Experimental Study of the Performance of the Calpeda B Cm 20e Type Centrifugal Pump as a Practical Tool

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Abstract.
Centrifugal pumps are widely used in industrial applications and educational laboratories because of their simple construction, ease of operation, and ability to provide a stable flow rate. This study aims to analyze the performance of the CALPEDA BCM 20E centrifugal pump through experimental testing as a laboratory learning medium. In addition, the study develops a practical testing system by integrating transparent piping and a digital flow meter to improve the accuracy of flow rate measurements and enable direct observation of fluid flow. The research employs an experimental method by operating the pump under several operating conditions to obtain data on flow rate, total head, hydraulic power, shaft power, and pump efficiency. The collected data are analyzed using fundamental fluid mechanics equations and centrifugal pump performance characteristics and are presented in the form of tables, graphs, and performance curves. The developed laboratory equipment is expected to improve students' understanding of fluid flow phenomena and the relationship among flow rate, head, hydraulic power, and pump efficiency. The findings of this research are expected to provide useful information for evaluating centrifugal pump performance and support the development of more effective and interactive laboratory learning media.
***Keywords**: Centrifugal Pump, Performance Analysis, Flow Rate, Digital Flow Meter and Laboratory Learning Media.*

I. INTRODUCTION

Centrifugal pumps are one of the most widely used pump types in various industrial sectors, such as processing, power generation, clean water treatment, mining, and the oil and gas sector. The widespread use of centrifugal pumps is due to their simple construction, relatively low maintenance costs, and their ability to produce large flow rates with stable operation. According to Darmawan, centrifugal pumps work by utilizing the centrifugal force generated by the rotation of the impeller to convert mechanical energy into fluid energy so that fluid can be moved from a lower location to a higher location or to the desired distribution system.(Generous, nd). Besides that,(Chandramouli et al., 2023),explains that centrifugal pumps have high efficiency when operated under design conditions so they are often chosen as the main equipment in pumping systems.

In the industrial world, the success of production processes is greatly influenced by the reliability of pumping systems. Pump failure can disrupt production processes, increase operational costs, and even lead to downtime. Therefore, pump maintenance is a crucial aspect of maintaining production continuity. According to(Milal & Puspitasari, 2025), the application of appropriate maintenance methods can increase equipment reliability and significantly reduce the risk of damage. This opinion is also supported by(Ansori, 2025),which states that preventive maintenance is an effective strategy in maintaining the performance of centrifugal pumps so that they continue to work according to specifications.

Centrifugal pump performance is influenced by various operating parameters, such as flow rate, total head, motor power, motor efficiency, pump efficiency, motor speed, impeller condition, and valve openings on the suction and discharge sides. Changing any of these parameters will affect the pump's overall performance characteristics.(Rasyid, 2022),states that changes in suction height will affect the flow capacity and efficiency of the pump.(Rasyid et al., 2023),also shows that increasing the suction height causes quite significant changes in discharge and efficiency so that performance testing is necessary to determine the most optimal operating conditions.

In addition to suction height, the condition of the impeller also has a significant impact on centrifugal pump performance. The impeller is the primary component responsible for converting mechanical energy into kinetic energy of the fluid.(Siregar & Damanik, 2020)Changes in impeller design and exit angle can affect pump head, flow capacity, and efficiency. The research results indicate that impeller characteristics are a key factor in determining the success of a pumping system.

Advances in maintenance technology have also encouraged the adoption of various methods for more accurate pump performance evaluation. One widely used method is testing pump characteristics by measuring flow rate, total head, motor power, and efficiency under various operating conditions.(Sitanggang et al., 2024),explains that pump characteristic testing aims to determine the optimum operating point so that the pump can be operated at maximum efficiency.(Salmon et al., 2024),stated that periodic pump performance evaluation is able to identify performance declines early so that corrective action can be taken before greater damage occurs.

Research on centrifugal pump performance also continues to develop in various industrial sectors.(Aulia, 2021),conducted a performance evaluation of centrifugal pumps in thermal oil systems and showed that changes in operating conditions affect pump efficiency.(Fahmi et al., 2024),also shows that the performance of an electric motor as a pump driver is directly related to the pump's ability to produce the desired flow rate and pressure. Furthermore,(Giawa, 2024),explained that evaluating the performance of drinking water distribution pumps is very necessary to ensure continuity of water distribution services to the community.

