International Journal of Engineering and Modern Technology (IJEMT) E-ISSN 2504-8848
P-ISSN 2695-2149 Vol 11. No. 2 2025 www.iiardjournals.org

Performance Optimization of Centrifugal Chemical Pumps Using Pressure Controllers

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DOI: 10.56201/ijemt.vol.11.no2. 2025.pg161.180

Abstract

In this study a traditional centrifugal chemical pump was modified to a self-priming pump by incorporating pressure controller in the operation of the pump to optimize its performance. The model centrifugal pump coupled to an energized motor was tied to a pressure controller that takes input signal from a pressure transmitter at the discharge line of the pump. A normally open solenoid valve installed at the discharge line and a normally closed solenoid valve for priming also at the discharge line downstream of the normally open solenoid discharge valve. With the pump in service and the discharge pressure not meeting the set point of the pressure controller as transmitted by the transmitter, the controller signals the normally closed solenoid valve to open for priming where the condition requires priming. Once the pump is primed with the discharge pressure attained, the controller signals the normally closed solenoid valve to close and open the normally open solenoid valve at the discharge line and the pump delivers the liquid to the users. Performance evaluation was carried out under varying operational conditions, including flow variation and low console levels. Average volumetric flow rate of 12.1m^3/hr was recorded for 10 experimental test run instances which is about the design flowrate. The efficiency of the pump improved from 19.2% to 26.5%, a maximum flowrate of 13.2m^3/hr as against 10.8m^3/hr and a head of 9.2m as against 8.2 were recorded. The results reveal that incorporating pressure controller to self-prime the pump greatly improves its performance. Thus, it is an effective approach to optimize traditional centrifugal chemical pumps characterized with manual priming challenges.

Keywords: *Traditional centrifugal pumps***;** *Solenoid valves***;** *Self-priming pumps; Set point; Pressure controller; Transmitter.*

1. INTRODUCTION

Pumps are mechanical devices that are used to transfer liquid or slurry from one point to another by mechanical action and are often driven by steam turbines, diesel engines or electric motors. There are two major categories of pumps in the pump industry, dynamic and positive displacement pumps. Positive displacement pumps move liquid by repeatedly enclosing a fixed volume and moving it through the system mechanically while dynamic pumps transmit velocity and pressure to the liquid as it moves past or through the impeller and subsequently, convert some of the velocity into additional pressure [1]. Centrifugal pumps are of the dynamic category and mostly used in the industry to move aqueous chemicals due to their proven smooth flow, corrosion resistance, energy efficiency, low maintenance and reliability.

The design and construction of centrifugal chemical pumps allow them to withstand harsh chemicals and conditions inside and out. Even environments that would quickly break down other pumps are not an issue for their corrosion-resistant make. Thus, they enable chemical manufacturers, distributors and users to convey wide variety of fluids in varying conditions; even liquids that would quickly break down other pumps [2]. When used for transporting highly corrosive chemicals, the pumps are able to withstand these conditions and deliver enhanced return on investment and are very durable. Centrifugal chemical pumps rank high in energy efficiency compared to other pumps which places them at a significant advantage over other pump styles [3]. Their efficiency reduces costs both on short term and on the long run. There high-efficiency operation also reduces the impact on energy systems. This can be crucial in settings that require simultaneous operation of multiple pumps and other machinery. They give smooth and pulseless flow [4]. These pumps avoid the pulsing, found in other pumping designs, that can result in potentially dangerous splashing and shaking of accompanying piping. They also avoid the extra expense of purchasing and installing equipment such as pulsation dampeners and other ancillaries. For reliability, talking about pumps that work when they are needed, centrifugal chemical pumps are one. Their durable design stands the test of time. They are quite rugged which further enhances their reliability. The pumps can be relied on for continuous, long-lasting performance. Centrifugal chemical pumps have low routine maintenance requirements. Their simple and efficient design minimizes the number of parts that require attention or replacement [5]. This is low-maintenance design and hence reduces repair costs and decreases downtime. As a result, technicians can spend more time managing their systems and less time working on the pumps themselves. Flow rates through centrifugal pump are controlled by a valve installed in the pipe and connected to the discharge end of the pump. This approach provides an inexpensive means to regulate flow rate, including momentary closure of the discharge valve to stop flow which will not damage the pump, it is used frequently in process plant operations [6]. There are models that can accommodate flow rates ranging from less than 1gpm to greater than 1,400gpm (318 m^3/hr) [2]. With this versatility, the pumps are suitable for different fluid transfer applications in a variety of settings [7].

One common issue is delivery when entrained with gases which could lead to overheating or cavitation of the pump [8]. Thus, like most pumps the entrained gases are removed through priming. The removal of these entrained gases is key for the pump to deliver effectively. Failure to remove same could cavitate the pump which is the formation of vapor bubbles due to these entrained gases and their subsequent collapse in the pump casing. This makes negative impact on the impeller blades and the internals of the pump casing; cause delivery issues, abnormal vibration and failure of the pump. Thus, priming a pump is probably the first and one of the most important things one should do before operating it. Not priming a pump or not doing it properly makes up about 80 percent of centrifugal pump problems [9]. While centrifugal pumps are relatively inexpensive, the downtime of your system due to a malfunctioning pump might be costly.

Manual priming is the common practice to restore the pump to normal operation and to get the expected delivery or flowrate. To manual prime the pump, the discharge valve is kept closed as the suction valve is lined up or opened and the vent valve on the pump casing is opened. Flow is allowed through the vent until all gases are expelled from the pump casing [10]. This is actually a priming method where the suction of the pump is above the pump. This method has some concerns sequel to inconveniences such as splashing of fluid on personnel as the fluid comes out through the vent. For hazardous aqueous chemicals, the operating personnel is exposed to the potential hazards of the chemical. The immediate surrounding and equipment could also be damaged by such chemical. Thus, the need to avoid priming operations manually or possible entrainment of gases in the pump. But to return the pump to normal operation and attain the desired flow rate, removal of the entrained gases in the pump suction and its casing is a must. Thus, priming operation is a must and should be carried out by using alternative and safer technique.

