Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

EXPERIMENTAL ANALYSIS OF RADIAL BLADE FORREGENERATIVE TURBO MACHINES

Dr.K.Anandan, Dr.M.P.Senthilkumar, Assistant Professor, Dept. of Mechanical Engineering, P S V College is Engineering and Technology, Anna University.
Mr.D.ShivaKumar, Mr.R.PraveenKumar, Final Year student, Dept. of Mechanical Engineering, P S V College is Engineering and Technology, Anna University.

ABSTRACT
Industry interest in regenerative pumps has grown because of its low cost, low specific speed, compact design, and extremely steady performance curve. A regenerative pump's primary feature is its capacity to produce more head at lower flow rates than any other turbo machinery with an equivalent tip speed. The fluid in regenerative pumps is frequently in contact with the impeller. Regenerative machines may achieve high-pressure ratios in a single impeller because of the "multi-staging" that occurs when the impeller balding repeats its impact on the fluid. A number of things influence the performance of a regenerative pump. Among such aspects, the impeller and its design play a significant influence, directly affecting the pump's performance. The performance of twisted impeller blades is superior to that of regular straight blades. By altering the side-blade exit and vane inlet blade angles, new modified impeller designs are modelled. Solid Works is used to construct the updated impeller model. Normally, the usage of costly CNC machines would be required due to the intricacy of the redesigned blade profiles. Therefore, CNC machines were used to develop both the regular impeller and newly redesigned impellers. In the end, all of the impeller experimental results were verified, and it was discovered that changing the vane angle might increase the efficiency of turbo machines.
Keywords: Impeller, blades, pumps, speed, flow rates, etc.

1. INTRODUCION
1.1 REGENERATIVEPUMPS
Despite having several industrial uses, regenerative flow pumps and compressors receive the least attention when it comes to research. Comparatively speaking, there are fewer publications in the literature than those that discuss axial and centrifugal turbo machines. The terms peripheral pumps, side channel pumps, drag pumps, turbine pumps, traction pumps, tangential pumps, and vortex pumps are other names for regenerative pumps. Regenerative machines expose the fluid to the impeller several times, as opposed to other common types of continuous flow machines where the fluid only goes through the impeller once.
1.1.2 REGENERATIVE PUMP PRINICIPLE
The main distinction between a regenerative turbine pump and a centrifugal pump is that the fluid in a centrifugal pump passes through the impeller just once, whereas in a turbine, as seen in Fig., it passes through the vanes several times.
The cross-sectional graphic (Fig. 1.1) the impeller vanes in Fig. 1.2 travel inside the water channel passageway's flow-through region. The liquid is forced forward and outward by the vanes as it enters the pump and is directed toward the impeller's perimeter by centrifugal force. Therefore, the impeller vane imposes an organized circulatory flow, creating fluid velocity.
Afterwards, fluid velocity, or kinetic energy, may be transformed into flow and pressure based on the flow resistance of the external system, which can be represented by a system curve. It is important to remember that strict internal clearances are necessary to keep a regenerative turbine's capacity to develop pressure from internalizing. Impeller to casing clearances may often be dependent on the pump's size. On each side, as small as one thousandth of an inch. As a result, only clean fluid and system applications are appropriate for these pumps. A suction strainer may be a useful tool in certain situations to safeguard the pump.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

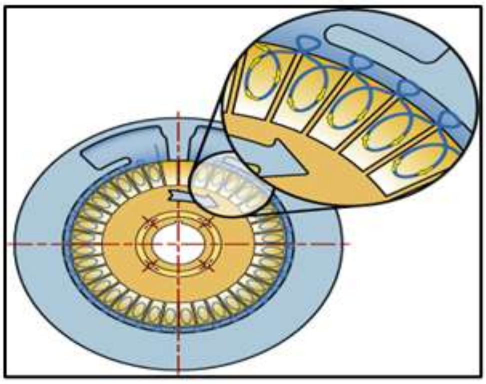


Fig.1.FlowoffluidinCasing

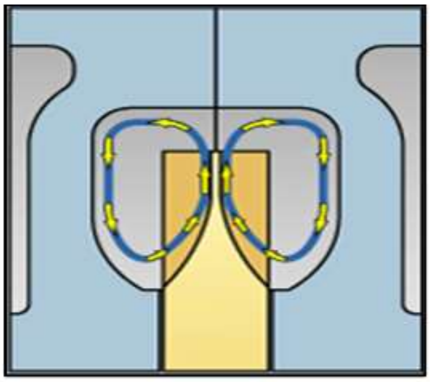


Fig.2.FlowoffluidinVane

Afterwards, fluid velocity, or kinetic energy, may be transformed into flow and pressure based on the flow resistance of the external system, which can be represented by a system curve. It is important to remember that strict internal clearances are necessary to keep a regenerative turbine's capacity to develop pressure from internalizing. Impeller to casing clearances can often be as tiny as one-thousandth of an inch on either side, depending on the pump's size. As a result, only clean fluid and system applications are appropriate for these pumps. A suction strainer may be a useful tool in certain situations to safeguard the pump.

2. RAPID PROTOTYPING

Using specialized machining equipment, a design may be physically modelled through the process of rapid prototyping (RP). Using three-dimensional (3D) computer-aided design (CAD) model data, magnetic resonance imaging (MRI) scan data, and other data generated by 3D digitizing systems, fast prototyping systems swiftly construct models and prototype components. By utilizing an additive method of shape construction, the RP systems combine various elements, such as liquids or powders, to create various tangible things. Layer by layer, the RP machines use extremely tiny horizontal cross sections of the created computer model to fabricate these powdered ceramic, wood, plastic, and metal powders. The definition of rapid prototyping, an emerging technology, comes from its fundamental idea of being quick. Rapid prototyping is having a significant effect on how businesses make tooling, models, and prototype components. It's now being used by a few businesses to make finished manufactured parts. It is anticipated that in the years to come, fast prototyping will play a significant role in manufacturing procedures.

