

Analysis of Centrifugal Pump with Closed Type Impeller for Slurry Operations

N.Subramani¹, Dr.J.Ganesh Murali², Dr.P.Suresh³, J.Anish Jafrin Thilak⁴, V.V.Arunsankar⁵

Assistant Professor, Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India^{1,4&5}

Professor, Department of Mechanical Engineering, Karpagam College of Engineering, Coimbatore, India^{2&3}

ABSTRACT: In this work, the design and analysis of the centrifugal slurry pump redesigned and analyzed. Slurry is a thin mixture of liquid, especially water and any of several finely divided substances, such as cement, plaster of Paris, or clay particles. Centrifugal pump of closed type Impeller is widely used nowadays in hydraulic system for pumping operation. These pumps cannot be used for the slurry pumping operation since the clearance between crown plate and base plate of Impeller is inadequate. In order to increase the clearance between base plate and crown plate vane width, numbers of vanes are altered to make way for the slurry water to pass through. Additionally trimming of crown plate is done to make the existing closed type Impeller into a semi open type Impeller. An experimental analysis using CFD is made over the pump for making it suitable to Slurry pumping operation.

KEYWORDS: Slurry, Impeller, CFD, Vane, Base plate, Crown plate.

I. INTRODUCTION

Presently wide varieties of slurry pumps are available in the market. The existing slurry pump is with open type Impeller, possess a large flow area for slurry water to move ahead without restriction. A centrifugal pump cannot do the same action with closed type Impeller.

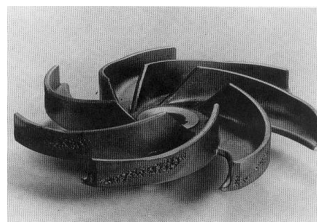


Fig.1 Open type Impeller



Fig.2 Closed type Impeller

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

A centrifugal pump is a rotating machine in which flow and pressure is generated dynamically. The operational characteristic of the pump, like head and flow rate depends on geometry of impeller. Modifying the geometry influences the complexities of the flow like recirculation, cavitations and pressure pulsations and increases the power requirement. Trials are conducted with single stage open well centrifugal pump. Initial trial reports with standard impeller are compared with results of modified Impeller trial reports.

To pump out slurry water the clearance between base plate and crown plate needs to be increased for a better flow. The angle of vane and its thickness to be redesigned for avoiding deposition of sediments.

The key factor in deciding the performance of centrifugal pump characteristic is the geometry of Impeller. Modifying the Impeller geometry gives better performance at best efficiency point (BEP). In this paper, Impellers with different geometry are considered for experimental investigation. The major geometry modified on Impeller are 1) Blade angle 2) Uniform blade thickness 3) Inlet diameter 4) Number of vanes 5) Outer diameter and 6) Impeller width.

II. METHODOLOGY

Many experimental studies have been reported on the performance of the centrifugal pump impeller. The performance of centrifugal pumps is mainly on the design parameters of the impeller. An experimental Analysis has been carried out to modify the performance characteristics of open well pump.

The methods of trials conducted are as follows

- Trials of standard Impeller with slurry water.
- Trials with reduction in vane thickness.
- Trial with number of vanes increased.
- Trial with increased inlet diameter of Impeller.
- Trials with trimming of crown plate.

Geometry of standard Impeller

A single stage centrifugal pump of design flow rate (Q) 611 m³/hr, with head 11.95 m and pump speed (n) = 2900 rpm. The design involves a large number of mutually dependent variables so there are numerous likely designs for the same duty. The design parameters are arrived using Stepanoff & Pfleiderer's slip power method.