One modern approach is the design of self-priming pumps which are so made to evacuate air from the pump suction side at start up, before commencing its pumping mode. Whereas the pump evacuates air from the suction side, liquid is drawn into the suction line by the surrounding air pressure [11]. Without the involvement of the operator, the pump can prime itself with the initial quantity of liquid at start up and begin pumping. The pump has the capability to re-prime and continue pumping if vacuum is broken. A common design on self-priming centrifugal pump has priming mode and pumping mode phases of operation. During the priming mode, the pump essentially acts as a liquid-ring pump. The impeller generates a vacuum at its eye which pulls air into the pump from the suction line and simultaneously create a cylindrical ring of liquid on the inside of the pump casing [10]. In this way, effectively forms an air-tight seal, restricting return of air from the discharge line to the suction line. Also, air bubbles are trapped in the liquid within the impeller's vanes and moved to the discharge port. Hence, the air is removed and the liquid returns under gravity to the reservoir in the pump housing [12]. The liquid rises up the suction line gradually as it is evacuated. This process continues until all air is replaced with liquid in the suction piping and the pump. The normal pumping mode commences at this stage and liquid is discharged. The design of the priming chamber ensures that enough liquid is retained when the pump is shut down, to enable the pump to self-prime for the next time it will be required for use. Therefore, it is important to check for losses from the casing due to leaks or evaporation before starting a centrifugal pump that has not been in use for a while. Thus, the concern is the plight of these existing traditional centrifugal chemical pumps that are handling hazardous chemicals, having delivery challenges occasioned by entrapped gases in the pump suction line and casing. It may not be necessary to continue to run these pumps with the attendant manual priming challenges or discarded for contemporary self-priming pumps.

This study is aimed at optimizing the performance of traditional centrifugal chemical pumps that are prone to entrainment of air in the suction line and casing using pressure controllers as self-priming mechanism. The pressure controller will use the discharge pressure to regulate the priming process and electrically controlled solenoid valves to self-prime and establish flow. This approach has the potential to greatly improve the efficiency and reliability of chemical pumps in various industrial applications. The study will investigate the feasibility of this approach by carrying out tests on a prototype system that incorporates a pressure controller on a centrifugal chemical pump. The performance of the system will be evaluated under different conditions, parameter ranges and the results will be compared with conventional self-priming pumps. The short- and long-term benefits will also be analyzed [13].

The ultimate goal of the work is optimizing the pump performance in terms of delivery and efficiency through the development of an efficient and reliable self-priming method for existing traditional centrifugal chemical pumps that do not self-prime and can operate in a wide range of chemical applications. This will have significant economic and environmental benefits, as it can increase productivity, reduce maintenance costs, and improve safety and sustainability in the chemical industry. The effectiveness of the pressure controller in ensuring reliable self-priming of the centrifugal chemical pump was also evaluated [14].

2. MATERIALS AND METHODS

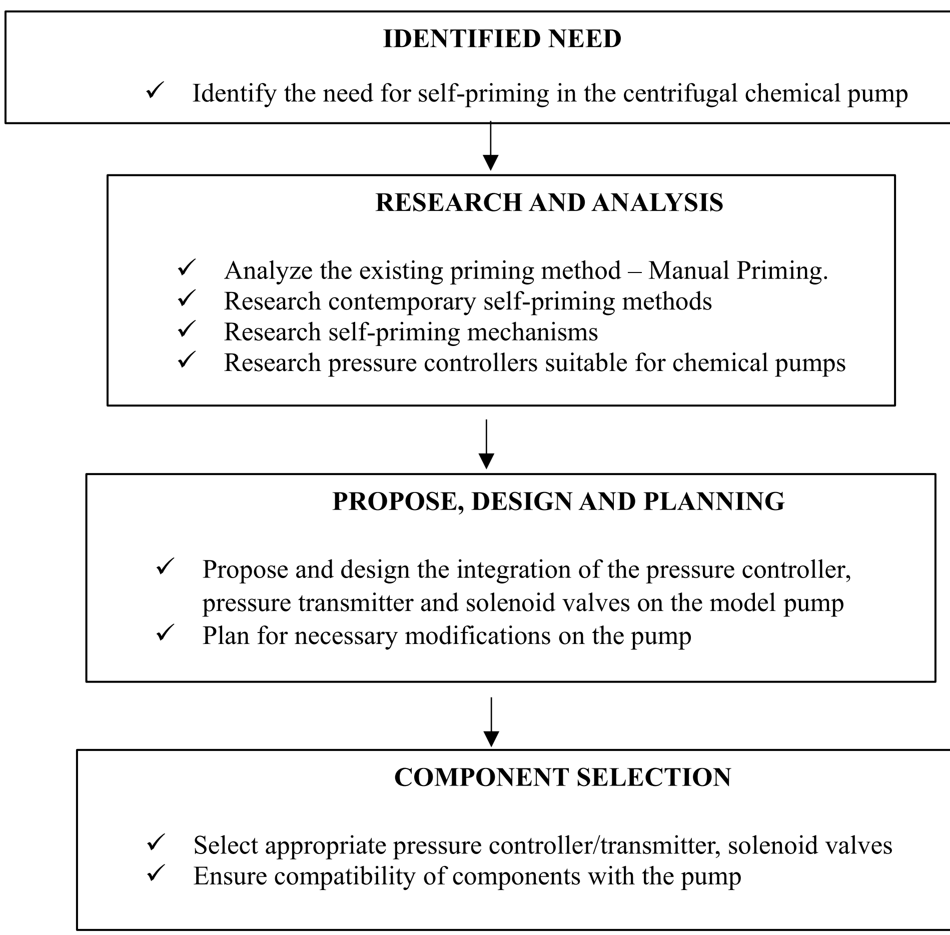
2.1 Research Design

This research entails an organized approach to systematically take a look at the effectiveness of pressure controllers in enabling and improving self-priming of traditional centrifugal chemical pumps, analyze and evaluate same to foster better performance in the chemical industry. The research uses a blend of experimental and analytical procedures, backed by theoretical frameworks associated to fluid dynamics, pump mechanics, and control systems engineering. The study is expected to develop a system that is controlled by pressure to enable self-priming of centrifugal chemical pumps, thereby enhancing efficiency and reducing operational downtime. The findings of this study will provide valuable insights for industries including pharmaceutical, water treatment and petrochemical industries relying on chemical pumps.

