable frequency drives (VFDs) and high-efficiency motors. By encouraging energy efficiency and reducing carbon footprints, this directly promotes SDGs 7 (Affordable and Clean Energy) and 13 (Climate Action).Smart sensors and control technologies that stop overpumping, find leaks, and improve water distribution are frequently incorporated into energy-efficient pumping systems. This supports SDG 6 (Clean Water and Sanitation) by reducing water loss, which is particularly important in municipal and agricultural applications. Furthermore, these solutions support SDG 12 (Responsible Consumption and Production) by reducing waste and encouraging more effective resource use (World Bank, 2020).Increased pumping efficiency also results in less mechanical strain on infrastructure, which prolongs the life of equipment and lowers the frequency of repairs and replacements. This reduces the amount of materials used and the related environmental effects of disposal and manufacturing. By promoting sustainable industrial practices, it advances SDG 9 (Industry, Innovation, and Infrastructure) and SDG 8 (Decent Work and Economic Growth) by generating green jobs in the construction and upkeep of energy-efficient systems (UNIDO, 2019).In addition to extending equipment lifespan and lowering the need for frequent repairs and replacements, increased pumping efficiency also results in less mechanical stress on infrastructure. As a result, less material is used, and the related environmental effects of production and disposal are reduced. It supports SDG 8 (Decent Work and Economic Growth) by generating green jobs in the creation and upkeep of energy-efficient systems, and SDG 9

(Industry, Innovation, and Infrastructure) by promoting sustainable industrial practices (UNIDO, 2019).

2.7 DESIGN CHALLENGES AND COMMON FAILURES

Hydraulic performance and system demand must be thoroughly understood in order to design a pumping system that is both effective and efficient. Nevertheless, a number of typical design errors, including cavitation, oversizing, and misaligned pump-system curves, routinely jeopardise the effectiveness, dependability, and energy economy of pumping operations.

I. **Pump Oversizing**: When pumps are chosen with capacities much more than the actual system requirements, this is known as oversizing. This frequently happens as a result of using cautious design techniques, using data that is out of date, or failing to take changeable system demands into consideration. According to the U.S. Department of Energy (2016), oversized pumps usually operate outside of their Best Efficiency Point (BEP), which results in excessive energy consumption, increased wear and tear, and frequent maintenance. Oversizing also leads to longterm operational inefficiencies and needless capital expenditures.

II. **Cavitation**: Cavitation is a Harmful phenomena that occurs when the pump's local pressure drops below the liquid's vapour pressure, causing vapour bubbles to form and burst. Usually, inadequate suction line design or a lack of Net Positive Suction Head Available (NPSHa) are the causes of this (Hydraulic Institute, 2021). Pump efficiency and service life are lowered as a result of impeller pitting, vibration, noise, and mechanical damage. Preventing cavitation requires that NPSHa be significantly greater than the Net Positive Suction Head Required (NPSHr).

III. **Inconsistent Pump-System Curves**: Unstable or ineffective pump operation is frequently the result of a mismatch between the hydraulic curve of the system and the pump curve (head vs. flow). According to Karassik et al. (2001), this discrepancy is typically caused by imprecise system modelling or modifications in process requirements that are not taken into account when choosing a pump. Operation away from BEP, higher energy consumption, vibration, and mechanical stress are the outcomes. In severe cases, flow surging or failure to meet process demands can occur. Corrective strategies include detailed system curve analysis and the use of variable frequency drives (VFDs) to allow flexible operation.

2.7.1 Pump Terminology

The following are the terms associated with pump

I. **Head**

The pressure or height a pump can achieve, measured in feet or meters, determining its ability to overcome resistance.

II. **Flow Rate**

The volume of fluid pumped per unit time, typically measured in GPM or L/s, indicating the pump's capacity.

III. **Cavitation**

The formation of vapor bubbles due to low pressure, potentially causing damage, noise, and vibration.

IV. **NPSH (Net Positive Suction Head)**

The difference between suction pressure and vapor pressure, crucial for preventing cavitation.

V. **Impeller**

The rotating component increasing fluid velocity, generating pressure and flow, with design and condition impacting performance.

2.7.2 Determination of Operating Point (Single Pump)

Pump Operating Point

The operating point is found where the pump's head-flow curve intersects the system's head loss-flow curve (Karassik et al., 2008).

Determining the Operating Point

i. Plot the pump's performance curve (head vs. flow rate).
ii. Plot the system curve (head loss vs. flow rate).
iii. Identify the intersection point, which represents the pump's operating point.