Several previous studies have discussed more about the influence of impeller design, maintenance methods, and general pumping system characteristics.(Permana, 2023),researching the maintenance of centrifugal pumps using the corrective maintenance method, while(Ahadi, 2025),(Iqram, 2025),(Khairil, 2025),(Mahendra, 2025),(Doan, 2025),(Akbar, 2025), And(Alkindi, 2025)focuses more on maintenance activities and pump performance analysis under various operating conditions. However, research on the effect of variations in suction valve openings on changes in flow rate, total head, motor power, motor efficiency, and pump efficiency on the Calpeda B-CM 20E centrifugal pump is still relatively limited, so further research is needed.

Based on the description, this study aims to analyze the performance characteristics of the Calpeda B-CM 20E type centrifugal pump through testing on several variations of suction valve openings. The parameters analyzed include flow rate, total head, motor power, motor efficiency, and pump efficiency. The results of this study are expected to be a reference in determining optimal operating conditions, increasing the efficiency of centrifugal pump use, and becoming a basis for maintenance activities and research development on pumping systems in the future.

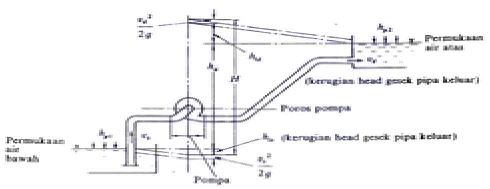
II. THEORETICAL STUDY

a. Centrifugal Pump

Centrifugal pumps are dynamic pumps that convert mechanical energy from the motor into kinetic energy and fluid pressure through the rotation of the impeller. Fluid enters through the suction side toward the center of the impeller, then is pushed outward by centrifugal force, resulting in higher pressure at the discharge side. This type of pump is widely used in water distribution systems, industry, and laboratories due to its simple construction, large flow capacity, and relatively low maintenance costs.

b. Pump Head

Head is the amount of energy per unit weight of fluid supplied by a pump to move fluid from the inlet to the outlet. Total head is influenced by the pressure difference, flow velocity, and elevation between the suction and discharge sides. Head is a key parameter in evaluating centrifugal pump performance because it indicates the pump's ability to overcome flow resistance in a piping system.



$$H_t = \frac{p_d + p_s}{\rho g} + \frac{v_d^2 - v_s^2}{2g} + (Z_d - Z_s)$$

Fig 1. Pump Head

With:

Ht = total pump head (m)

Pd = pressure on the compression side (Pa)

Ps =suction side pressure (Pa)

Vd =pressure side velocity (m/s)

Vs = suction side velocity (m/s)

Zd =pressure side elevation (m)

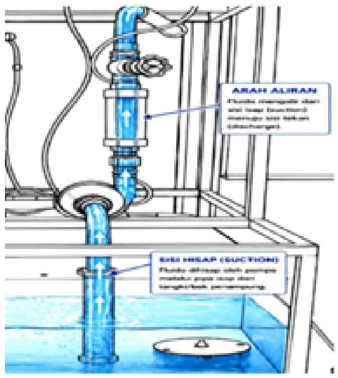
Zs= suction side elevation (m)

P = fluid density (kg/m³)

g= acceleration due to gravity (m/s²)

c. Flow Rate

Flow rate is the volume of fluid flowing through a cross-section per unit of time. The flow rate indicates the pump's capacity to move fluid and is influenced by the pump's characteristics and the condition of the piping system. Mathematically, flow rate can be expressed as:



$$Q = \frac{v}{t}$$

with:

Q= flow rate (m³/s)

V= fluid volume (m³)

t= time (s)

Pig 2. Flow Discharge Illustration

d. Hydraulic Power

Hydraulic power is the force received by a fluid as a result of pump operation. The value of hydraulic power is influenced by the fluid density, gravitational acceleration, flow rate, and total pump head. Mathematically, it is formulated as:

Hydraulic power formula:

$$P_h = \rho . g . Q . H$$

Information:

ρh= fluid density (kg/m³)

g= acceleration due to gravity (m/s²)

Q = flow rate (m³/s)

H = pump head (m)

e. Pump Efficiency

Pump efficiency indicates the pump's ability to convert mechanical energy from the shaft into hydraulic fluid energy. The higher the efficiency, the better the pump's performance in transferring energy. Pump efficiency is calculated based on the ratio of hydraulic power to shaft power, which is expressed as:

$$\eta pompa = \frac{Ph}{BHP} \times 100\%$$

Information:

$\eta pompa$ = pump efficiency (%)

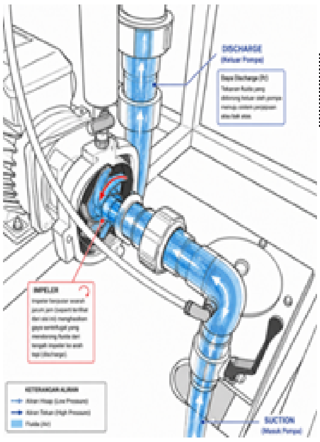
Ph = hydraulic power (Watt)

BHP = pump shaft power (Watt)

f. Suction Power

The way to increase the suction power of a water pump machine requires very complex calculations and all of them are related to technical matters starting from the length or suction distance, pipe diameter, water discharge and the power of the pump unit itself.

