Defining the parameter for optimisation the performance, and Vacuum level of water ring pump of 904 series.

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1.Abstract: With increasing demand of vacuum pump also require high performance of pump demanded by market. Vacuum pump to give their function properly but many vacuum pumps not give work properly as per requirement just because of poor design of vacuum pump. So design of pump being changed to improve function, but it is costly and time consuming using experimental work. So CFD analysis use for this purpose.

The main objective of this project is to improve vacuum level of water ring vacuum pump. In Fine tech engineering during testing process of water ring vacuum pump see that in WRVP the vacuum level is very low as per requirement and therefore efficiency is low.

To improve the efficiency of SV-20 water ring vacuum pump, Computational Fluid Dynamics analysis is one of the advanced tools used in the pump industry. A detailed CFD analysis is used to predict the flow pattern inside the impeller which is an active pump component. From the result of CFD analysis, vacuum level of impeller is justified and validated with experimental result here with very low deviation in result of 2.24%. Now modified impellers are modelled using CAD modelling software. Here we changed thickness of blade, inlet and outlet angle of impeller based on empirical relation and literature. Here 11 modified impellers remodelled. These models are analysed individually using CFD analysis to fing the performance of the modified impeller WRVP. By using CFD analysis impellers with the improved value of vacuum level 485.88mm of hg vacuum get and by means improved efficiency achieve.

Key word :Vaccum pump,CFD,Impeller,Blade Thickness.

2.Introduction

A **pump** is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. A vacuum pump is a device for creating, improving and/or maintaining a vacuum. Mechanical vacuum pumps work by the process of positive gas displacement, that is, during operation the pump periodically creates increasing and decreasing volumes to remove gases from the system, and exhaust them to the atmosphere. Two basically distinct categories may be considered gas transfer pumps and entrapment or capture pumps.

Different types of vacuum pumps are listed as below:

- liquid ring(water ring)
- rotary vane
- rotary piston
- dry vacuum pumps
- vacuum boosters

3.Working Principle of WRVP

- The major component of the liquid ring pump is a multi-bladed rotating assembly positioned eccentrically in a cylindrical casing. (See Figure) This assembly is driven by an external source, normally an electric motor. Service liquid (usually water) is introduced into the pump. As the impeller rotates, centrifugal force creates a liquid ring which is concentric to the casing. At the inlet, the area between the impeller blades increase in size, drawing gas in. As the impeller continues to rotate toward the discharge, the impeller bucket area decreases in size, compressing the gas. This gas, along with the

- Two-impeller straight-lobe compressors are rotary positive displacement machines in which two straight mating lobed impellers trap gas and carry it from intake to discharge. There is no internal compression.

Helical or spiral lobe compressors are rotary positive displacement machines in which two intermeshing rotors, each with a helical form, compress and displace the gas liquid from the pump, is discharged through the outlet nozzle. In addition to being the compressing medium, the liquid ring performs two other important functions:

1) It absorbs the heat generated by compression, friction, and condensation of the incoming vapor.

2) It absorbs and washes out any process contaminants entrained in the gas.

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4.PROBLEM FORMULATIONS

Water ring vacuum pump is mostly used for vacuum creation purpose in many applications. PARAG ENGINEERING company is manufacturer of water ring vacuum pump and facing problems related to this water ring vacuum pump which gives very low efficiency. In water ring vacuum pump vacuum level requirement is not achieved properly by SV-20 pump. Experiment work with accuracy take place and get vacuum level is 450 mm of hg. Pump creates very low vacuum level so not very efficient pump in its application.