3. PROBLEM DEFINITION

Regenerative pumps are used in many different sectors for various industrial purposes. Their pumps operate less well as a result. The pump is not providing enough performance. As a result, they express interest in advanced pump efficiency. When a business pursues the goal of improving pump performance, they meet several requirements. Creating the twisted blade profiles throughout the development phase is the primary issue. A new model is going to be constructed by making reference to earlier hypotheses. After analyzing the production costs, an appropriate quick manufacturing process is chosen. Next, the quick manufacturing process is used to create the modified impeller model and the regular impeller model. Both impellers undergo performance trial testing, and a comparison is produced. All of the earlier hypotheses were predicated on conjecture rather than thorough measurements or extensive CFD simulations that would have improved comprehension of the intricate flow inside the regenerative pump.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

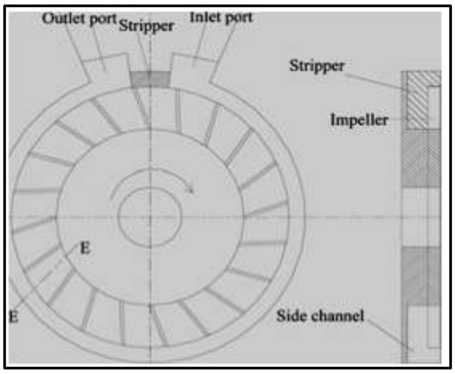


Fig.3. One Sided Impeller

Because previous mathematical models are predicated on oversimplified assumptions, they do not adequately capture the flow characteristics. T Mikhail and S O Park provide an enhanced model for the pump's performance. The model may be used to construct twisted blades that would boost the pump head and efficiency. It can handle one intake angle and two exit angles for the impeller blades. A novel aspect of the pump's features, grounded in the suggested model, is examined.

It is demonstrated that the suggested model produces outcomes that closely match the findings of the experiments. The new model also demonstrates that, contrary to the prior assumption, the side-blade exit angle has a significant impact on the regenerative pump's performance. The performance and efficiency of regenerative pumps are developed with the aid of these earlier theories. Pumps are used in a wide range of industries. The industries demand that pump efficiency be improved. This work uses experimental tests to implement the notion of developing pump efficiency.

4. SCOPEOF THEPROJECT

The primary goal of the project is to fill the performance gap left by regenerative pumps in numerous industrial applications by introducing a new class of high-performance impellers. Industries are competing to develop their pumps in order to receive a star rating for them. Pump development phases are crucial, and they must to be maximized. Reducing the regenerative pump's development stage's cost and duration is taken into account. In the future, industry should find it easier to produce complicated blade profiles with great performance at cheap cost and time.

5. OBJECTIVEOFTHEPROJECT

- To improve the performance of the pump by developing the regenerative pump impeller by altering the current impeller design that is available on the market.
- Make a complicated blade profile quickly and cheaply by employing the Rapid Prototyping Technique.
- To do an impeller test run was made using the Rapid Prototyping process in order to evaluate the pump discharge behaviour and pressure.
- To research the new modified impellers and the traditional impeller's pressure and discharge tests.

6. METHODOLOGY

Currently available on the market, regenerative pumps are considered the standard model. That pump's impeller is a typical impeller. The impeller's dimensions are accurately predicted. The

modelling program is then also used to model an altered impeller. Solid Works 2010 is the modelling program utilized to create the impeller models.
Then, using the Rapid Manufacturing process, the modelled impellers are produced. After careful research, a suitable Rapid Manufacturing technology is chosen, and that method is used to produce the impellers. The performance of both impellers is then verified through experiments.
Two experiments are carried out to verify the pump's functioning. They are listed below.
Pressure Testing and Discharge Testing

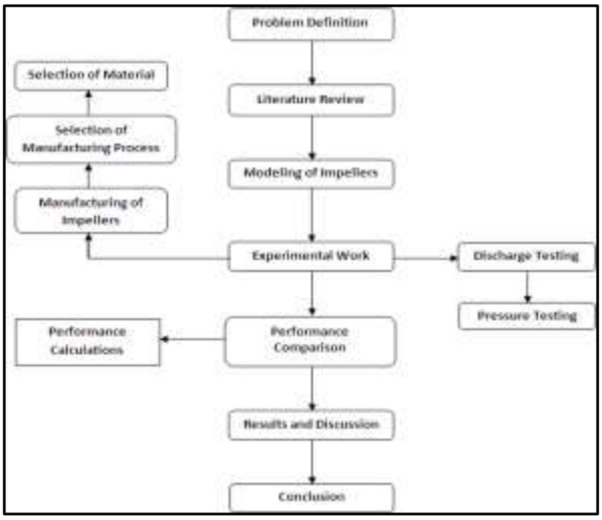


Fig.4 Flow Chart – Methodology

6. DESIGNOFREGENERATIVEPUMP IMPELLER

The regenerative pump is driven by a half-horsepower motor in the design. The foundation of an impeller's design is its design flow rate, pump head, and pump-specific speed. A 0.5 HP induction motor was used to drive the pump, which ran at a steady 2800 rpm. The motor was attached to a dynamometer with a load cell so that the input torque to the impeller could be precisely measured and the pump efficiency could be computed. A flow control valve that metered the flow to the extent required to Figure 4 Flow Chart - Methodology create a running characteristic was used to calculate the fluid flow rate. Input power, suction pressure, and discharge pressure were to be measured over a range of flow rates during the test procedure. The test impeller had 36 blades, measuring 65 mm in diameter and 7.5 mm in thickness. The impeller's twin suction form was engineered to balance axial thrust through blade alignment. Therefore, in order to construct the regenerative pump, the design data are needed.