Inlet diameter [d ₁]	=	28 mm
Outlet diameter [d ₂]	=	144 mm
Inlet blade angle [β ₁]	=	20°
Outlet blade angle [β ₂]	=	19°
Outlet blade width [b ₂]	=	4.5 mm
Blade thickness [S ₁]	=	7.0 mm

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

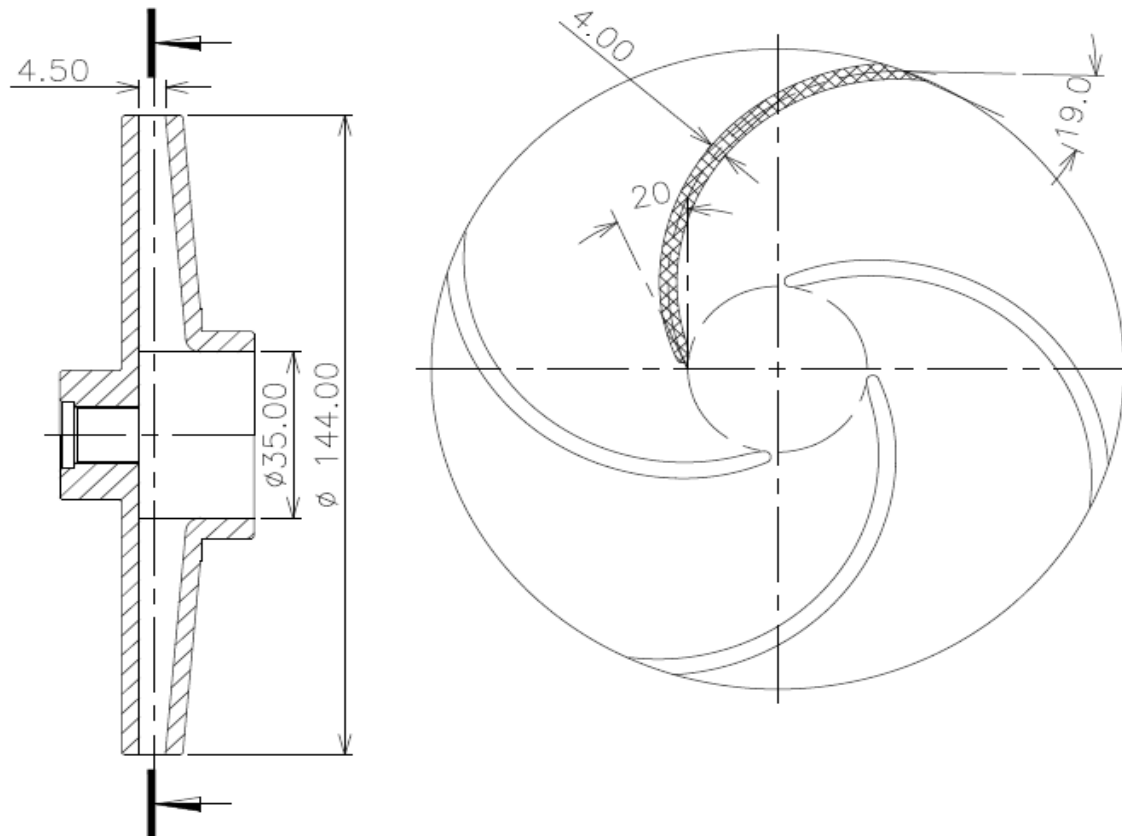


Fig.3 Standard Impeller

III. EXPERIMENTAL ARRANGEMENT

The flow rate is adjusted from the discharge valve, located at the outlet of the pump. If the discharge valve is fully opened, current consumption will be more but discharge remains maximum. If the discharge valve is fully closed, current consumption is too low and discharge is very low. During very low discharge operation water churns inside pump casing, which lead to damage of impeller and casing, hence it should be avoided. Pressure gauges are mounted at discharge side of the pump. The flow rate is measured using Rotometer, which is a vertically installed device, which operates when the upward fluid drag on the float is balanced by the weight of the float. The float operates in a diverging tube. Float, tube geometry and material depend on the range of operation of the Rotometer. Power analyzer is used for measuring, volt, Ampere and power factor, which are used for obtaining the power input to the motor of the centrifugal pump.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

Experimental procedures

Pump is tried out with standard Impeller in fresh water and the practical result obtained is as follows.

Pump is tried out with standard Impeller in fresh water and the CFD result obtained is as follows.