The components implored in this work are on an existing chemical skid. These components include a motor driven 3.0HP centrifugal chemical pump, a chemical storage tank with 45% Sodium Hydroxide solution, installed pressure controller/transmitter, 2 inch and ¾ inch pipes and valves connecting the pump to the fluid source (suction line) and the destination (discharge line), two (2) solenoid valves on the 2-inch discharge line and on a 3/4-inch pipe serving as the priming line. The skid also has flow indicator, pressure indicators on the suction and discharge lines. The centrifugal chemical pump is coupled to an energized motor as the pump driver, suction and discharge pressure indicators, pressure controller that takes the signal from pressure transmitter at the discharge line, a normally open solenoid valve at the discharge line and a normally closed solenoid valve for priming also at the discharge line but downstream of the normally open solenoid discharge valve.

Before the pump is given a kick to start, it was ensured that the normally closed solenoid valve for priming is in the closed position. With this, the pump will be started, the suction and discharge pressure indicators observed. With the discharge pressure below the set point of the pressure controller as transmitted by the pressure transmitter, the pressure controller sends signal to open the normally closed solenoid valve for priming where the condition requires priming. The priming process monitored until the discharge pressure reaches the set point of the pressure controller. Once the pump is primed with the discharge pressure attained, the pressure controller will send a signal to close the normally closed solenoid valve for priming and open the normally open solenoid valve at the discharge line and the pump delivers the fluid to the delivery point or users. As the pump operates, the suction and discharge pressure indicators are constantly monitored.

Pressure fluctuations are intentionally created at intervals at the discharge line by partially closing the discharge valve thus, simulating a change in the process conditions [15]. The response of the pressure controller and the solenoid valves observed. The pressure controller monitored to ensure it is able to maintain the desired discharge pressure by opening and closing the solenoid valves accordingly. Fault conditions such as a blockage in the suction or discharge lines were simulated to observe the behavior of the system. The pressure controller and solenoid valves were verified functioning correctly and were able to respond to the changes in pressure. Figure 1 is a flow chart detailing how the work was carried out.



SYSTEM INTEGRATION

- ✓ Integrate the components on the pump
- ✓ Modify the pump and its system as required

TESTING AND VALIDATION

- ✓ Conduct initial testing of the integrated system
- ✓ Validate the self-priming functionality
- ✓ Make necessary adjustments based on test results

FINAL TESTING

- ✓ Perform comprehensive testing
- ✓ Ensure all safety and performance standards are met

Figure 1: Flow chart of how the work was carried out

2.2 Experimental Set-up

Figure 2 shows the experimental setup flow diagram which consists of a storage tank, a motor driven centrifugal chemical pump with suction and discharge piping, pressure controller, pressure transmitter, solenoid control valves and pressure indicators on the suction and discharge piping while Figure 2 and Figure 3 show respectively the model pump before and after installation of pressure controller, pressure transmitter and solenoid valves as self-priming mechanisms on the pump as seen on the chemical skid. The abbreviations PC, PT and PI shown on the experimental setup flow diagram on Figure 2 represents pressure controller, pressure transmitter and pressure indicator respectively. Also, SOV1 and SOV2 represents solenoid valve#1 and solenoid valve#2 respectively.

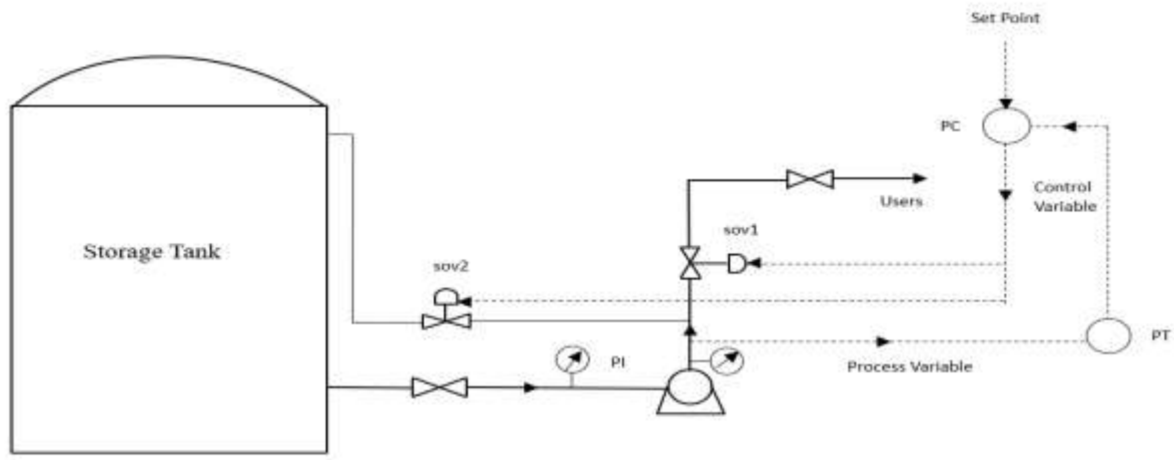


Figure 2: Flow diagram of the experimental set-up

Figure 3: shows the model pump before installation of pressure controller, pressure transmitter and solenoid valves

Figure 4: The model pump after installation of pressure controller, pressure transmitter and solenoid valves

The pump model is D-65X40-200 manufactured by NIIGATA WORTHINGTON. The pump casing, impeller, shaft, gland, shaft sleeve and wear rings are all made of Alloy 20 to withstand the corrosive nature of Hydrogen tetra-oxo-sulphate (IV) Acid (98wt % H_2SO_4) and 45% Aqueous Sodium Hydroxide solution (NaOH). The Pump's Base Plate is Fabricated Steel Drain Rim type.