The following design parameters are used in the design calculation:

Table.1 Properties of Nylon

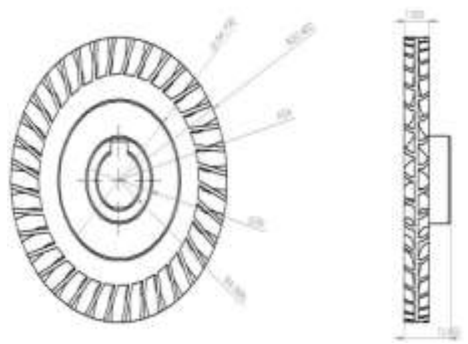
Flow Rate	-	40 lpm/6mheight
Pump Speed	-	2800 rpm Maximum Current
Diameter	-	25.4 mm
Gravitational acceleration	-	9.81 m/s^2
Hydraulic Efficiency	-	35-50%

The number of circulations, or the number of times the flow passes through the impeller blades from the pump's intake port to its exit port, is another significant parameter that influences performance.

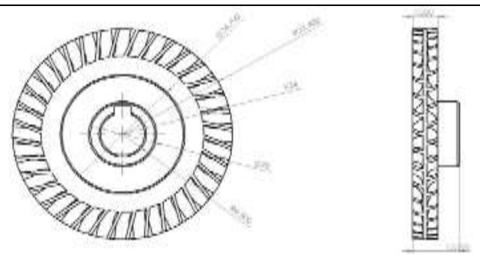
Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

Every blade channel is where the flow reaches the impeller, according to the CFD data. Therefore, it is simple to determine the number of circulations as a function of the impeller blade count. The amount of blades directly affects the head that the pump produces.

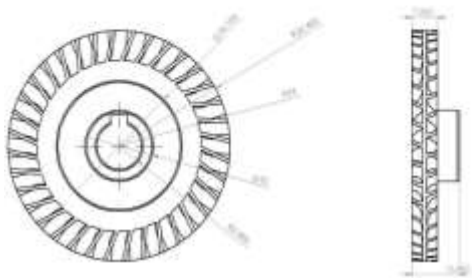
DIMENSIONSOF THEMODIFIED IMPELLER-I

<table>
<tr><td rowspan="6">
Fig.5
View of Modified Impeller–I</td><td>Impeller diameter</td><td>65mm</td></tr>
<tr><td>Thickness</td><td>7.5 mm</td></tr>
<tr><td>No. of vanes</td><td>36</td></tr>
<tr><td>Vane inlet blade angle – β1</td><td>45</td></tr>
<tr><td>Outlet blade at its side – β2S</td><td>45</td></tr>
<tr><td>Outlet blade at its tip – β2t</td><td>90</td></tr>
</table>

DIMENSIONSOFTHEMODIFIEDIMPELLER-II

<table>
<tr><td rowspan="6">
Fig.6
View of Modified Impeller–II</td><td>Impeller diameter</td><td>65mm</td></tr>
<tr><td>Thickness</td><td>7.5 mm</td></tr>
<tr><td>No. of vanes</td><td>36</td></tr>
<tr><td>Vane inlet blade angle – β1</td><td>50</td></tr>
<tr><td>Outlet blade at its side – β2S</td><td>50</td></tr>
<tr><td>Outlet blade at its tip – β2t</td><td>90</td></tr>
</table>

DIMENSIONSOF THEMODIFIEDIMPELLER-III

<table>
<tr><td rowspan="6">
Fig.7
View of Modified Impeller– III</td><td>Impeller diameter</td><td>65mm</td></tr>
<tr><td>Thickness</td><td>7.5 mm</td></tr>
<tr><td>No. of vanes</td><td>36</td></tr>
<tr><td>Vane inlet blade angle – β1</td><td>55</td></tr>
<tr><td>Outlet blade at its side – β2S</td><td>55</td></tr>
<tr><td>Outlet blade at its tip – β2t</td><td>90</td></tr>
</table>

7. MANUFACTURINGPROCESSSELECTIONOFRPPROCESSANDMATERIAL

Choosing the right material for a rapid prototype is an essential step in the process. Over half of the real cost is spent on materials. The manufacturing technique is chosen based on material selection. Certain qualities are present in the prototype materials. They are divided into materials with low fidelity and those with high fidelity. Since the impellers are tested experimentally, high fidelity material is used for manufacture. The material first approach and the process first approach are the two methods used to choose the rapid prototyping technique. The method and the material are both crucial factors to take into account when choosing a procedure.

In any case, precision and flawless finishing are regarded as essential. Thus, the process first technique is used to pick the process. The Selective Laser Sintering technique of production is chosen to create the impellers out of all the other types of RP processes. The selection of SLS is based on its fast building speed and superior precision in product construction. The primary benefit is that the manufactured prototypes have a lower surface polish and strength since they are porous (about 60% of the density of molded components). Parts made of polycarbonate and nylon have mechanical properties. The most crucial step in the production process is choosing the materials after the SLS technique has been chosen. Because polyamide material has a high degree of stiffness, it is chosen for manufacturing. RP Process Selective Laser Sintering Material - Polyamide (Nylon)

7.1 SELECTIVE LASER SINTERING (SLS)

The SLS machine used to manufacture the impeller models is shown in the Figure 8.