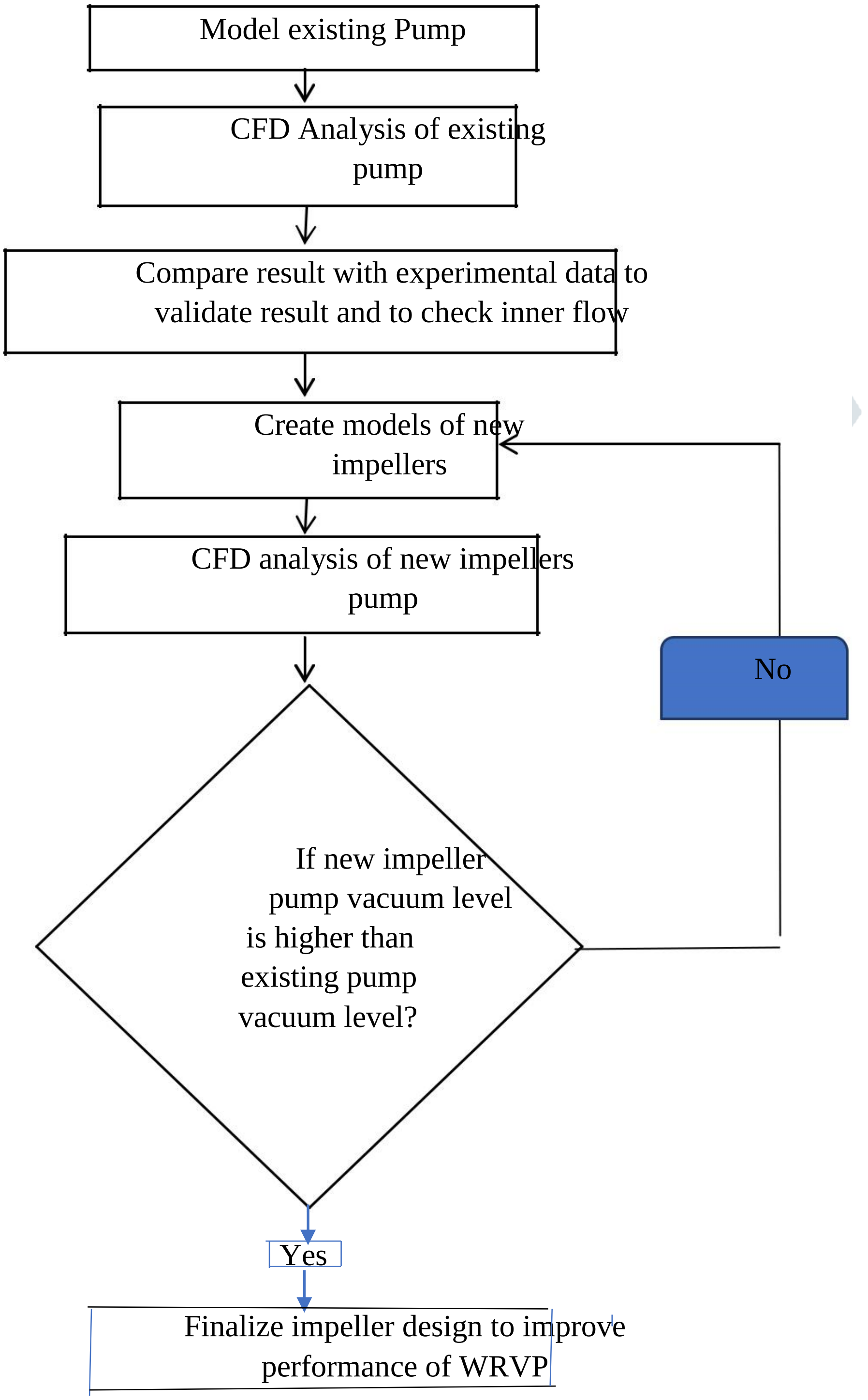
So SV-20 vacuum pump not giving high efficiency as per requirement and to solve this problem and get higher vacuum using CFD analysis.

5.METHODOLOGY

SV-20 is WRVP which create low vacuum level so to improve that level following steps to be follows:

Modeling of existing WRVP and its CFD analysis.
Compare result with experimental data to validate result and to check inner flow.
Create new modified impellers and CFD analysis of those modified impellers pump.
Compare result of new modified impeller with existing pump vacuum level to get improve performance with high efficiency.