For example, if someone wants to suck up water from a glass using a short, small-diameter hose, it will certainly be easier than using a larger-diameter hose. This illustrates how suction power is influenced by various factors.Mathematically, the suction power of the pump is formulated as:



$$\mathcal{P}_{hisap} = \rho . g . Q . \mathcal{H}_s$$

Where:

Ph= hydraulic power of the pump (Watt)

ρ= fluid density (kg/m³)

g = acceleration due to gravity (m/s²)

Q= fluid flow rate (m³/s)

H= total pump head (m)

Pig 3. Illustration of Pump Suction Power

III. RESEARCH METHODS

This study uses an experimental method to analyze the performance of a CALPEDA BCM 20E centrifugal pump as a practical medium in the Mechanical Engineering Fluids Laboratory. Testing was conducted by operating the pump at several valve opening conditions to obtain the pump's performance characteristics.

Fig 4. Centrifugal Pump Test Equipment

a. Tools and materials

NO	Tool	Function
1	Calpeda B-CM 20E Centrifugal Pump	Flowing fluid from the lower reservoir to the upper reservoir
2	Digital Flow Meter	Measuring flow rate during testing
3	Tachometer	Measuring motor rotation during testing
4	Manometer	Measuring suction and pressure during testing
5	Stopwatch	Measuring time during testing
6	PVC pipes and transparent pipes	Distribute andvisualize the flow during testing
7	Reservoir	Holds water during testing
8	Valve	Regulating the flow rate during testing
9	Water	Working fluid pumped during testing

b. Data analysis

The test data were analyzed using basic fluid mechanics equations and centrifugal pump characteristics. The parameters analyzed included flow rate (Q), total head (H), hydraulic power (Ph), and pump efficiency (η). The analysis results were presented in tables, graphs, and performance curves to illustrate the relationship between flow rate, head, hydraulic power, and pump efficiency under each test condition.

c. Research Variables

In this study there are three types of variables, namely independent variables, dependent variables, and controlled variables.

- **Independent Variable**

The independent variable in this study was the suction valve opening variation, which the researchers intentionally changed to determine its effect on centrifugal pump performance. The suction valve opening variations used consisted of 0.25 revolutions, 0.50 revolutions, and 0.75 revolutions. These differences in openings were expected to produce changes in fluid flow conditions, allowing for analysis of their effect on pump performance characteristics.

- **Dependent Variable**

The dependent variables in this study are parameters affected by changes in the suction valve opening. Observed parameters include flow rate, total head, hydraulic power, motor power, motor efficiency, and pump efficiency. All of these parameters were measured and analyzed to determine changes in centrifugal pump performance at each suction valve opening variation.

- **Controlled Variables**

The controlled variables in this study are all parameters that are kept constant during the testing process so that the research results are only influenced by variations in the suction valve opening. The controlled variables include the type of Calpeda B-CM 20E pump, motor power of 370 W, fluid used in the form of water, pipe diameter, electrical voltage of 220 V, frequency of 50 Hz, position of the measuring instrument, and the test installation circuit. Control of these variables is carried out to maintain the consistency of the testing conditions so that the data obtained has a good level of accuracy and reliability.

IV. RESULTS AND DISCUSSION

This study was conducted to determine the performance of the CALPEDA BCM 20E centrifugal pump through experimental testing at several valve opening variations. The parameters observed included flow rate, total head, hydraulic power, pump power (BHP), pump efficiency, and Net Positive Suction Head (NPSH). All test data were obtained through direct measurements using a digital flow meter, pressure gauge, vacuum gauge, tachometer, and other supporting measuring instruments.

Based on the test results, the calculated discharge value is in the range of 0.000843–0.000978 m³/s, while the total head produced by the pump is in the range of 1.81–1.96 m. The hydraulic power produced is in the range of 14.98–18.76 Watts, while the pump efficiency is in the range of 32.20–40.35%. These data indicate that the pump is able to work well at every variation of valve opening and produces different performance characteristics at each operating condition.

a. Effect of Flow Rate on Total Head

Based on the test results, the total head value changes with the flow rate. As the flow rate increases, the total head generated by the pump also increases until it reaches a certain operating condition. This indicates that the pump is still capable of delivering energy to the fluid to offset the energy losses occurring in the piping system.