Fig. 8 Selective Laser Sintering Machine

SLS Machine Specification DTMSLSSinterStation2500RapidPrototypeEquipment

Table.2 Properties of Nylon

Build Volume	:	13"x11"x16.5"
Materials	:	Dura Form PA, Dura Form GF
Build Step Size	:	0.004"
Printer	:	Dtm3dPrinterHi – Q thermal Control Module

8. POLYAMIDEMATERIAL (NYLON)

By raising the powder temperature to the melt temperature using a laser, highly crystalline polymers—most notably nylons—are sintered. As a result, there is excellent particle contact, which produces components with generally good mechanical qualities. The polyamide group of polymers is referred to as nylon. In addition to being used to make films and fibers, nylon may also be purchased as a molding compound.

8.1 Properties of Nylon

Most nylon is made of extremely durable, semi-crystalline polymers that have strong chemical and heat resistance. With specific gravity, melting temperature, and moisture content tending to decrease as the number of nylon rises, the various varieties provide a wide range of qualities.

Table.3 Properties of Nylon

Physical properties	:	Value
Tensile Strength	:	90- 85N/mm^2
Notch Impact Strength	:	5.0- 3.0KJ/m^2
Density	:	1.13 -g/cm^3
Thermal coefficient of expansion	:	80x10^{-6}

9. RAPIDPROTOTYPE IMPELLERS

The conventional and modified impellers are utilized for studies after being produced in nylon material using the Selective Laser Sintering method. Figures 9 and 10 below depict the produced conventional impeller and the modified impeller.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

Fig.9 Proto type of Standard Impeller

Fig.10 Proto type of Modified Impeller

10. EXPERIMENTALTESTING

10.1 PRESSURE AND DISCHARGE TESTING

Prior to being released into the market, all pumps undergo testing to verify the discharge and exit pressures. There are two crucial tests that must be performed in order to evaluate a pump's functionality. They are listed below:

Pressure Testing
Discharge Testing

The new pump design was created so that these tests could only confirm the design. These tests are conducted to validate the newly created impeller design. First, the regenerative pump's produced standard impeller is installed. Following that, these two tests are run, and the results are recorded. The standard impeller prototype is now replaced with the produced modified impeller installed in the pump. After that, the redesigned impeller is put through these two tests, and the results are recorded.

10.2 PRESSURE TESTING

In order to examine the outlet pressure and conduct experimental measurements of the setup with the impeller completely opened and fully closed, the prototyped standard impeller is installed inside the pump. Next, a customized impeller is used in place of the normal impeller. Examine the completely open and fully setup readings of the outlet pressure; the results are recorded in the respective tables beneath the redesigned impellers.

Table. 4 Pressure Testing of Standard Impeller & or Modified Impeller- I

Pressure Testing for Standard Impeller			Pressure Testing for Modified Impeller - I		
Description	**Full Open**	**Full Setup**	**Description**	**Full Open**	**Full Setup**
Voltage (volt)	237	238	Voltage (volt)	236	235
Current (amp)	2.05	2.1	Current (amp)	2.01	2.5
Power (watts)	350	422	Power (watts)	360	532
Frequency (Hz)	49.7	49.8	Frequency (Hz)	49.5	49.6
Speed (rpm)	2800	2800	Speed (rpm)	2800	2800
Pressure Head (m)	0	14	Pressure Head (m	0	26

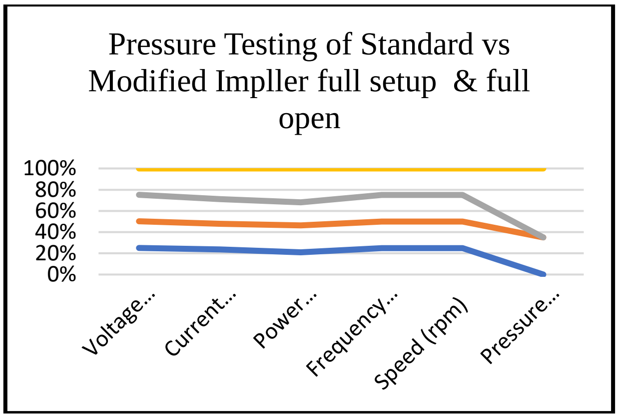


Fig.11 Comparison of Standard Impeller vs Impeller Design I(full open setup)

Table .5 Pressures Testing of Standard Impeller II & Modified Impeller – III

Pressure Testing for Standard Impeller- II			**Pressure Testing for Modified Impeller -III**		
Description	**Full Open**	**Full Setup**	**Description**	**Full Open**	**Full Setup**
Voltage (volt)	236	240	Voltage (volt)	236	235
Current (amp)	2.01	2.26	Current (amp)	2.01	2.22
Power (watts)	360	470	Power (watts)	360	480
Frequency (Hz)	49.5	49.6	Frequency (Hz)	49.5	49.6
Speed (rpm)	2800	2800	Speed (rpm)	2800	2800
Pressure Head (m)	0	20	Pressure Head (m)	0	18