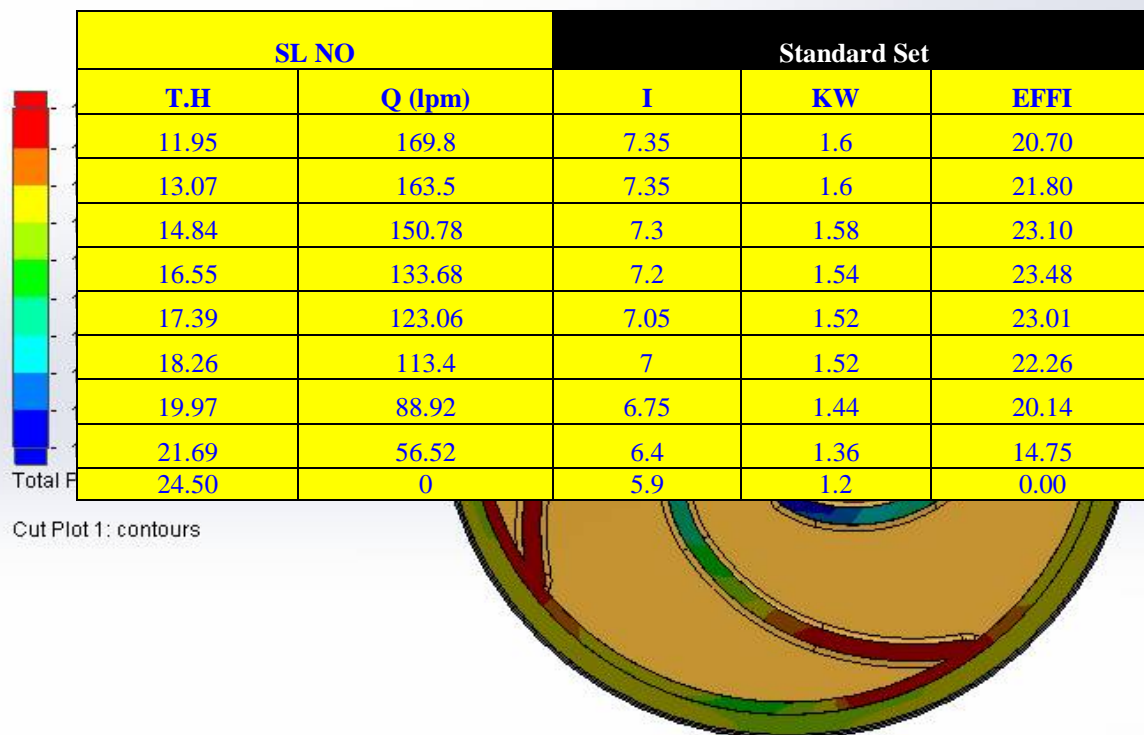


Fig.4 CFD report of standard Impeller

T.H	Q (lpm)	I	KW	EFFI
6.10	73.80	6.50	1.58	18.70
6.10	69.50	6.50	1.58	20.80
6.80	63.24	6.48	1.54	22.20
7.50	59.90	6.45	1.54	23.58
8.50	55.16	6.42	1.52	23.01
9.30	52.46	6.35	1.52	22.26
10.50	48.35	6.15	1.44	20.14
12.70	36.28	6.00	1.36	14.75
14.50	0	5.90	1.20	0.00

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

CFD report gives a discharge of 213.8 lpm in fresh water.

Operating pump with outlet valve fully closed draws very low current of 5.9 Ampere and total head available is 24.5m. The output from the pump is zero and the power consumption is 1.2KW. Obviously, the efficiency of the pump remains zero since output is zero. Pump should not be operated in such condition for long time to avoid churning. Slowly outlet valve of the pump is opened and the above said parameters are monitor and recorded. You will find an increase in discharge, current flow, power consumption and efficiency with a little sacrifice in total head. The same procedure is repeated for different position of outlet valve. All readings are analyzed to get optimal flow rate with maximum efficiency. This same procedure is followed with trimmed impellers to get optimal flow rate and efficiency.

Test report of pump with Standard Impeller in slurry water

Geometric properties of the test impellers

Parameter	Standard	Impeller A	Impeller B	Impeller C	Impeller D	Impeller E
Inlet diameter (Di)	28	28	28	35	28	28
Outlet diameter	144	144	144	144	142	140
Vane number	4	3	3	3	3	3
Inlet angle	20	20	20	20	20	20
Outlet angle	19	19	19	19	19	19
Impeller Width	4.5	4.5	5	5	4.5	4.5
Vane thickness	7	4	4	4	7	7

Test-I

Test report of pump with vane thickness reduced to 4mm and number of vanes reduced to 3.