6.SOLUTION PROCEDURE



7.Solution

Optimization Using Inlet Angle, Outlet Angle and Thickness of Blade

In figure of impeller we consider main three parameters, blade inlet angle, blade outlet angle and blade thickness for optimization. We will change these three parameters of impeller and we will do CFD analysis of new modified impeller WRVP and analyze and compare result with CFD analysis of existing model of pump.

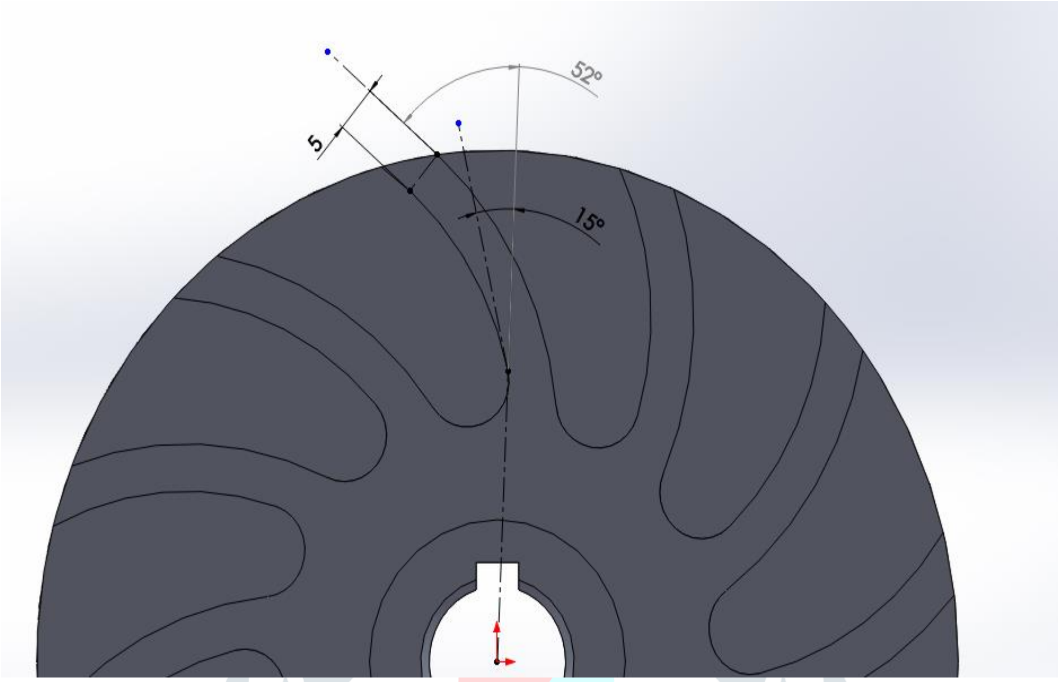


Figure 5.1: Existing impeller parameters

8. Modification in Thickness

In existing impeller thickness of impeller is 5 mm. and modify thickness of existing impeller using empirical relation and its CFD analysis result shown below.

Thickness of impeller blade of existing impeller is calculated by using empirical relation,

t= 0.07 to 0.12 R

= 0.09*0.054

= 5 mm

Thickness of blade of modified impeller-1 is calculated by using empirical relation,

t= 0.07 to 0.12 R

= 0.11*0.054

= 6 mm

Thickness of blade of modified impeller-2 is calculated by using empirical relation,

t= 0.07 to 0.12 R

= 0.074*0.054 = 4 mm

⇒ 1 mm Increases thickness of blade of impeller (6 mm):

In existing WRVP impeller first modify that impeller with 1 mm increment in thickness of blade and by CFD analysis getting result shown below in figure and thickness of blade is 6 mm of impeller by modifying existing impeller.