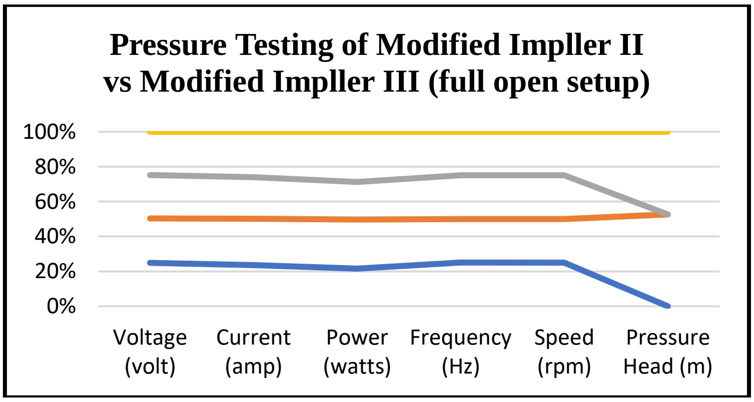


Fig.12 Comparison of Modified Impeller II vs. Impeller Design III (full open setup)

11. DISCHARGE TESTING

First, the pump's standard impeller prototype is installed within. After that, the discharge test setup is corrected. By changing the delivery head, the discharge change is seen. Next, the modified impeller is used in lieu of the conventional impeller, and the experiment is repeated.

11.1 Standard Impeller

In the discharge testing setup, the standard impeller is built and connected into the regenerative pump. Throughout the test run, a 3 m suction head is maintained, and the delivery head is initially left open to free flow. Table 4 illustrates the experimental circumstances, which include a steady increase in delivery head and a marked shift in discharge.

Table.6 Discharge Testing for Standard Impeller

Sl.No	Voltage (volts)	Current (amp)	Power (watt)	Frequency (Hz)	Suction (m)	Delivery (m)	Discharge x10-3(m3/s)
1	234	1.64	334	51.9	3	0	6.203
2	237	1.74	372	51.9	3	6	3.7
3	237	1.78	386	51.9	3	8	2.6
4	237	1.84	405	51.9	3	10	1.3
5	237	1.91	420	51.9	3	12	0

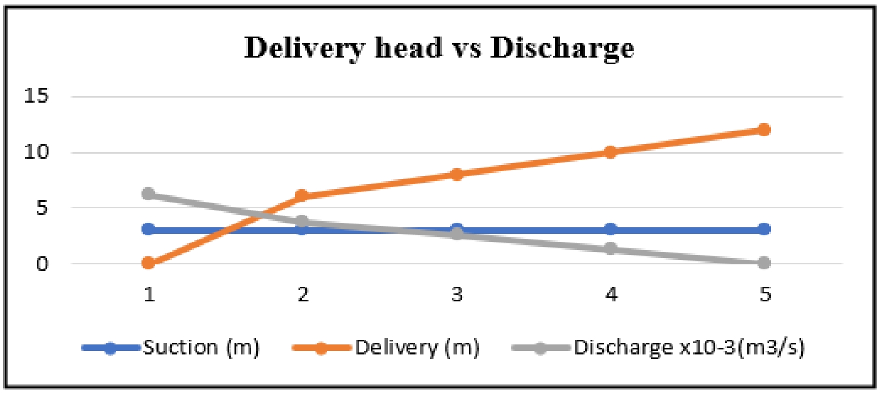


Fig.13Comparison of result of Delivery head vs. Discharge

The 12 m delivery head is not discharged. Consequently, the pump has a 10 m delivery head capacity. These reading sets are retained in order to verify the newly adjusted impeller readings.

The regenerative pump is equipped with the redesigned impeller, which is then installed in the discharge testing setup. Throughout the test run, a 3 m suction head is maintained, and the delivery head is initially left open to free flow. The necessary readings are noted and the test run is initiated. The primary necessary output is discharge. Subsequently, the delivery head is raised progressively while the discharge change is recorded. The test run readings are shown in table 5.6. The test run is conducted with the suction head remaining constant.

For each set of readings, the delivery head is raised by 2 m, and the difference in discharge is recorded.

Table.7 Testing of Modified Impeller – I

Sl.No.	Voltage (volts)	Current (amp)	Power (watt)	Frequency (Hz)	Suction (m)	Delivery (m)	Discharge x10-3(m3/s)
1	235	2.01	364	49.6	3	0	6.5
2	235	1.93	390	49.6	3	6	4.75
3	235	2.00	430	49.6	3	10	3.44
4	235	2.13	465	49.7	3	14	1.99
5	237	2.27	502	49.7	3	18	0.625

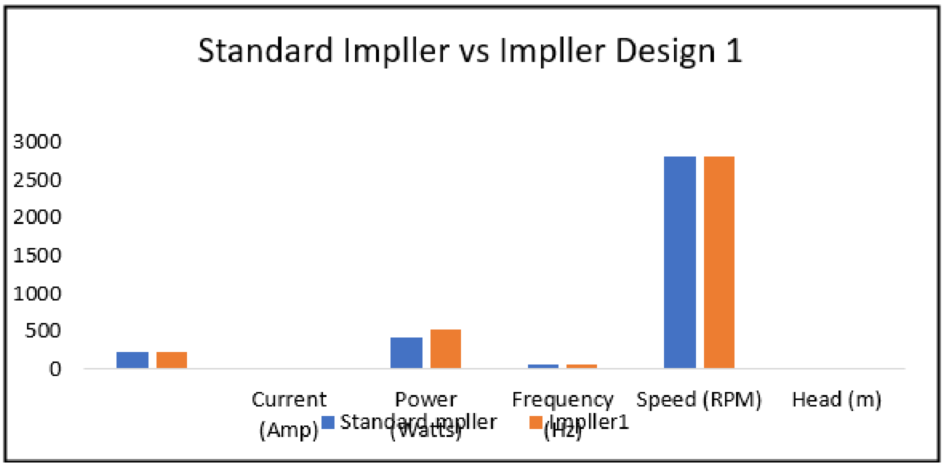


Fig.14 Comparison of Standard Impeller vs Impeller Design - I

The delivery head at 22 meters is not discharged. Consequently, the pump has a 22 m delivery head capacity. These reading sets are retained in order to verify the newly adjusted impeller readings.