T.H	Q (lpm)	I	KW	EFFI
14.60	158.00	7.30	1.58	28.54
15.32	153.80	7.20	1.56	28.21
16.84	151.20	7.00	1.52	27.38
17.60	137.04	6.90	1.48	26.64
18.40	129.48	6.75	1.44	25.78
19.99	98.56	6.50	1.40	21.37
23.00	35.20	5.90	1.20	7.39
24.50	0.00	5.75	1.16	0.00

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

CFD report of pump with vane thickness reduced to 4mm and number of vanes reduced to 3.

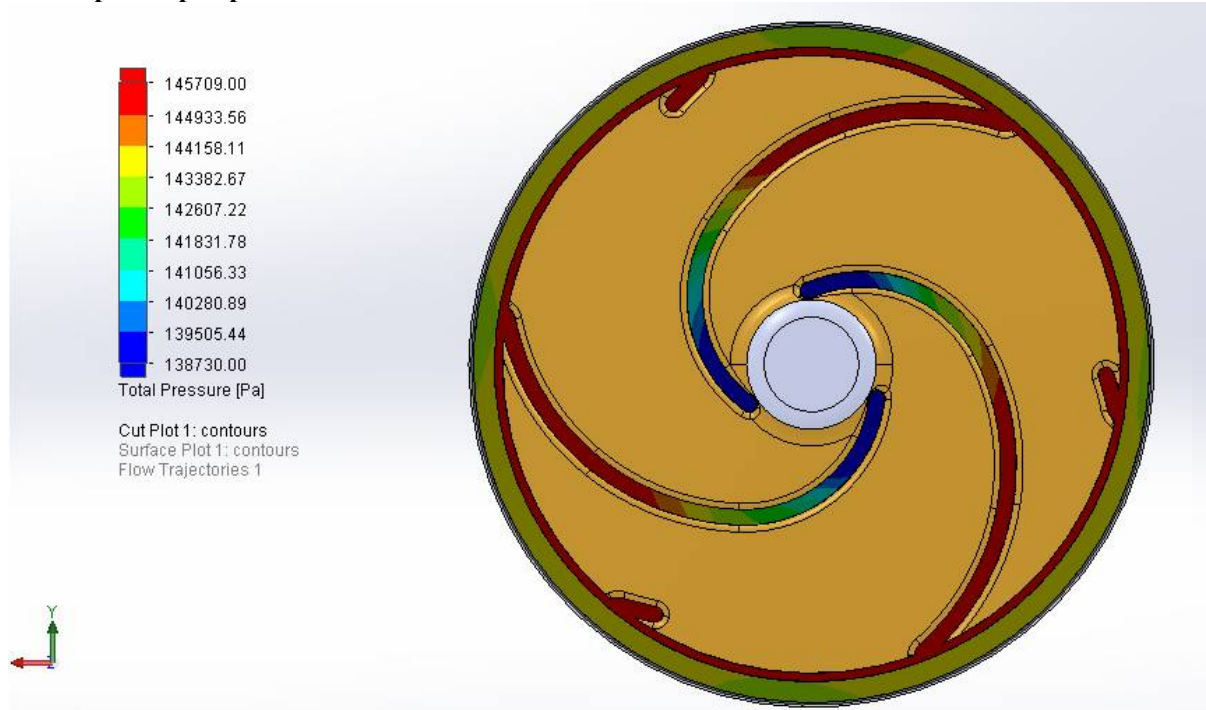


Fig.5 CFD report of Impeller - A

CFD report gives a discharge of 168 lpm.

Trial II

The trial report of Pump with number of vane reduced to three, Impeller width increased to 5mm and vane thickness reduced to 4mm.