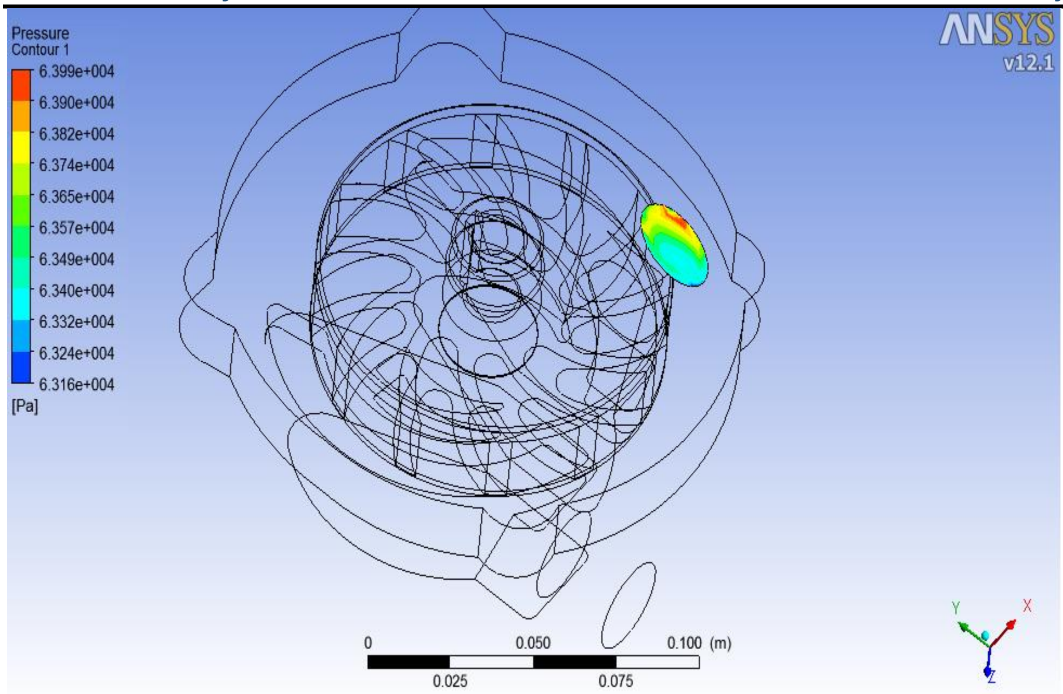


Figure 5.2: Generated Vacuum at inlet in impeller-2 pump

Here if we increase thickness of blade of impeller with 1 mm and that impeller pump CFD analysis same as above procedure done in CFD analysis of existing pump get generated vacuum pressure is 63990 Pa means that get 480 mm of hg vacuum pressure. It means that get higher vacuum pressure than existing pump.

⇒ 1 mm Decrease thickness of blade of impeller (4 mm):

In existing WRVP impeller first modify that impeller with 1 mm decrease in thickness of blade and by CFD analysis we get result shown below in figure and thickness of blade is 4 mm of impeller by modifying existing impeller.