11.2 Modified Impeller - II (500)

The regenerative pump is equipped with the modified impeller 500, which is then installed in the discharge testing setup. Throughout the test run, a 3 m suction head is maintained, and the delivery head is initially left open to free flow. The necessary measurements are noted as the test run is initiated. The primary necessary output is discharge. Subsequently, the delivery head is raised progressively while the discharge changes are noted. The test run readings are shown in table 5.7. The test run is conducted with the suction head remaining constant. Every set of readings causes the delivery head to raise by 2 m, and the difference in discharge is noted.

Table.8 Discharge Testing for Modified Impeller - II

SI.No.	Voltage (volts)	Current (amp)	Power (watt)	Frequency (Hz)	Suction (m)	Delivery (m)	Discharge x10-3(m3/s)
1	240	1.69	354	49.5	3	0	6.38
2	235	1.95	387	49.5	3	6	4.36
3	234	2.04	417	49.5	3	10	2.81
4	233	2.15	459	49.6	3	16	0.93
5	232	2.26	472	49.7	3	20	0

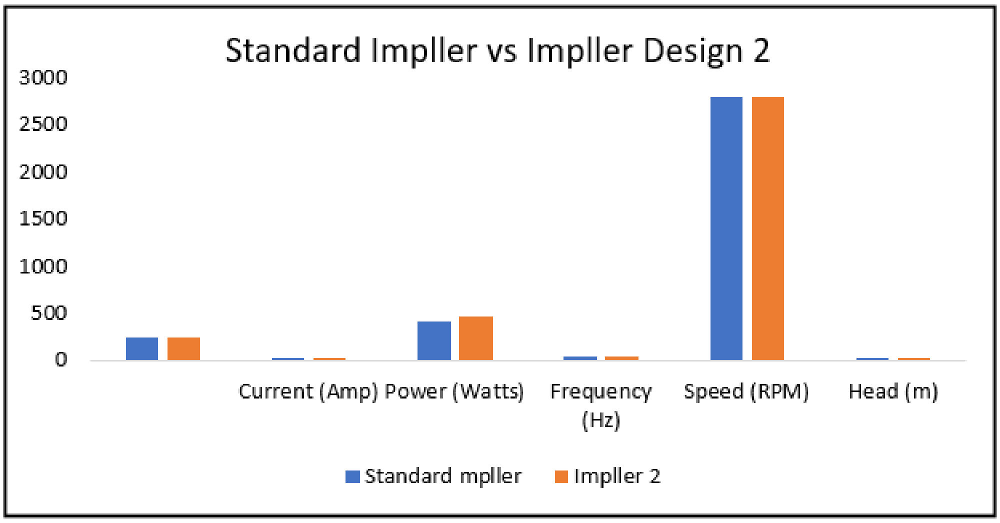


Fig.15 Comparison of Standard Impeller vs Impeller Design - II

The delivery head at 20 meters is not discharged. Consequently, the pump has a 16 m delivery head capacity. These reading sets are retained in order to verify the newly adjusted impeller readings.

11.3 Modified Impeller - III (55°)

The regenerative pump is equipped with the redesigned impeller III, which is then integrated in the discharge testing setup. Throughout the test run, a 3 m suction head is maintained, and the delivery head is initially left open to free flow. The necessary readings are noted and the test run is initiated. The primary necessary output is discharge. Subsequently, the delivery head is raised progressively while the discharge change is recorded. The test run readings are recorded in table 5.8. The test run is conducted with the suction head remaining constant. For each set of readings, the delivery head is raised by 2 m, and the difference in discharge is recorded.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

Table.9 Discharge Testing for Modified Impeller - III

Si.No.	Voltage (Volts)	Current (amp)	Power (watt)	Frequency (Hz)	Suction (m)	Delivery (m)	Discharge x10-3(m3/s)
1	232	1.78	342	49.8	3	0	6.12
2	228	1.75	377	49.7	3	6	3.98
3	229	1.89	418	49.6	3	10	2.46
4	236	2.11	457	49.7	3	14	0.67
5	234	2.22	481	49.6	3	18	0

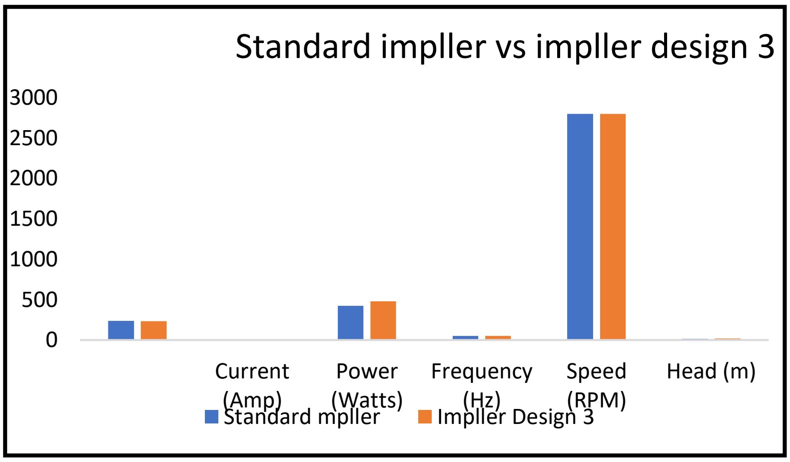


Fig.16. Comparison of Standard Impeller vs. Impeller Design- III

There is no discharge at 18 m delivery head. So the pump can perform up to 14 m delivery head. These sets of readings are kept for validating the new modified impeller readings.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