T.H	Q (lpm)	I	KW	EFFI
14.90	188.76	7.4	1.72	26.71
17.22	170.76	7.2	1.64	29.29
18.86	151.86	7	1.6	29.23
20.51	130.86	6.9	1.56	28.11
22.18	107.28	6.7	1.5	25.92
24.69	57	6.2	1.36	16.91
25.50	0	5.9	1.24	0.00

CFD report of Pump with number of vane reduced to three, Impeller width increased to 5mm and vane thickness reduced to 4mm.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

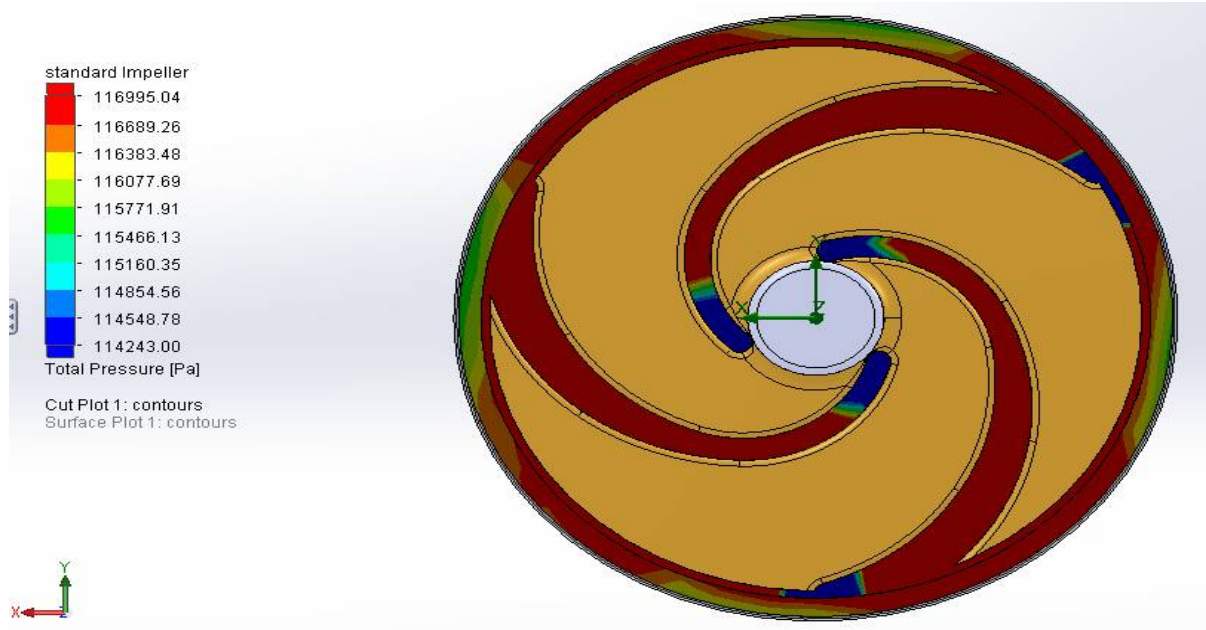


Fig.6 CFD report of Impeller - B

CFD report gives a discharge of 203 lpm.

Trial iii

Trial report of Pump with inlet diameter of impeller increased to 35mm, vane thickness reduces to 5mm and Impeller width increased to 5mm

CFD report of Pump with inlet diameter of impeller increased to 35mm, vane thickness reduces to 5mm and

T.H	Q (lpm)	I	KW	EFFI
17.54	207.96	8.0	1.80	33.12
18.57	187.80	7.8	1.74	32.76
19.27	173.40	7.7	1.72	31.74
20.01	160.20	7.5	1.68	31.18
20.77	147.00	7.4	1.64	30.42
21.52	132.00	7.3	1.60	29.02
22.29	115.80	7.1	1.56	27.03
23.08	98.88	6.9	1.52	24.53
23.80	71.10	6.7	1.44	19.20
24.71	0.00	6.1	1.34	0.00