2.2.1 The Control Algorithm

The objective of the pressure controller is to ensure that the pump delivers fluid at a consistent pressure, irrespective of fluctuations in inlet conditions or changes in process requirements. Achieving this goal demands a sophisticated control strategy that integrates sensor feedback, computational logic, and actuation mechanisms to dynamically adjust pump valve positions as necessary.

The control algorithm acts as the intelligent core of the pressure controller, continuously analyzing real-time data from pressure sensors. By leveraging this data, the algorithm makes calculated decisions to modulate pump operation, thereby optimizing energy efficiency, extending equipment lifespan, and safeguarding against potential operational anomalies such as cavitation or excessive pressure surges. The algorithm's adaptability is critical in accommodating operating scenarios and fluid properties commonly encountered in chemical transfer processes. It must be capable of rapid response and precise control to maintain the desired pressure setpoints while mitigating risks associated with aggressive chemicals or variable flow rates. The control algorithm for pressure controller is as outlined in Figure 5.

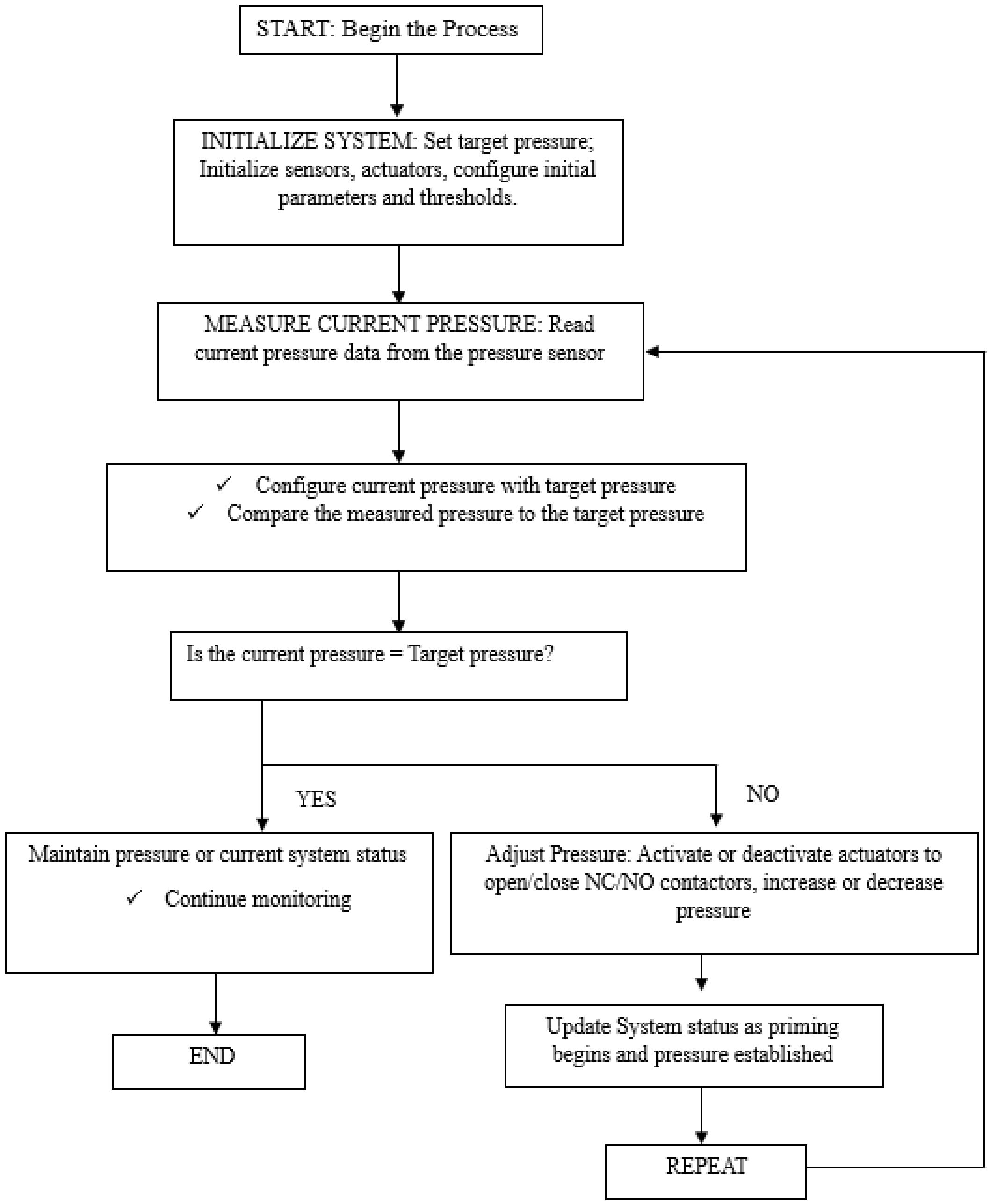


Figure 5: Control algorithm of the pressure controller

2.3 The Governing Equations

The study explores the use of a pressure controller to enhance pump performance through self-priming of centrifugal chemical pumps. This involves performance parameters such as Pump discharge pressure (P_d), Suction pressure (P_s), and the Pump head (H). Other parameters include hydraulic power ($P_{Hydraulic}$), volumetric flow rate, Q and efficiency (η) on pump operations. In centrifugal pumps, all these parameters are commonly defined by Equations (1) to (4) as defined below [16]. Once the discharge and suction pressures on the pump test are obtained, the pump head and subsequent desired flow rate can be calculated using the equations as follows:

The Pump Head,

$$H = \frac{Pd - Ps}{\rho g} \tag{1}$$

Where, H is the pump Head (m), P_d is the Discharge Pressure (kg/cm^2), P_s is the Suction Pressure (kg/cm^2), ρ is the Density of the liquid (kg/m^3), g is the acceleration due to gravity (m/s^2)

The Hydraulic Power of the fluid,

$$P_{hydraulic} = \rho * g * H * Q \tag{2}$$

Where ρ is the Density of the liquid (kg/m^3), g is the acceleration due to gravity (m/ s^2), H is the pump Head (m), Q is the volumetric flow rate (m^3/s),

Efficiency (η) of the pump is expressed in Equation (3),

$$\eta = \frac{\rho * g * H * Q}{P} \tag{3}$$

where η is the pump efficiency (expressed as a decimal), P is the power consumed by a centrifugal pump or shaft power, Q is the volumetric flow rate (m^3/s), H is the pump head (m), ρ is the Density of the liquid (kg/m^3), g is the acceleration due to gravity (m/ s^2)

Also,

The Pump's Volumetric Flowrate Q, is given in Equation (4),

$$Q = \frac{\pi * D^2 * N * H}{4g} \tag{4}$$

Where Q is the volumetric flow rate of the pump (m^3/s), D is the Impeller Diameter (mm), N is the pump speed in (rev/min), H is the pump Head (m), and g is the acceleration due to gravity (m/ s^2).

2.3.1 Input Data

The input data for the system include 2.1kg/cm^2 discharge pressure, 1460rpm speed, 192mm impeller diameter, 2.9m pump head, fluid density of 1830kg/m^3 and acceleration due to gravity of 9.81m/s^2. Applying equation 3.4, the volumetric flowrate of the pump is 12.5m^3/hr.

2.4 Model Pump Parameters

The parameters of the model centrifugal chemical pump including the design flowrate are as shown in Table 1.

Table 1: Parameters of the model centrifugal chemical pump

S/N	Parameters	Unit	Value
1	Volumetric Flow rate, Q	m^3/hr	12.5
2	Pump Efficiency, η	%	43
3	Suction Pressure, P_s	kg/cm^2	0.56
4	Discharge Pressure, P_d	kg/cm^2	2.07
5	Maximum Head, H	m	13
6	Impeller Diameter, D	mm	192
7	Pump Speed, N	RPM	1460
8	NPSHA	m	4.85
9	NPSHR	m	1.7
10	Pump Power Rating	kw	1.66
11	Pump Max. Power Rating	kw	2.36
12	Motor Power Rating	kw	3.7

2.5 Data Collection

Maintenance Records on the Model Centrifugal pump (Panel Operator's logbook September 03 through December 30, 2023) was sourced and collated. On an average of 50 Days operation of the Plant, Mechanical maintenance attended to priming the pump 15 times. The remote cause was that of low console level which made the pump suction air bound and the subsequent ingress of air into the pump casing. Low console level was established during the test run and the console level later made up on each of the 10 test run days. Table 2 gives the Priming activities (Frequencies) on model pump 3rd September through 30th December, 2023.

Table 2: Frequency of Manual Priming September 3 thru December 30, 2023

S/N	Days/Date	Frequency of Priming
1	3-Sep-23	1
2	10-Sep-23	1
3	16-Sep-23	1
4	22-Sep-23	1
5	2-Oct-23	1

6	15-Oct-23	1
7	22-Oct-23	1
8	31-Oct-23	1
9	6-Nov-23	1
10	15-Nov-23	1
11	26-Nov-23	1
12	11-Dec-23	1
13	17-Dec-23	1
14	23-Dec-23	1
15	30-Dec-23	1

Series of test runs/experiments were conducted on the test rig to observe the self-priming behavior of the pump under different operating conditions, such as varying pressure controller settings. The data collated will be analyzed in the next chapter to identify the key factors that influence the self-priming performance of the centrifugal chemical pump. This will involve statistical analysis and optimization techniques to understand the relationships between the various parameters which include the self-priming time, efficiency of the pump, volumetric flow rate and cost implication or analysis.

3. RESULTS AND DISCUSSION

The output parameters in this work are the head, volumetric flow rate, efficiency and the power consumption of the pump. Table 3 shows the results of the experimental test carried out on the 10 test runs. Table 4 shows volumetric flow rate, pump dynamic head, efficiency and power readings before modifying the model centrifugal chemical pump to self-priming pump while Table 5 shows the volumetric flow rate, pump dynamic head, efficiency and power readings after modifying the model centrifugal chemical pump to self-priming pump. Also, Figures 5-9, show the model pump performance in terms of head, efficiency, and power input against volumetric flowrate plots, before and after the modification and also, the characteristics of the model centrifugal chemical pump before and after the modification.

Table 3: Model Centrifugal Chemical Pump Performance Data on the 10days test run

Days	Discharge Pressure(kg/cm^2)	Suction Pressure(kg/cm^2)	Self-Priming Time(s)	Flow rate (m^3/hr)
1	2.1	0.0	66	12.4
2	2.0	0.0	79	10.6
3	2.1	0.0	62	12.6
4	2.1	0.0	61	13.4
5	2.0	0.0	67	11.9
6	2.1	0.0	64	12.6

7	2.0	0.0	69	11.7
8	2.0	0.0	70	10.8
9	2.1	0.0	62	13.2
10	2.1	0.0	67	12.1

Table 3 shows the performance of the model pump on the ten test run days. The average self-priming time of the model pump on the 10days test run is 67seconds which agrees with the research works that it takes seconds to a few minutes to self-prime centrifugal pump [12]. The average volumetric flowrate is 12.1m^3/hr which is approximately the model pump normal flowrate of 12.5m^3/hr.