2.7.3 Concept of Specific Speed

Specific speed (Ns) characterizes pump performance by combining:

i. Speed (N)
ii. Flow rate (Q)
iii. Head (H)

It enables prediction, design comparison, and informed pump selection. Specific speed (Ns) is a dimensionless parameter that characterizes pump performance, calculated as:

$Ns = (N \times Q^{0.5}) / H^{0.75}$

Where:

N = rotational speed (rpm)

Q = flow rate (gpm or m^3/h)

H = head (ft or m).

2.8 CAVITATION

Cavitation occurs when low pressure creates vapor bubbles, which collapse with force, potentially causing:

i. Component damage
ii. Performance loss
iii. Noise and vibration

The following are the ways to prevent cavitation:

i. Maintain sufficient NPSH
ii. Select and size pumps correctly
iii. Perform regular maintenance.

2.8.1 Priming of Centrifugal Pump

Priming fills the pump casing and suction piping with fluid, removing air pockets (Karassik et al., 2008), and helps to

i. Prevents cavitation and damage
ii. Ensures smooth suction
iii. Optimizes performance and efficiency

Priming Methods

i. Foot valve and external fluid source
ii. Vacuum pump
iii. Self-priming pump designs

2.8.2 Pump Comparison

In These Research there many kinds of pump, the table below show the comparTable 2.1 Comparison of different pumps.ison between different kind of pump base on their applications, flow rate, head range, efficiency, energy use, priming, maintenance, installation footprint and cost.

Table 2.1 Comparison of different pumps.

Feature/parameter	**Grondfos 75hp**	**Submersible pump**	**Vertical turbine pump**	**Positive displacement(PD)**	**End-suction centrifugal pump**
Application	Industrial/HVAC/Water supply	Boreholes/sewage/irrigations	Deep wells/municipal/irrigation	Oil, chemicals, slurry	Water supply, HVAC
Pump Type	Multistage centrifugal	Mixed or radial flow	Vertical shaft centrifugal	Gear, screw, or diaphragm	Single stage centrifugal
Flow Rate(m3/hr)	50-500+	20-200	200-1500+	Low(<100)	50-250
Head Range(m)	40-300	30-200	50-300+	Very high(with low flow)	20-120
Efficiency	High (70-85%)	Moderate (60-75%)	High (70-85%)	Low to medium (40-70%)	Medium (65-75%)
Energy use	Efficient with VFD	High energy in deep installs	High in large systems	Inefficient for high flows	Moderate
Priming	Self priming (if inline vertical)	Self priming	Requires slump or barrel	Self priming	Requires primin

					g
Maintenance	Low (sealed systems)	Medium(motor-submerged)	High (complex shafting)	High(more moving parts)	Low to medium
Installation footprint	Compact(inline/ vertical)	submerged	Tall structure, requires sump	Compact with piping complexity	compact
Cost	Medium to high	medium	High	Medium to high	Low to medium

2.9 REVIEW OF PREVIOUS STUDIES

The performance, dependability, and sustainability of water supply systems are significantly impacted by the design and choice of pumps. The literature offers a variety of perspectives on energy considerations, modelling approaches, and the best ways to choose pumps. Numerous studies emphasise that hydraulic characteristics such the needed flow rate, total dynamic head, and system curve alignment must be taken into consideration when choosing a pump (Mays, 2011). Long-term operational efficiency and dependable service delivery are guaranteed by appropriate pump sizing. Mismatched pump systems can lead to increased energy consumption and shortened pump life (Karassik et al., 2008). Contemporary methods place a strong emphasis on life-cycle performance and energy efficiency.

Energy-efficient pump selection is crucial since, according to studies by Khan et al. (2017), energy expenses can make up more than 85% of a pump's lifetime operating costs. Thus, it is advised to use tools like life-cycle cost analysis (LCCA) to help with pump selection (EPA, 2012). Furthermore, field experiments by Zhang et al. (2019) have shown that the use of variable frequency drives (VFDs) improves energy efficiency by enabling pumps to change speed based on demand. in pump system analysis, using computer modelling tools like EPANET and WaterGEMS has become commonplace. With the aid of these technologies, engineers can discover pressure losses, model demand variations, and improve network configurations (Rossman, 2000). Pump efficiency under various circumstances has also been assessed using MATLAB-based simulations (Rahman et al., 2016). Solar-powered water pumping systems have drawn interest as a clean energy option in terms of sustainability, especially in off-grid locations. Solar-powered systems dramatically lower greenhouse gas emissions and operational costs, according to studies conducted in South Asia and sub-Saharan Africa (Fraenkel, 2014; Mandelli et al., 2016).