Impeller width increased to 5mm

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

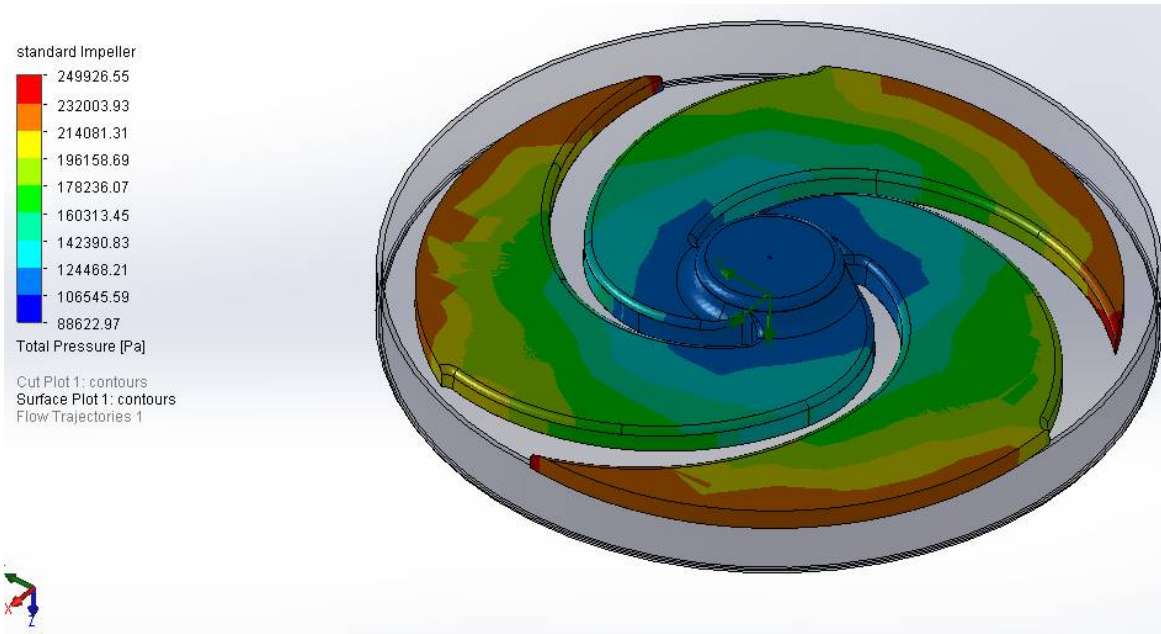


Fig.7 CFD report of Impeller - C

CFD report gives a discharge of 249 lpm.

Trial iv

The trial report of Pump with crown plate of Impeller trimmed to 142mm.

T.H	Q (lpm)	I	KW	EFFI
10.95	186.33	7.46	1.62	23.78
12.07	172.30	7.41	1.60	23.70
15.94	157.16	7.35	1.58	23.50
16.85	140.34	7.30	1.54	23.48
17.00	130.00	7.15	1.51	23.01
17.96	119.51	7.10	1.54	22.26
18.97	92.25	6.80	1.44	20.14
20.59	59.297	6.50	1.36	14.75
23.00	0	5.9	1.2	0.00

CFD trial report of Pump with crown plate of Impeller trimmed to 142mm.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