Table 4: Volumetric flow rate, pump dynamic head, efficiency and power readings before modifying the model centrifugal chemical pump to self-priming pump

Flow, Q(m3/Hr)	Head, H(m)	Efficiency, η(%)	Power, P(watts)
0	13.0	0.0	0.0
3.6	12.0	13.0	233.4
5.2	10.8	16.9	337.1
6.8	9.2	18.8	440.8
7.8	8.2	19.2	505.7
8.0	8.0	19.2	518.6
8.8	6.8	18.0	570.5
9.0	6.4	17.3	583.4
9.4	5.8	16.4	609.4
9.6	5.4	15.6	622.3
9.8	5.0	14.7	635.3
10.0	5.0	15.0	648.3
10.8	3.1	10.1	700.1
10.8	3.1	10.1	700.1

Table 4 shows the Volumetric Flowrate, Pump Dynamic Head, Efficiency and Power readings before modifying the model centrifugal chemical pump to self-priming pump. The power consumption of the pump is unsteady and the maximum flowrate recorded is 10.8m^3/hr as against 12.5m^3/hr expected of the pump. The maximum recorded efficiency is 19.2%.

Table 5: Volumetric Flow rate, Pump Dynamic Head, Efficiency and Power readings after modifying the model centrifugal chemical pump to self-priming pump

Flow, Q(m3/Hr)	Head, H(m)	Efficiency, η(%)	Power, P(watts)
0.0	13.0	0.0	0.0
5.0	12.0	18.0	324.1
8.0	10.8	26.0	518.6
9.6	9.2	26.5	622.3
10.6	8.2	26.1	687.2
10.8	8.0	26.0	700.1
11.6	6.8	23.7	752.0
11.8	6.4	22.7	765.0
12.2	5.8	21.3	790.9
12.4	5.4	20.1	803.9
12.6	5.0	18.9	816.8
12.6	5.0	18.9	816.8
13.2	3.1	12.3	855.7
13.2	3.1	12.5	855.7

Table 5 shows the volumetric flow rate, pump dynamic head, efficiency and Power readings after modifying the model centrifugal chemical pump to self-priming pump. The power consumption of the pump is steady compared to its previous state and a maximum of 13.2m^3/hr flow rate was recorded. The efficiency improved from 19.2% to 26.5%.

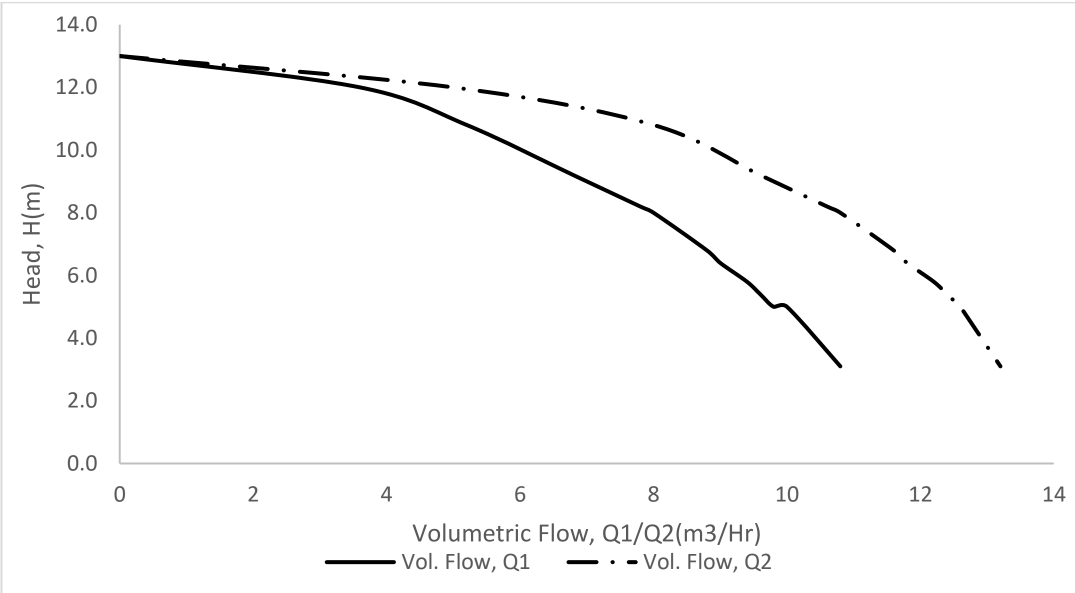


Figure 5: Model pump performance plot before and after the modification – pump head vs volumetric flowrate

Figure 5 shows the model pump performance, pump head versus volumetric flowrate plot before and after the modification. The dotted line shows the head performance curve after the modification while the straight line gives the head performance curve before the modification. From the curve, it is obvious that the pump performs better after the modification.