Implementation issues including sporadic solar availability and expensive capital expenditures still exist, though. Solar-powered water pumping systems have drawn interest as a clean energy option in terms of sustainability, especially in off-grid locations. Solar powered systems dramatically lower greenhouse gas emissions and operational costs, according to studies conducted in South Asia and sub-Saharan Africa (Fraenkel, 2014; Mandelli et al., 2016). Implementation issues including sporadic solar availability and expensive capital expenditures still exist, though. Even with the breadth of current research, there are still a number of unanswered questions, especially when it comes to rural and low resource environments. the majority of the literature now in publication concentrates on intricate computational models appropriate for urban systems.

The absence of technical know-how in rural water systems makes it challenging to implement these methods. mollel et al. (2020) point out that community-based water committees and local technicians urgently require easy-to-use, field-adaptable pump selection tools. few studies incorporate life-cycle assessments (LCA), carbon footprint analyses, or long-term sustainability indicators into the pump selection process, despite the fact that some look at energy consumption. Köberle et al. (2018) claim that incorporating energy data into decision frameworks can aid in prioritising economically and ecologically sound alternatives. the impact of seasonal water availability, climate change, and unstable energy sources on pump performance is frequently overlooked. For instance, few models dynamically adjust to seasonal variations that have a substantial impact on groundwater levels in semi-arid environments (Kumar et al., 2015). Although IoT-based monitoring and SCADA systems have sophisticated data collection capabilities, these solutions are sometimes too costly or unfeasible for rural applications. Low-cost, open-source technologies may be able to supply crucial data for system upkeep and u, according to studies by Musademba et al. (2021), but acceptance is still slow.Rural water systems depend on community participation to be successful and sustainable. However, social and participatory factors are rarely included in technical research that focus on pump design and selection. Systems are more likely to stop working if they don't adapt to local capacities and preferences (Harvey and Reed, 2007). This study will use real operating data from existing facilities to concentrate on water utility pump systems in Nigeria. This method ensures applicability to local infrastructure and energy supply concerns and fills the gap in context-specific research (Garcia & Patel, 2022).

The study will evaluate possible reductions in energy consumption and operational costs by comparing traditional versus optimised pump selection procedures, with a focus on long-term sustainability (U.S. Department of Energy, 2006).The study's findings will support economically and environmentally sustainable practices by aligning with the Sustainable Development Goals (SDGs), especially SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action) (United Nations, 2015). positive Suction Head Available (NPSHa) vs Required (NPSHr). We will also check for Energy efficiency and life-cycle cost analysis with Compatibility with local environmental and economic conditions.

CHAPTER THREE

METHODOLOGY

3.1 OVERVIEW

This chapter outline the procedures and Steps that will that will be used to design and select a suitable pump for a water supply system. This involves collection, organization of data and tools used in the analysis of data. This covers the research design, materials used, sources of data and techniques used for the collection of Data and the design procedure.

3.2 RESEARCH MATERIALS

In this research we will look at the manufacturer specifications which will include punp curves and motor data and also consult the necessary engineering manuals such as the Grundfos product manual, pump handbook, hydraulic institutes standards, EPANET manual, Grundfos product manual, pump hand book and hydraulic institutes standardard.

3.3 PUMP COMPARISON

In this research we are going to Carryout a comparison on different types of pumps for a water supply system base on their application requirements, design parameters such as flow rate and head, pump materials, power source, pump size and weight, efficiency and performance, motor specification, maintenance and serviceability, cost and energy efficiency consideration

3.3.1 SUBMERSIBLE PUMP VS CENTRIFUGAL PUMP

A submersible pump and a centrifugal pump both rely upon the centrifugal force to pump out the water. However, the installations are different as they are both built in different ways. A submersible is installed on underwater whereas a centrifugal pump is installed on the ground. However, submersible pumps are used for groundwater extraction through deep wells and centrifugal pumps are ideal for water supply and drainage application in urban areas or for industrial purpose (www.unnatipumps.com). This two pumps will be compared base on the following citerials.

i. **Operation**: Submersible pumps operates under water, while centrifugal pumps are typically installed above ground

ii. **Efficiency**: submersible pumps are often more efficient for deep well applications, while centrifugal pump are more suitable for low to moderate head application.