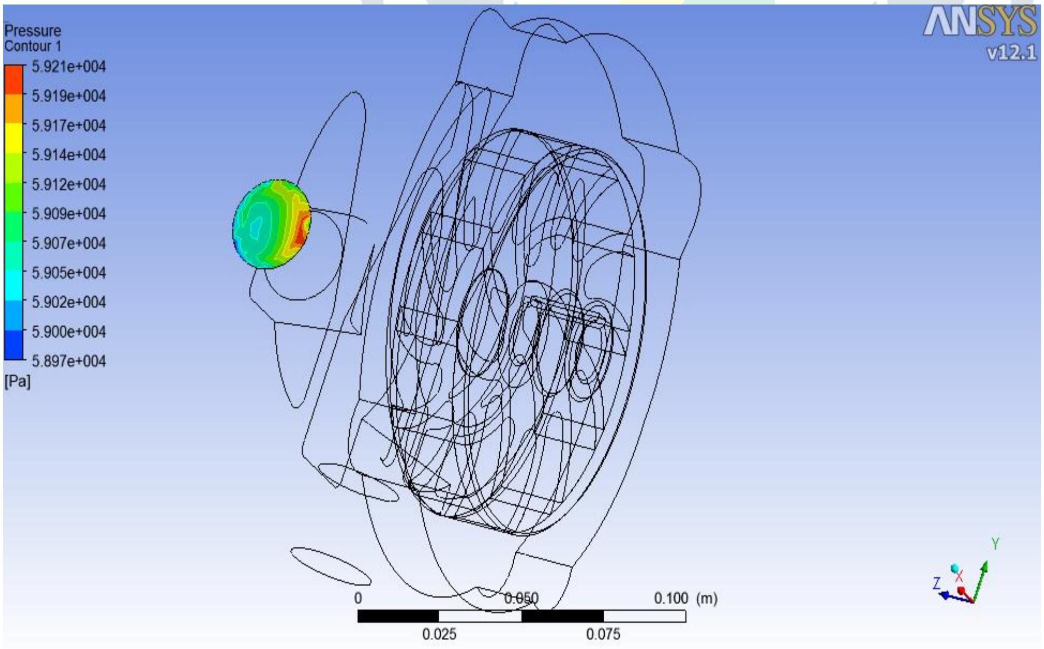


Figure5.3 : Generated Vacuum at Inlet in impeller-1 pump

Here if we decrease thickness of blade of impeller with 1 mm and that impeller pump's CFD analysis same as above procedure done in CFD analysis of existing pump and get generated vacuum pressure is 59210 Pa means that get 444 mm of hg vacuum pressure. It means that get lower vacuum pressure than existing pump.

⇒ **Comparison of two modified impeller WRVP with Existing Pump**

Table 5.1 comparison of vacuum of three impeller

Sr No.	Thickness(mm)	Generated Vacuum (mm of hg)
1	6	480
2	5	460
3	4	444

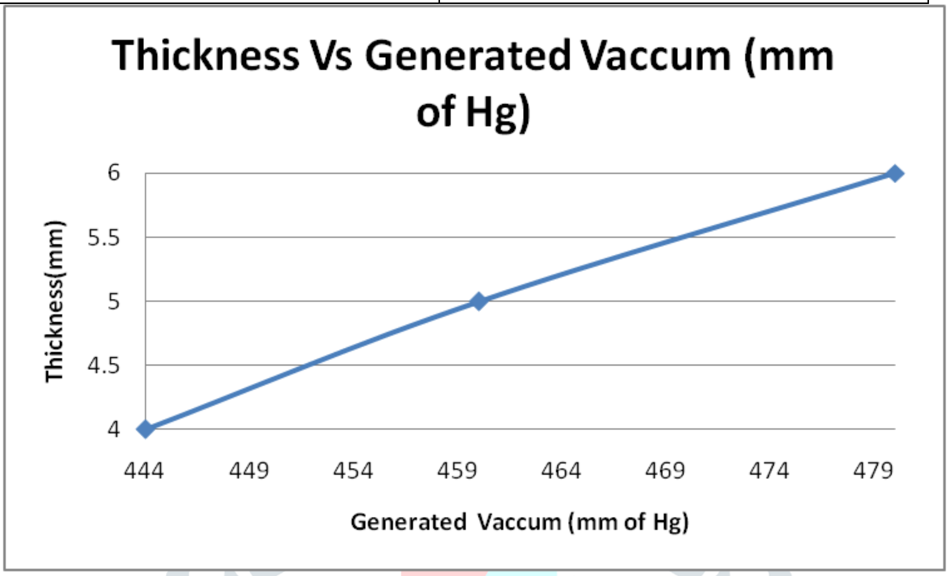


Figure 5.4: Graph of Thickness VS Generated vacuum

Here above given graph and table shows thatif increase 1 mm thickness of impeller blade vacuum pressure is higher than existing pump vacuum value and it is 480 mm of hg and after decrease 1mm thickness of impeller vacuum pressure is 444 mm of hg which is lower than existing pump value of vacuum. In above figure shown value of thickness vs generated vacuum in which how thickness affect vacuum pressure value.

⇒ **Comparison of four modified impeller WRVP with Existing Pump**

Table 5.2 comparison of five impeller

Sr No.	Inlet Angle (Degree)	Generated Vacuum (mm of hg)
1	18	462.86
2	17	470
3	16	464.21
4	15	460
5	13	459.30

Table gives comparision of five different value of inlet angle and vacuum generated by them also shown in graph below.