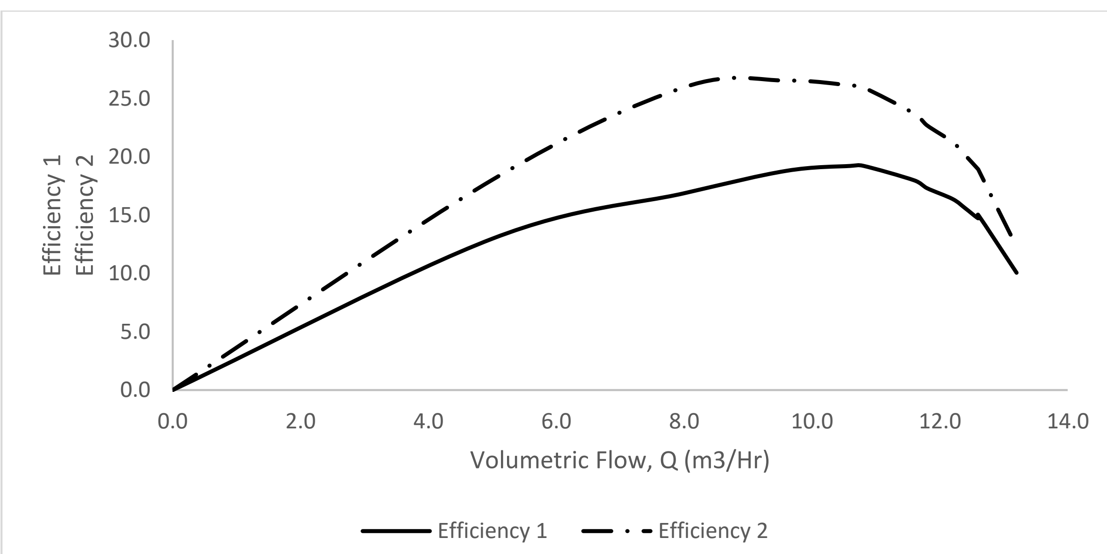


Figure 6: Model pump performance plot before and after the modification – efficiency vs

volumetric flowrate

Figure 6 shows the model pump performance, efficiency vs volumetric flowrate plot before and after the modification. The dotted line shows the efficiency performance curve after the modification while the straight line gives the efficiency performance curve before the modification. From the curve, it is obvious that the pump became more efficient after the modification.

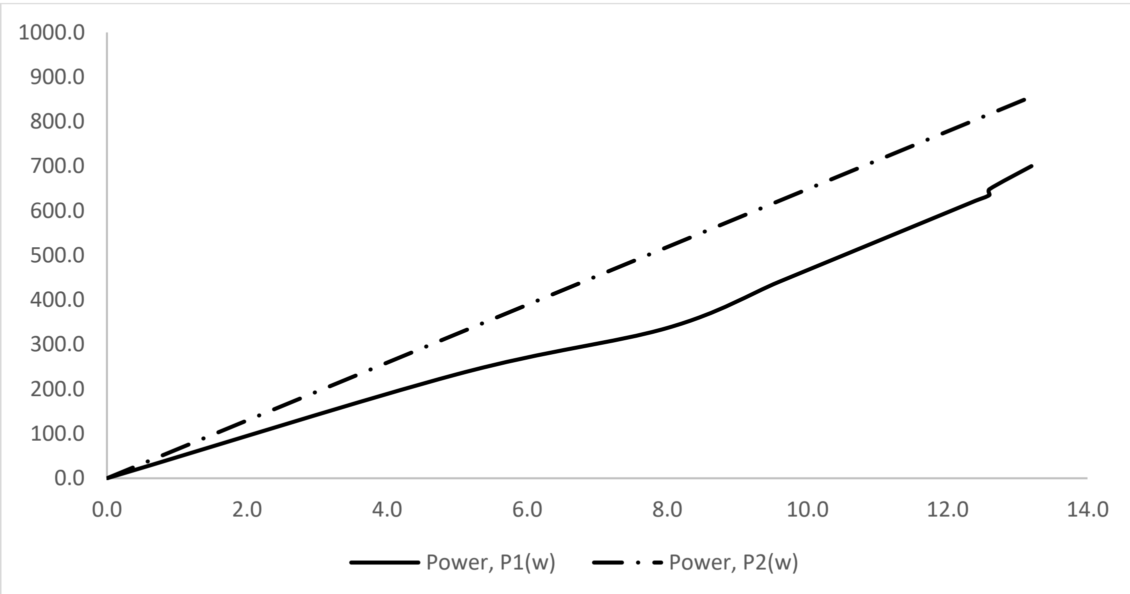


Figure 7: Model pump performance plot after the modification – power input vs volumetric flowrate

Figure 7 shows the model pump performance, power input versus volumetric flowrate plot before and after the modification. The dotted line shows the power input performance curve after the modification while the straight line gives the power input performance curve before the modification. From the curve, it is obvious that the pump input power performs is better after the modification.

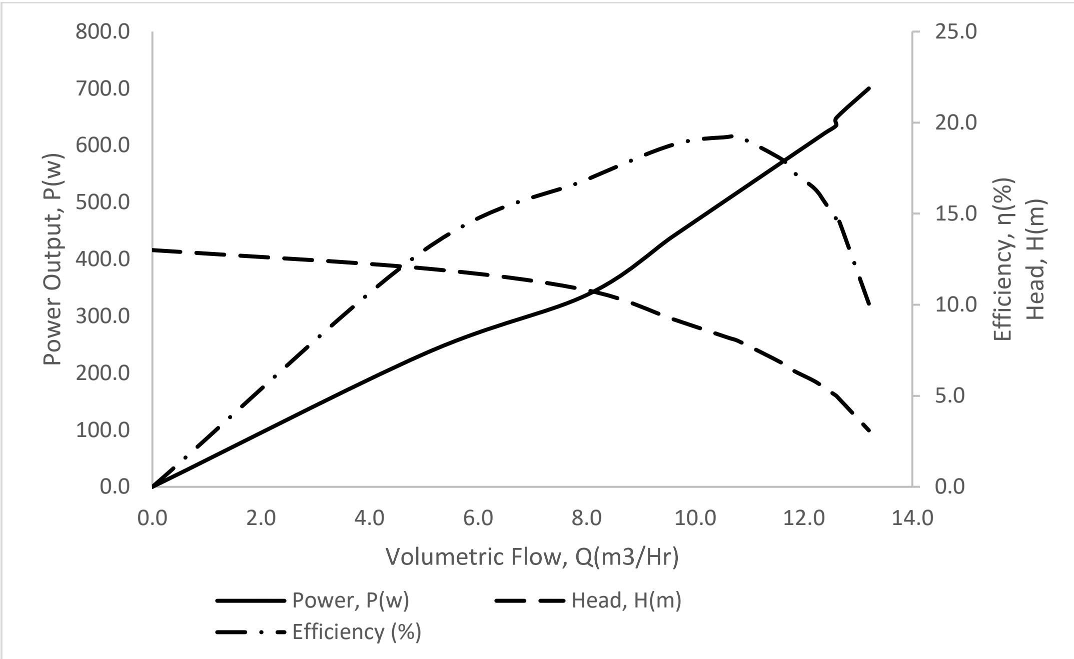


Figure 8: Characteristics of the model centrifugal chemical pump before the modification