Differences in total head values are influenced by major losses due to fluid friction with the pipe walls and minor losses from pipe connections, bends, and valves. The greater the flow rate, the greater the flow losses, which affect the pump's total head.

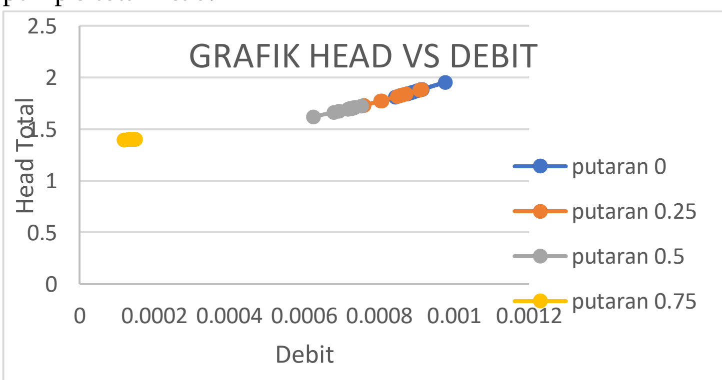


Fig. 5. Graph of the Relationship between Flow Rate and Total Head

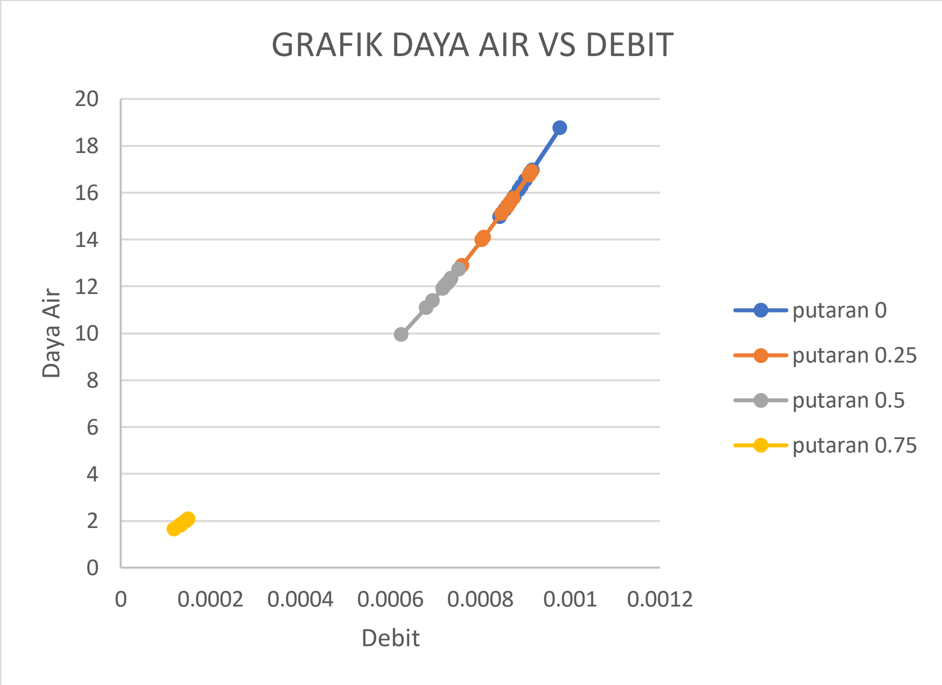
The graph of the relationship between flow rate and total head shows that changes in flow rate affect the head produced by a centrifugal pump. Based on the test results, the highest total head was obtained at a flow rate of approximately 0.000978 m^3/s with a head value of 1.956 m, while the lowest head occurred at a flow rate of approximately 0.000876 m^3/s with a head value of 1.844 m.

This condition indicates that the pump is still capable of maintaining the flow pressure within the tested flow range. Head changes are influenced by energy losses due to fluid friction within the pipe (major losses) and local losses (minor losses) at valves, connections, and pipe bends. The greater the flow rate, the greater the flow losses, which affect the pump's total head.

b. The Effect of Flow Rate on Hydraulic Power

The calculations show that hydraulic power increases with increasing flow rate. This is consistent with the hydraulic power equation, which is influenced by fluid density, gravitational acceleration, flow rate, and total head. The greater the flow rate delivered by the pump, the greater the energy transferred to the fluid.

This condition shows that the pump is capable of converting mechanical energy into hydraulic energy well within the test range carried out.