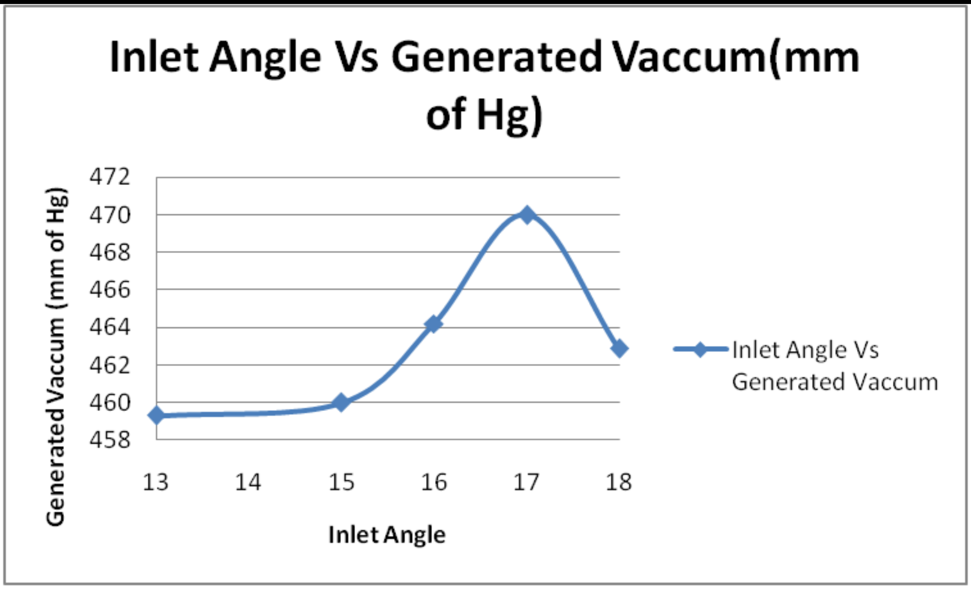


Figure 5.9 Graph of inlet angle vs generated vacuum

If we modify existing impeller of vacuum pump in that in first case we increase 1˚ inlet angle and so on get vacuum level 464.21 mm of hg so after increasing value of inlet angle we get higher vacuum, then we increase 3˚ inlet angle and generated vacuum is lower than above first case of 1˚incresed in inlet angle. So we increase 2˚ inlet angle and get higher vacuum than both of case. If we decrease 2˚ inlet angle of impeller, get generated vacuum is lowest in all case. By generating graph we can see that from 13˚ to 17˚ inlet angle impeller pump vacuum is increased and get highest value at 17˚ inlet angle impeller WRVP but more than 17˚inlet angle if we take 18˚ we get vacuum is lower which can see in graph which shows inlet angle vs generated vacuum.

⇒

⇒ **Comparison of five modified impeller WRVP with Existing Pump**

Table 5.3 comparison of six impeller

Sr No.	Outlet Angle (Degree)	Generated Vacuum (mm of hg)
1	54	450.86
2	52	460
3	51	472.01
4	50	481
5	49	485.88
6	48	458.21

Table gives comparision of six different value of outlet angle and vacuum generated by them also shown in graph below.