Figure 8 shows the model pump performance characteristics curve plot before the modification. The dashed line shows the pump versus volumetric flowrate curve, the dashed-dotted line shows the efficiency versus volumetric flowrate curve while the straight line shows the input power versus volumetric flowrate curve, all before the modification.

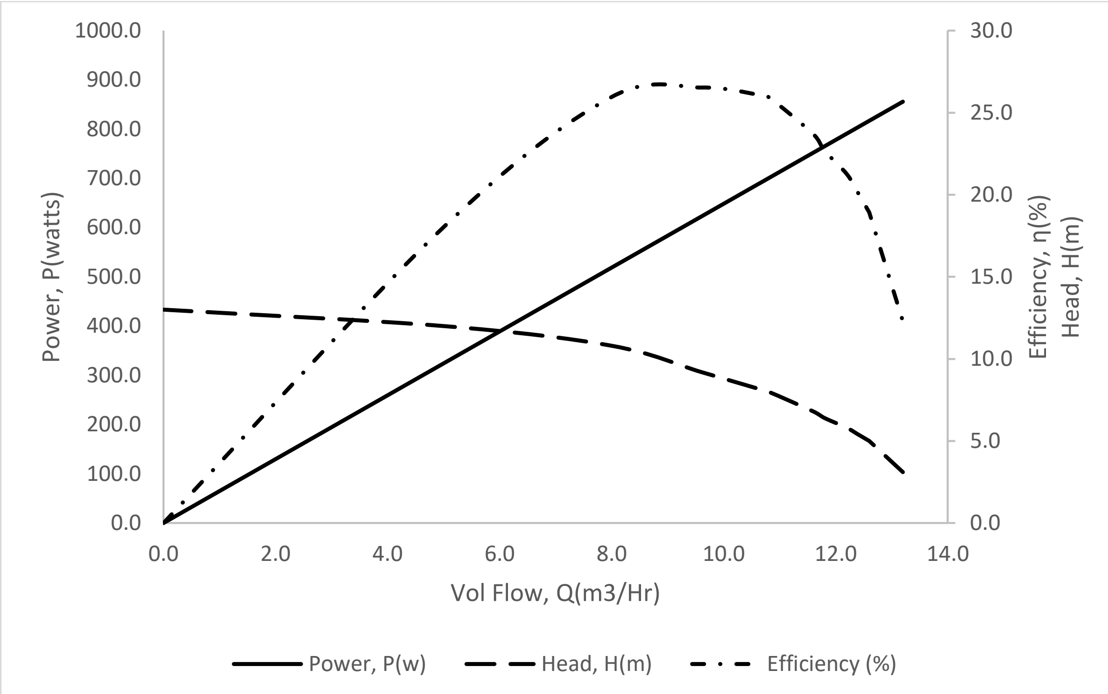


Figure 9: Characteristics of the model centrifugal chemical pump after the modification

Figure 9 shows the model pump performance characteristics curve plot after the modification. The dashed line shows the pump versus volumetric flowrate curve, the dashed-dotted line shows the efficiency versus volumetric flowrate curve while the straight line shows the input power versus volumetric flowrate curve, all after the modification. From the curve, it is conspicuous that the pump characteristic curve is better after the modification.

In fifty (50) operational days (September 3, through December 30, 2023), the pump failed to deliver in fifteen (15) days which implies that on the average, the pump fails three (3) days on every ten (10) days it is put to use. From the test run after modification, the pump did not fail to deliver in all the ten (10) test run days. The average volumetric flowrate was 12.1m^3/hr which is approximately the design flowrate of 12.5m^3/hr of the model pump as recorded on Table 3. This is an obvious remarkable improvement. Thus, modifying the pump using pressure controller to achieve self-priming enhances the performance of the pump in terms of delivery or volumetric flow rate, efficiency, head and stability in power consumption.

4. CONCLUSIONS

Performance optimization of centrifugal chemical pumps was investigated in this study by implementing a pressure control system. Significant improvements were observed in terms of operational stability, energy efficiency and system reliability. The analysis demonstrated that optimized pressure control system minimizes pressure fluctuations, and ensures consistent flow rates under varying load conditions. The outcome of the experiment revealed that pressure controllers not only enhance pump efficiency by sustaining optimal operating parameters but also contribute to reduced energy instability and consumption, aligning with industrial applications in sustainability goals. In addition, the integration of pressure controller provides a robust mechanism to handle transient conditions, reducing maintenance downtime and the risk of system failures. Subsequent work could delve into extending the study to include multi-pump systems and their interaction under networked pressure control system which can provide insights into system-wide optimizations. Finally, there is absolutely no reason discarding or abandoning existing centrifugal chemical pumps having manual priming issues. No point sticking to the condition of these pump thereby exposing operation and maintenance personnel, the equipment itself and immediate surrounding to unsafe acts and conditions. The results underline the critical role of pressure control systems in achieving enhanced performance and reliability of centrifugal chemical pumps in various industrial processes and applications.

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