iii. **Noise**: Submersible pumps are generally quieter than centrifugal pumps.

iv. **Flow rates and head**: a submersible pump is suitable for a wide range of flow rate(0.5-1000m^3/h) and heads(up to 600 meters or more) while a centrifugal pump is suitable for high flow rates(up to 10,000m^3/h) and moderate head (up to 200 meters).

v. **Pump Materials**: a submersible pump is made of stainless steel, cast iron, or other corrosion-resistant material, while centrifugal pump on the other hand is made of cast iron, stainless steel, or other materials depending on the application.

vi. **Power:** a submersible pump is typically powered by electric motors (up to several hundred KW) or solar panels while a centrifugal pump is often powered by electric motors or diesel engines.

vii. **pump size and weight**: a submersible pump has a compact design, often weighing between 10-500kg which typically depends on the size and application while a centrifugal pump can be larger and heavier and weighs up to several tons depending on its application

viii. **Efficiency considerations**: a submersible pump can be highly efficient (up to 80-90% efficient), especially for deep well applications while a centrifugal pump can be efficient (up to 70-80% efficient), but efficiency can vary depending on the application and design of the pump.

ix. **Energy Efficiency**: a submersible pump can offer significant energy savings, especially for deep well applications, due to its high efficiency and ability to operates at optimal speed, while a centrifugal pump can be energy efficient especially when properly sized and operated, it may require more energy for several operations.

x. **Cost**: a submersible pump can be more expensive upfront, especially for deep well applications, but offer long-term efficiency and reliability benefits while a centrifugal pump often has less expensive upfront, but may require more maintenance and energy costs over time.

3.3.2 POSITIVE DISPLACEMENT PUMPS VS VERTICAL TURBINE PUMPS

Below are the comparison of positive displacement pumps with vertical turbine pumps

i. **Operation**: positive displacement pumps use a mechanical mechanism to displace fluid, often used for specific flow control, while the vertical turbine pumps use centrifugal pumps with a vertical shaft and multiple stages making use of impellers to generate pressure.

ii. **Efficiency**: a positive displacement pump can be less efficient (up to 50-70% efficient) due to mechanical losses while vertical turbine pump can be efficient (up to 80-90% efficient) especially when properly sized and operated.

iii. **Noise:** a positive displacement pumps can be noisy, especially when operating at high pressure, while vertical turbine pump can be noisy when operating at high speeds.

iv. **Flow rate and Head:** a positive displacement pump is often used for low to moderate flow rates (up to $100m^3/h$) and high-pressure applications while a vertical turbine pump is suitable for high flow rate (up to 10000m^3/h) and moderate to high heads (up to 300 meters or more).

v. **Pump materials**: Positve displacement pumps can be made of a variety of materials, including stainless steel, cast iron and plastics, while a vertical turbine pump on the other hand is often made of cast iron, stainless steel, or other durable material.

vi. **Power**: a positive displacement is mostly powered by electric motors (up to several KW) or diesel engines. While vertical turbine pump by electric motors (up to several MW)

vii. **Pump size and weight:** a positive displacement pump can be compact or larger, depending on the application and flow rate. A vertical turbine pump can be larger or heavier depending on the application.

viii. **Efficiency consideration:** a positive displacement can be less efficient up to 50-70% efficient due to mechanical losses, offer precise flow control. While vertical turbine pump can be efficient up to 80-90% efficient.

ix. **Energy efficiency**: a positive displacement is less efficient due to mechanical losses while a vertical turbine pump can be efficient up to 80-90%.

x. **Cost:** a positive displacement pump is less expensive compared to a vertical turbine pump.

3.3.3 HYDRAULIC COMPUTATIONS

Hydraulic computations will be carried out in other to determine the Total dynamic head, power needs, net positive suction head and flow rate.

i. **Total dynamic head**: Total Dynamic Head (TDH) is the total equivalent height that a fluid is to be pumped, including everything that adds resistance to the flow. It represents the total energy per unit weight of fluid that the pump must deliver. Mathematically, Total Dynamic Head is given as:

TDH = Static Head (H_s) + Friction Losses (H_f) + Pressure Head (H_p) + Velocity Head (H_v) where,

H_s is the Static Head represents the vertical height the fluid needs to be lifted from the source (like a tank or well) to the final discharge point.

H_S is the friction losses due to the resistance the fluid faces while moving through pipes, fittings, bends, valves, etc.

H_p is the Pressure Head is the extra pressure needed if it's pushing into a pressurized system or tank to overcome it.