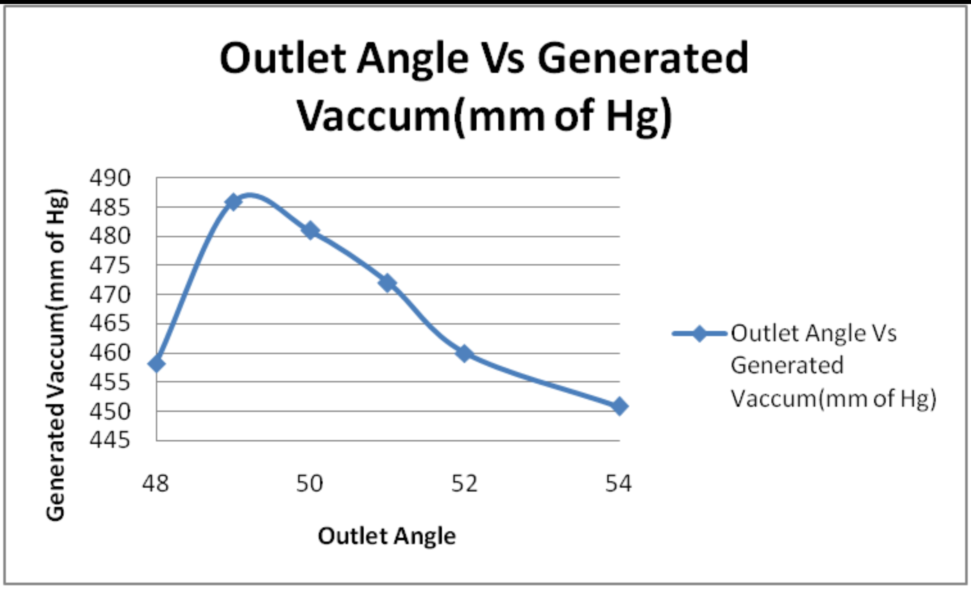


Figure 5.15: Graph of inlet angle vs generated vacuum

In above figure graph shows outlet angle vs generated vacuum. If we modify existing impeller of vacuum pump in that in first case we increase 2˚ outlet angle and so on get vacuum 450.86 mm of hg which is lower than existing impeller WRVP, so after increasing value of outlet angle we get lower vacuum, so will decrease outlet angle 1˚ will get higher vacuum than existing WRVP after that also 2˚ decrease in outlet angle also get higher vacuum and also decreasing 3˚ outlet angle will get more higher vacuum. After decreasing 4˚ outlet angle get lower vacuum than existing impeller vacuum pump. So we see that we get highest vacuum at 49˚.Thus we see that in all condition we get higher vacuum if we decreasing outlet angle but it is up to 49˚,after that get lower value of vacuum and also increasing outlet angle getting lower vacuum than existing impeller vacuum pump.

9.Results

Table 5.4 comparison of all modified impeller WRVP

Sr No.	Modified Impellers	Thickness	Inlet Angle	Outlet Angle	Result
1	Existing	5	15	52	460
2	Impeller-1	4	15	52	444
3	Impeller-2	6	15	52	480
4	Impeller-3	5	13	15	459.30
5	Impeller-4	5	16	15	464.21
6	Impeller-5	5	17	15	470
7	Impeller-6	5	18	15	462.86
8	Impeller-7	5	15	48	458.21
9	Impeller-8	5	15	49	485.88
10	Impeller-9	5	15	50	481
11	Impeller-10	5	15	51	472.01
12	Impeller-11	5	15	52	450.86

We can see that after all CFD analysis of all new modified impeller WRVP get highest vacuum pressure of highest value at impeller-8 and its result is 485.88 mm of hg which gives improved result of water ring vacuum pump than existing WRVP and also lowest value is 444 mm of hg which is given when thickness of blade is decreased with 1 mm in impeller-1 which is shown in above table, and finally get improved performance Water ring vacuum pump using CFD analysis.

10.Conclusion

WRVP in which impeller is most critical part so choose it for modification in its design and to get higher effect in performance. We have seen that changes in inlet angle and outlet angle of impeller and also blade thickness based on empirical relation and also these three parameters are critical parameters of impeller and they are very important parameters to improve performance so these three parameters are modified in existing impeller and all these modified impellers are used in existing pump model and took place CFD analysis of all those pumps. After CFD analysis of those all modified impeller pumps getting different results in terms of vacuum. In existing Vacuum pump generated vacuum is 460 mm of hg, in existing impeller model thickness of blade is 5 mm,15˚ inlet angle and 52˚ outlet angle. But when modification in outlet angle of impeller and angle is 49˚,in that model After CFD analysis generated vacuum pressure is 485.88 mm of hg vacuum. So result is improved in terms of vacuum using CFD analysis of water ring vacuum pump.

11.ACKNOWLEDGEMENT

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