12. MATHEMATICALCALCULATIONS

Table.10 Hydraulic Efficiency of a Regenerative Pump

Properties	Standard Impeller (90°)	Modified Impeller I (45°)	Modified Impeller II (50°)	Modified Impeller III (50°)
Discharge	3.7×10^{-3} m^3/s	4.75×10^{-3} m^3/s	4.36×10^{-3} m^3/s	3.98×10^{-3} m^3/s
Power Input	372 W	382 W	387 W	377 W
Gravity force (g)	9.81 m/s^2	9.81 m/s^2	9.81 m/s^2	9.81 m/s^2
Density (p)	1000kg/m^3	1000kg/m^3	1000kg/m^3	1000kg/m^3
Delivery head (h)	6 m	6 m	6 m	6 m
Pressure	58860 Pa	58860 Pa	58860 Pa	58860 Pa
Hydraulic efficiency	Hydraulic efficiency = 58.54%	Hydraulic efficiency = 73.18%	Hydraulic efficiency= 66.31%	Hydraulic efficiency = 62.13%

13. RESULTS AND DISCUSSION

13.1 COMPARISON OF PRESSURE TESTING

The results of the conventional and modified impeller pressure testing experiments are compared, and the modified impeller's pressure head change was noted.

Table.11 Comparison of Pressure Testing Result of Impellers

Sl.No.	Description	Standard Impeller full setup	Modified Impeller I full setup	Modified Impeller II full setup	Modified Impeller III full setup
1	Voltage (volt)	238	235	240	235
2	Current (amp)	2.1	2.5	2.26	2.22
3	Power (watts)	422	532	470	480
4	Frequency (Hz)	49.8	49.6	49.6	49.6
5	Speed (rpm)	2800	2800	2800	2800
6	Head (m)	14	26	20	18

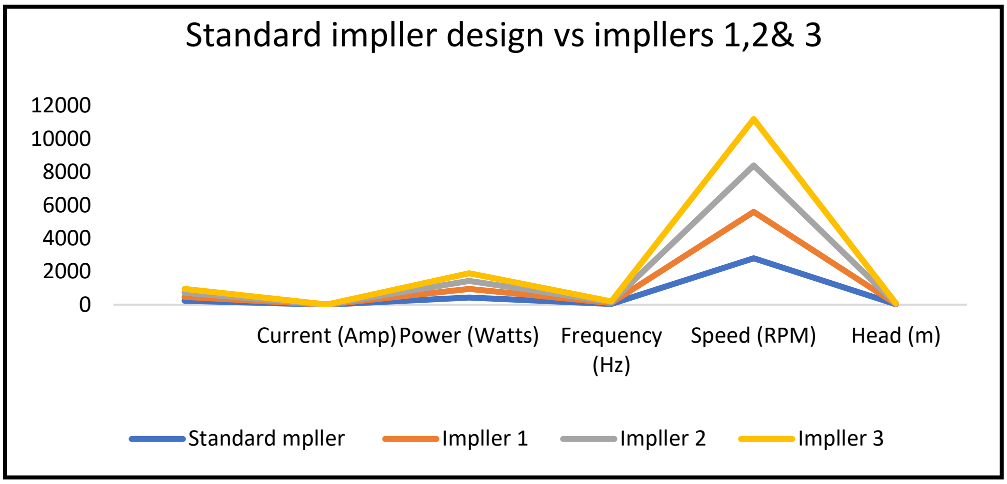


Fig.17 Comparison of Standard Impeller vs. Impeller Design 1.2&3.

When comparing the conventional and modified impeller I (45°) to each other, table 7.1 shows an increase in power input of 110 watts and an increase in current of 0.4 amp. It appears that it also uses more power and current. However, the economic impact of this increase in power and current will be minimal. An increase in pressure of 85% of the typical impeller pressure is seen. The current consumed in the following two models decreases somewhat, as does every other component, including the pressure head. The Modified Impeller I provides 12 m of more pressure head over the Standard Impeller. The pressure head in Impeller II drops by 6 meters, and the head drops by 2 meters in Impeller III as well. This suggests that the pressure head is impacted by changes in the vane angle. There is a decrease in the pressure head as the vane angle increases.

13.2 COMPARISON OF DISCHARGE TESTING

The experimental readings and the discharge testing outcomes of both conventional and modified impellers are compared.

Table.12 Comparison of Discharge Testing Results of Impellers

Sl.No	Description	Standard Impeller fully open	Modified Impeller I fully open	Modified Impeller II fully open	Modified Impeller III fully open
1	Suction (m)	3m	3m	3m	3m
2	Delivery (m)	6m	6m	6m	6m

Only the discharge result for the fully opened configuration is displayed in table 7.2. Here, the pump is operated at a 3 m suction, which is maintained for the duration of the test and to verify the discharge in every instance. Three modified impellers were used to evaluate the discharge of a standard impeller. Modified impeller I (45°) had a high discharge, but the discharge of the other two modified impellers decreased in comparison to Impeller I.At a delivery head of 12 meters, the conventional impeller does not discharge; the upgraded impellers II and III only discharge up to 16 meters. Up to 20 meters of delivery head can be discharged from modified impeller I (45). This suggests that the pressure and discharge are both impacted by the change in vane angle under investigation.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 2, December : 2023

13.3. COMPARISON OF HYDRAULIC EFFICIENCY

Examine the hydraulic efficiency of each impeller to determine which of the three designed versions has a superior, more optimized design. In contrast to the Standard, Modified Impeller II, and III, the Modified Impeller I (45°) has a better hydraulic efficiency. The aforementioned mathematical computation demonstrates that, in comparison to Impeller I, the redesigned impellers II and III have decreased in efficiency.