H_v = v2/2g is the Velocity Head, represents the energy needed to move the fluid at a certain speed through the discharge pipe.

The sum of these head components make up the Total Dynamic Head (TDH).

Net positive suction head: A submersible positive suction head (NPSH) is a measurement of the absolute pressure at the suction inlet that is higher than the liquid's vapour pressure in order to avoid cavitation. The head of a liquid is the difference between the pressure at the pump suction and the vapour pressure of the liquid being pumped. It is advisable to always ensure NPSHa > NPSHr for safe operations without cavitation.

NPSHa = Atmospheric Pressure Head − Vapor Pressure Head + Static Suction Head − Friction Losses in suction line. This computation will be carried out in other to determine the suction inlet.

ii. **Flow rate**: the flow rate of the pump will be determined using this formula:

Q= (TDH×ŋ) /(P×g×H)

Where:

Q= flow rate(m^3/s or gpm)

TDH = total dynamic head (m or ft)

Ŋ = pump efficiency

P =fluid density

g = acceleration due to gravity

H= Head

iii. **Power needs:** The efficient power that a pump provides to move fluid against obstacles like pressure, friction, or elevation is known as hydraulic power. It symbolises the energy that is delivered to the fluid as pressure (head) and flow. Hydraulic power **depends on the** flow rate**, the** total head**, and the** fluid's density**. It** formula is given as**:**

$$\mathbf{P_h = P.\ g.\ Q.H/100}$$

Where in S.I. units:

H is the **Total Dynamic Head (m)**

P_h is the **Hydraulic Power (in kW)**

ρ is the fluid density **(kg/m^3)**

g is the **acceleration due to gravity (m/s^2)**

Q is the **flow rate (m^3/s)**

3.4 PUMP SELECTION BASE ON PERFORMANCE CURVE, MANUFACTURER DATA

In this research will be choosing a borehole submersible pump base on the following system requirement

i. flow rate :we will be considering a submersible pump has a flow rate of $100m^3/h$

ii. Head: considering a head of 50meters
iii. Power: a submersible borehole pump requires 15KW to operate.
iv. Efficiency: considering a submersible pump of 75% efficiency.

3.4.1 Manufacturers Data:

We will be using a reputable manufacturer manual like Grundfos or franklin electric. Based on their reputable product catalogs, we will be able select a suitable pump that meets our system requirements. According the manufacturers manual that meets our system requirement is the SP 95-3 Submersible pump which has the following specification

i. Flow rate: 95-115m^3/h
ii. Head: 45-55 meters
iii. Power: 15KW
iv. Voltage: 400volts
v. Efficiency: 75%

This pump meets our system requirements and is a suitable choice for our water supply system.

3.4.2 Pump Performance Curve

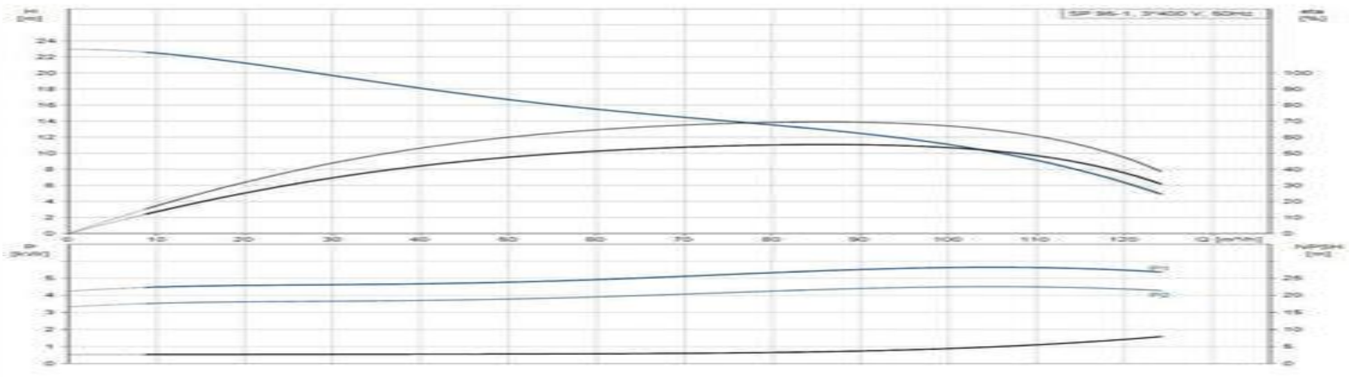

Fig 3.1 Grundfos SP 95-33 performance curve.