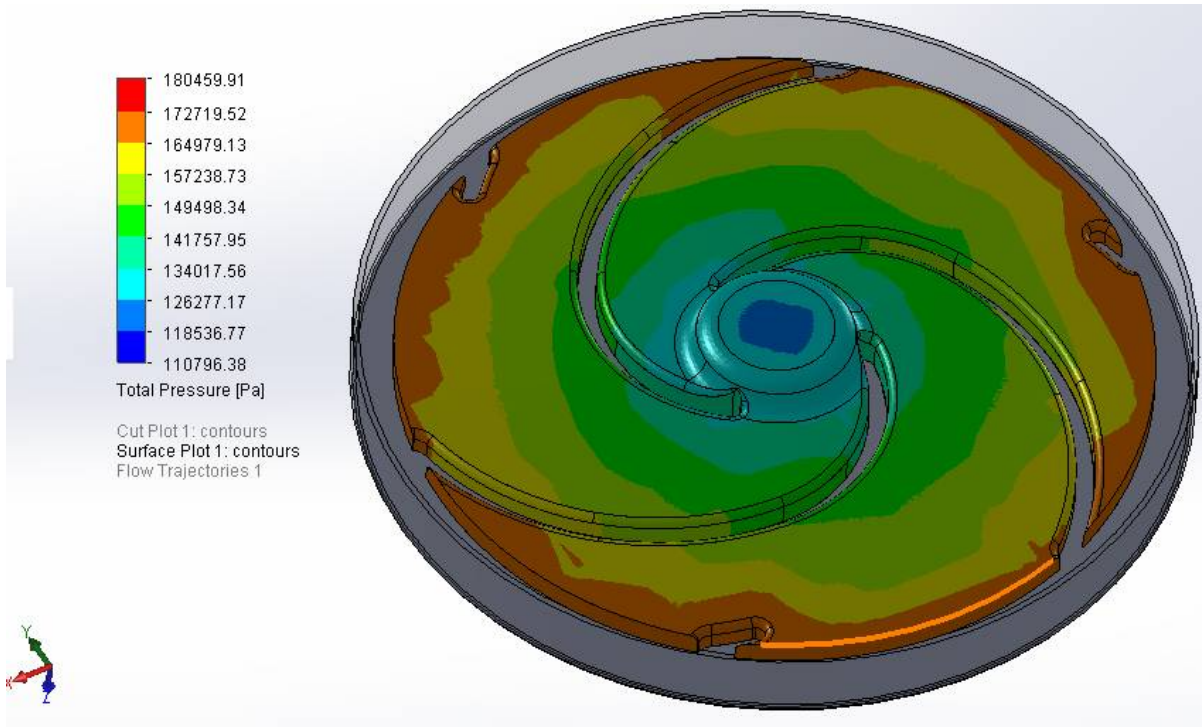


Fig.8 CFD report of Impeller – D

CFD report gives a report 198 lpm.

Trial V

The trial report of Pump with crown plate of Impeller trimmed to 140mm.

1T.H	Q (lpm)	I	KW	EFFI
10.70	197.480	7.50	1.64	27.38
12.00	180.672	7.42	1.61	26.50
14.90	164.125	7.39	1.60	25.38
16.80	145.902	7.32	1.56	25.48
16.90	132.822	7.25	1.53	24.21
17.00	122.300	7.20	1.53	22.98
18.90	93.733	6.80	1.44	21.14
20.59	60.686	6.50	1.36	14.75
23.00	0.000	5.9	1.2	0.00

CFD report of Pump with crown plate of Impeller trimmed to 140mm.

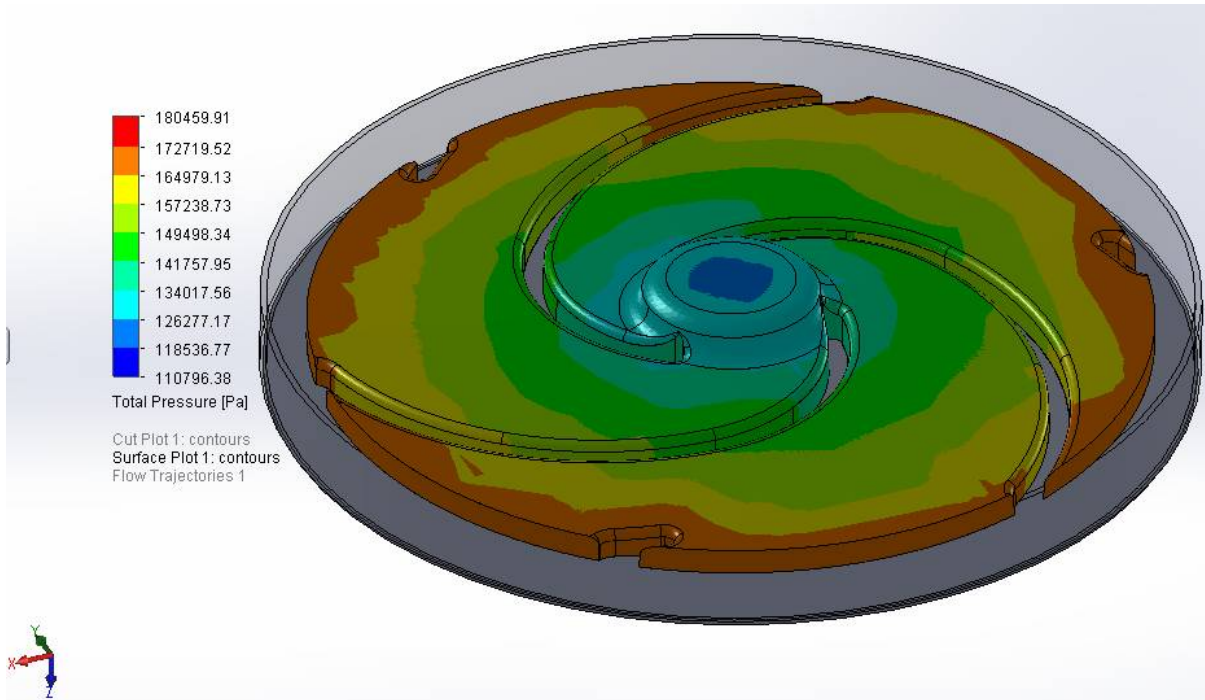


Fig.9 CFD report of Impeller – E

CFD report gives a report 182 lpm.