Picture 2. Graph of the Relationship between Flow Rate and Hydraulic Power

Based on test results, hydraulic power increases with increasing flow rate. The greater the flow rate delivered by the pump, the greater the hydraulic energy delivered to the fluid. This is consistent with the hydraulic power equation, which is influenced by fluid density, gravitational acceleration, flow rate, and the total pump head. Therefore, increasing flow rate will increase the hydraulic power value as long as the head change does not experience a significant decrease.

These results indicate that the CALPEDA BCM 20E centrifugal pump is capable of converting mechanical energy from the motor into hydraulic energy effectively under a range of test conditions. However, the magnitude of hydraulic power is also affected by energy losses due to fluid friction within the pipes and piping system components. Overall, the graph of the relationship between water power and flow rate shows that increasing flow rate has a positive effect on the hydraulic power generated by the pump.

c. Effect of Flow Rate on Pump Efficiency

Pump efficiency changes with each variation in flow rate. The highest efficiency value is achieved when the pump operates close to its best operating point (BEP). Conversely, efficiency decreases when the flow rate is too small or too large due to increased hydraulic and mechanical losses in the system.

These results indicate that selecting appropriate operating conditions significantly impacts pump performance. Therefore, pump operation should be carried out in a work area close to the BEP for optimal efficiency.

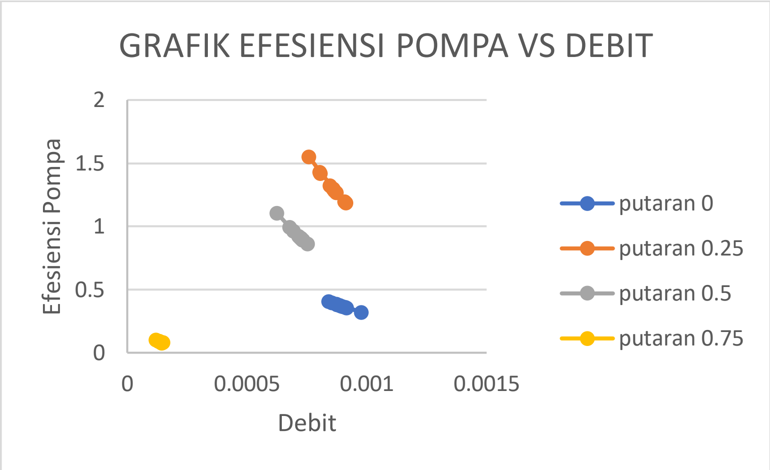


Fig. 3. Graph of the Relationship between Flow Rate and Pump Efficiency

Based on Figure 6, the relationship between flow rate and pump efficiency shows that pump efficiency changes with each variation in valve rotation. The highest efficiency is obtained at 0.25 rotation, then decreases at 0.5 and 0 rotation, while the lowest efficiency occurs at 0.75 rotation. This indicates that the pump has optimal operating conditions at a certain flow rate, thus being able to convert mechanical energy into hydraulic energy more effectively.

The decrease in efficiency at higher or lower rotational speeds is influenced by increased hydraulic losses, mechanical losses, and fluid friction within the piping system. This condition causes not all of the energy supplied by the motor to be utilized as hydraulic energy. Thus, the test results show that the CALPEDA BCM 20E centrifugal pump has an optimum operating point at 0.25 rpm, so that under these conditions the pump performance is better than other rotational speed variations.

V. CONCLUSION AND SUGGESTIONS

a. Conclusion

Based on the results of research and discussions that have been carried out on the performance of the Calpeda Bcm 20e type centrifugal pump, the following conclusions can be drawn:

Test results show that changes in valve opening affect flow rate, total head, hydraulic power, and pump efficiency. The greater the flow rate, the greater the hydraulic power generated, while the head and efficiency values change according to the pump's operating characteristics.

The CALPEDA BCM 20E centrifugal pump performs well as a practical tool in the Mechanical Engineering Fluids Laboratory. The addition of transparent pipes and a digital flow meter facilitates direct fluid flow monitoring and increases the accuracy of flow rate measurements.

Test results show that the pump operates optimally at a valve speed of 0.25, demonstrating the highest pump efficiency compared to other speed variations. This demonstrates that selecting the correct operating point significantly impacts pump performance.

b. Suggestion

Based on the results of the research that has been conducted, there are several suggestions that can be given for further research, namely:

Further research is recommended to use more variations in valve openings and pump rotation so that the pump performance characteristics can be analyzed in more detail.

The use of measuring instruments with a higher level of accuracy and calibration before testing is necessary to increase the accuracy of research data.

Further research can develop the practical system by adding digital sensors and an automatic data logging system so that the data collection process becomes faster, more accurate, and more efficient.

VI. THANK-YOU NOTE

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