Source: www. landwater.com

The performance curve above for the Grundfos SP 95-3 Submersible pump shows that it can deliver a flow of 100m^3/h at a head of 50meters, which meets our system requirement. by selecting this pump we can ensure that our water supply systems operates efficiently.

3.4.3 Pump Selected

After a lot of comparison and considerations, we will be choosing a submersible borehole pumps over other pumps for a water supply system due to its unique advantages. In terms of space-saving design a submersible pump is designed to be submerged in fluid they are pumping, which makes it them ideal for where space is limited. Submersible pump is more efficient than other pumps, because it does not require a separate priming system and can operate with a lower net positive suction head(NPSH) requirements. A submersible pumps is designed with corrosion-resistance materials which makes it suitable for application the fluid being pumped is corrosive.

A submersible pump is designed to be energy efficient, which help in the reduction of operation cost. In terms of quiet operation, a submersible pump is quiter than other types of pump. Finally a submersible pump is design for low maintenance, with some models featuring sealed and they don't require regular lubrications.

3.5 DESIGN METHODS

The Pump design will be carried using manual calculations base on the necessary parameters such as flow rate, total dynamic head (TDH), and also checking for the best efficiency point(BEP). Energy and cost analysis will be carried out.

3.5.1 Flow Rate Measurements

Flow rate measurements is a critical step in pump selection and design process. This will be used to determine the actual volume of water being moved through the system and help in establishing the correct pump size and operation point. The formula below can be used to calculate the flow rate:

$Q=AV$

Where Q=flow rate (m^3/s or L/s)

V= velocity of liquid(m3/s or L/s)

T= time taken for the liquid to flow(seconds)

3.5.2 Determination of Static Head and Elevation Differences

Static head refers to the vertical distance between the surface of the fluid in the source and the center line of the pump inlet or discharge point. Static head is a critical factor in pump design and operation as it's effects pump performance, efficiency and power requirements. This can be calculated using:

Static head = Discharge elevation – suction elevation

3.5.3 Pump Performance Curve

Pump performance curves are graphical representation of pump's performance characteristics including flow rate, head, efficiency and power consumption. These curves are important for pump design and selection. Performance curves will be observed in other to carryout proper design of the pump.

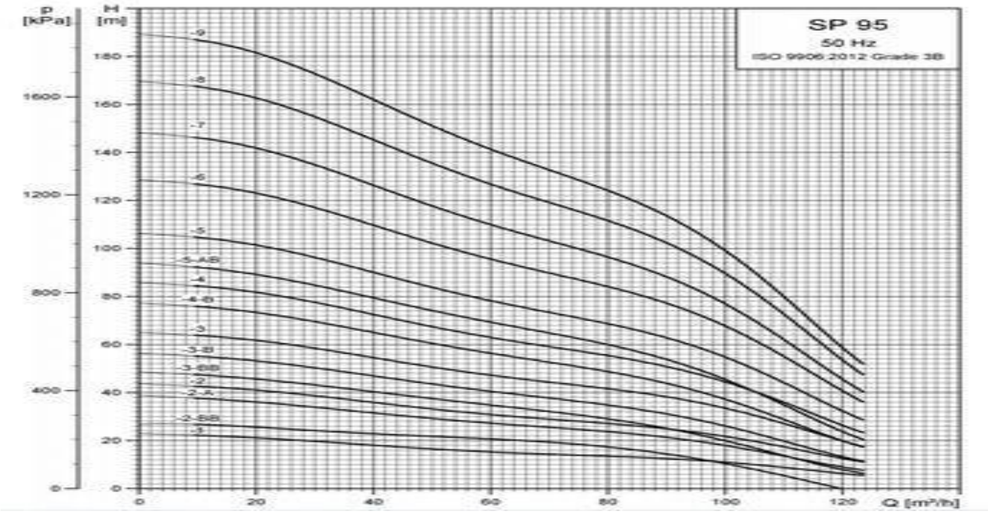

Fig 3.2 pump performance curve

Source: grundfos design maual

3.5.3 Determination of Pump Power

Pump power is crucial for pump design because it directly affects the pump's performance, efficiency and reliability. This will aid in the selection and design of the right pump for a specific purpose and minimize energy consumption.

3.5.4 Pump Testing and Validation

This is the final stage of the pump design, this involves verifying that the pump meets up with the pump performance characteristics such as flow rates, head and efficiency. at this point the pump must meet up with design specification and application requirements.

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