Experimental Analysis

A test is conducted over a pump with standard Impeller in fresh water and found its total head 11.95 metre, discharge 168.9 lpm.

A test is conducted over a pump with standard Impeller in Slurry water and found its total head 6.10 metre, discharge 73.80 lpm. This performance of pump with standard impeller is compared with altered impeller pump.

Case - i

The performance of the pump with standard impeller is compared with another pump of same capacity with a little modifications in dimensions of impeller. Here the vane thickness of the impeller is reduced to 4 mm from 7mm. The other parameter of impeller remains same as that of the standard impeller. During trials there is a significant improvement in total head, efficiency and discharge.

Test report shows

Total head 14.60 metre.

Discharge risen to 158 lpm.

Case - ii

In an another comparison test, performance of a pump with standard impeller is compared with a pump having modified impeller. Here in the modified impeller number of vanes is decreased to 3.

Test report shows

Total head 14.60 metre.

Discharge risen to 188.76 lpm.

Case - iii

The performance of a pump with standard impeller is compared with another pump with a modified impeller. Here impeller inlet diameter is increased to 35 mm from 28 mm. Other parameters remains the same as in case II trial.

Test report shows

Total head 17.54 metre.

Discharge 207.96 lpm.

Case – iv

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

Trial is conducted with trimming crown plate of Impeller to 142 mm and rest of the parameter of Impeller is as of case iii.

Test report shows
Total head 10.95 metre.
Discharge 183.36 lpm.

Case – v

Trial is conducted with trimming crown plate of Impeller to 140 mm and rest of the parameter of Impeller is as of case iv.

Test report shows
Total head 10.70 metre.
Discharge 197.48 lpm.

IV. CONCLUSION

Recommended Impeller for slurry pumping operation

From these results it is observed that case iii trial with impeller vane thickness reduced to 4 mm from 7 mm, number of vanes decreased to 3 from 4 and its inlet diameter increased to 35 mm from 28 mm is recommended for slurry pumping operation. In this pump with a modified impeller gives an efficiency of 33.12%, discharge 207.96 lpm, total head available is 17.54 metre but with a hike in power consumption to 1.8 KW.

REFERENCES

1. Numerical Studies on Effects of Blade Number Variations on Performance of Centrifugal Pumps at 4000 RPM S.Chakraborty and K.M.Pandey.
2. Numerical Prediction and Performance Experiment in a Deep well Centrifugal Pump with Different Impeller Outlet Width SHI Weidong, ZHOU Ling*, LU Weigang,
3. Impeller Trimming of an Industrial Centrifugal Viscous Oil Pump Wen- Guang Li Department of Fluid Machinery, Lanzhou
4. Effect of Impeller Exit Width Trimming on Compressor Performance Abraham Engeda Turbo machinery Lab, Michigan State University.
5. Impeller Trimming of an Industrial Centrifugal Viscous Oil Pump Wen-Guang Li Department of Fluid Machinery, Lanzhou University of Technology, Gansu, China, E-mail: Liwg47@ymail.com Received 13 November 2011; Revised 01 December 2011; Accepted 25 December 2011
6. The effect of impeller and tank geometry on power number for a pitched blade turbine d. Chapple, s. M. Kresta, a. Wall and a. Afacan, *Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Canada.*
7. Performance Characteristics of Centrifugal Pump Conveying Soft Slurry Mohamed F. Khalil, Sadek Z. Kassab, Ahmed A. Abdel Naby, A. Azouz, Department Mechanical Engineering, Faculty of Engineering, Lebanese International University, Beirut, Lebanon *American Journal of Mechanical Engineering, 1(5), 103-112.*