Table.13 Comparison of Hydraulic Efficiency

Description	Standard Impeller	Modified Impeller-I	Modified Impeller-II	Modified Impeller-III
Hydraulic Efficiency	58.54 %	73.18 %	66.31 %	62.13 %

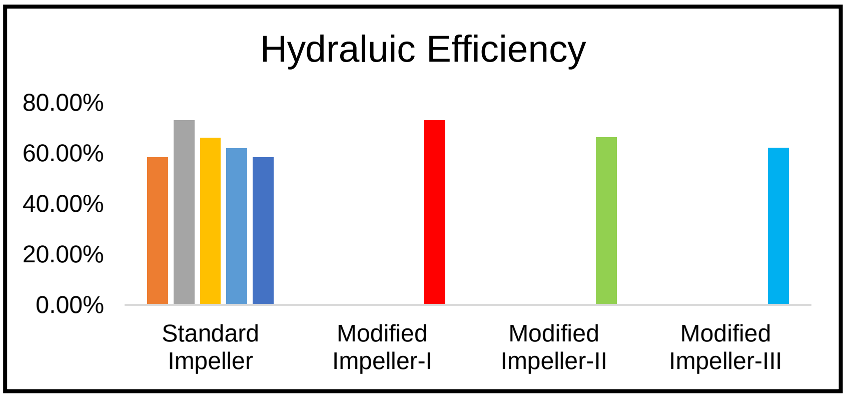


Fig.18 Comparison of hydraulic efficiency for modified impellers I, II&III

We found that the performance of the Modified Impeller I (45°) under the experimental conditions is superior to that of the Standard Impeller and the other two Modified Impellers. The primary cause of the reduced head and hydraulic efficiency in situations with β2S90o is the vortex development behind the blade, as the flow angle is quite far from the blade angle in these circumstances. When β2S is less than 90 degrees, the flow angle approaches the blade angle, preventing the creation of a vortex behind the blade and resulting in increased efficiency. When comparing the standard impeller result to the pump's original specification, it is extremely low. Since the prototype impeller is made of nylon and the original is made of brass, there is a material discrepancy.

14. CONCLUSION

When designing twisted blades to boost the pump head and efficiency, the Regenerative Pump model can accommodate one inlet angle and two exit angles for the impeller blades. The ability to account for the impact of side-blade exit angle, which has a significant impact on the functioning of the regenerative pump, is a unique feature of the newly improved model. It has been demonstrated experimentally that a change in vane angle directly affects the pressure and discharge testing of the pump with both conventional and customized impellers.

When pressure testing was conducted in Modified Impeller I (45°) at a constant speed of 2800 rpm, it was found that the voltage fluctuated, the current increased from 2.1 to 2.5 amperes, and the pressure head increased from 14 to 26 meters above the Standard Impeller and the other two Modified Impellers.

1. The modified impeller I (6.5x10-3 m3/s) has a higher value than the standard impeller and the modified impellers II and III, according to measured discharge tests conducted at a constant suction head of 3 m.

2. Compared to the Standard impeller (58.54%), Modified impeller II (66.31%), and Modified impeller III (62.13%), the computed hydraulic efficiency value of Modified impeller I (73.18%) is higher.
3. This shows that when the inlet vane angle increases, the pump's performance decreases due to the impeller's 45° angle, and the efficiency of the modified impellers II and III decreases sequentially.
The aforementioned study leads one to the conclusion that impeller I (45°) performs better than both the current impeller and other modified impellers (II and III).

15. REFERENCES

[1] SAE Technical Papers Series, No. 971074, 1997; Badami, M. "Theoretical and experimental analysis of traditional and new peripheral pumps."
[2] "Review of regenerative compressor theory," Burton, D. W. Applications of Rotat. Machin. Gas-Cooled Reactors", TID-7631, 228-242, 1962.
[3] Engeda, A. ASME Fedsm2003-45681, 2003 "Flow analysis and design suggestions for regenerative flows pumps."
[4] H. W. Iverson, "Performance of the Periphery Pump," ASME Vol. 7, 1955, pp. 19–22.
[5] "An Improved theory for regenerative pump performance," Meakhail, T., and Park, S.O. Part A of IMECHE Vol. 219, 2005.
[6] "Development of a Regenerative pump impeller using Rapid Manufacturing Techniques" by Francis J. Quail, T.J. Scanlon, and M.T. Strickland. Quick Prototyping, 2007; ISSN 1355-2546.
[7] "Systematic design approach for radial blade regenerative turbomachines," Racheal, M., and Engeda, A., Journal for Propulsion and Power, Vol. 21, 2005.
[8] "A New k-å Eddy-Viscosity Models for High Reynolds Number Turbulent Flows-Model Development and Validation," Computers Fluids, 24 (3), pp. 227-238, 1995, by Shih, T.H., Lieu, W.W., Shabbier, A., Yang, Z., and Zhu, J.