The effect of splitter blade on performance of centrifugal pump

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***Abstract*— Nowadays centrifugal pumps are very crucial and important part in turbo-machinery. Centrifugal pumps are used in general domestic supplies, protection system, industries, commercial application, water management etc. An improvement can be brought in the performance of centrifugal pump by making various changes in the geometry of impeller. Geometrical changes like number of blades, blade inlet and outlet diameter, blade inlet and outlet angles, microgrooves, splitter blades etc can be done. In the improvement of performance of pump number of blades is important parameter for analysis. Because if there will be more number of impeller blades there will be congestion of fluid and when number of blades are less then there will be diffusion losses. To overcome this problem splitter blade is the one of the solution of this problem. It reduces clogging and diffusion losses and also reduces pressure fluctuations. The purpose of this dissertation is to analyse the performance of centrifugal pump by changing different parameter like splitter blade characteristics and groove in impeller.**

***Index Terms*—centrifugal pump, impeller design, number of blades, splitter blades.**

I. INTRODUCTION

A turbo-machine is basically a rotating machine. The rotating wheel is called a rotor/runner/impeller. The rotor will be immersed in a fluid continuum. The fluid medium can be gas/steam/water/air. Energy transfer takes place either Energy transfer takes place either from rotor to fluid, from fluid to rotor.
Thus, they are classified in power producing and power absorbing machines

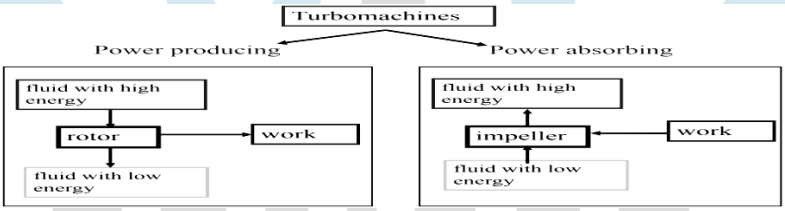

Fig.1 classification of turbo-machines

A turbo-machine is a device where mechanical energy in the form of shaft work, is transferred either to or from a continuously flowing fluid by the dynamic action of rotating blade rows. The interaction between the fluid and the turbo-machine blades also results in fluid dynamic lift. A turbo-machine produces change in enthalpy of the fluid passing through it.

Applications where these pumps are used are:- pumping water from cells, aquarium filtering, pond filtering and aeration, water cooling and injection in car industry, pumping oil, natural gas and operating cooling towers in the energy industry, developing and manufacturing medicine for biomedical process, also in artificial body parts replacement, in particular penile prosthesis and artificial heart.

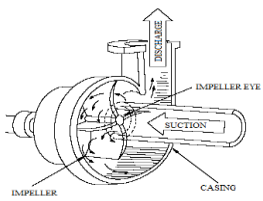

Fig.2. – Centrifugal pump

II. WORKING PRINCIPLE

The pump component (impeller), which is rotating with fast speed in the casing, thereby subjecting the fluid to centrifugal force. And because of this force, the fluid goes to discharge opening. The fluid accelerates radically outward from casing to discharge, vacuum is created at the impeller of eye, which draws more fluid from the sump. Thus it converts the rotational kinetic energy

of fluid to the hydrodynamic energy of fluid. The fluid enters the pump in the axial direction and leaves in radically outward direction.

Fig.3. – working principle of centrifugal pump

III. ADVANTAGES OF CENTRIFUGAL PUMP

1. Simple operation
2. Low first cost and maintenance
3. Insignificant excessive pressure build up in casing
4. Impeller and shaft are the only moving parts
5. Quiet operations - Wide range of pressure, flow and capacities
6. Utilize small floor space in different positions
7. Able to work at medium to low head.
8. Able to work medium to low viscous fluid
9. Deals with large volume Environmentally friendly.

IV. LITERATURE REVIEW

A. Manivannan et.al. [1] The efficiency of the mixed flow impeller is improved by changing the inlet and outlet vane angles. There are three impellers. The impeller 3, the percentage increase in the head, power rating and efficiency are 13.66%, 12.16% and 18.18% respectively.

E.C. Bacharoudis,1et.al [2] The influence of the outlet blade angle on the performance is verified with the CFD simulation. As the outlet blade angle increases the performance curve becomes smoother and flatter for the whole range of the flow rates. When pump operates at nominal capacity, the gain in the head is more than 6% when the outlet blade angle increases from 20 deg to 50 degree.

Wen-Guang LI et.al [3] The singularity method is an numerical approach for solving blade to blade flows within centrifugal impeller and involved in the analysis of hydrodynamic performance. In this analysis impeller blades were redesigned with controlled blade shape and flow pattern. Its camber line changed by varying blade angle Hydraulic performance is improved in the redesigned impeller

Janusz Skrzypacz et.al [4] The impeller with micro grooves provides much better velocity distribution in impeller passage, which results in increase of head and total efficiency of pump of the impeller. But it also increase the power consumption.

T. Shigemitsu1et.al [5] 1. Flow condition at the outlet of the rotor became uniform for TypeB due to the splitter blades. Therefore, the volute efficiency of TypeB was higher than that of TypeA. On the other hand, the rotor efficiency of TypeB decreased due to the existence of the splitter blades. 2. Back flow at the outlet of the rotor was suppressed especially near the casing tongue for TypeB. Then, the back flow vortex loss decreased for TypeB compared to that of TypeA. This result could contribute to the improvement of performance of TypeB.

Mustafa Go˙lcu et.al [6] As the number of impeller blades increases, the pump head rises, however, too many blades result in a decrease in efficiency due to the increasing blockage and skin friction in the impeller passage. The highest efficiency and the lowest energy consumption were obtained in DWPwsb with 80% of the main blade length.

Wei yanget.al [7] It can be seen that the splitter blades increase the pump efficiency especially under high flow rate conditions.
It can be seen that the compound impeller with splitter blades postpones the critical cavitation apparently, especially at high flow rates. In fact at 70% design flow rate condition the calculated critical NPSH of compound pump decreases 16.7% compared with the conventional pump.

V. EXPERIMENT SETUP

To analyse centrifugal pump experiment setup is fabricated. The line diagram of centrifugal pump setup is shown in Fig.

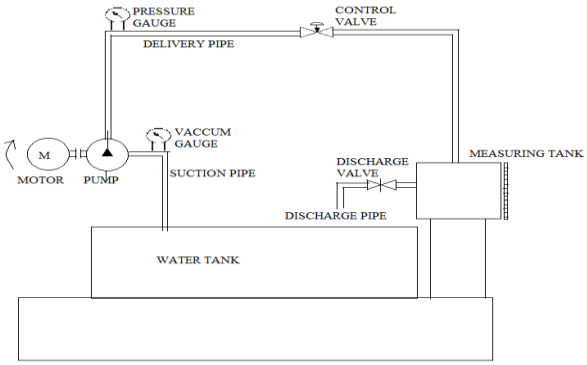

Fig.4. –Line diagram of experimental setup

Table 1 specifications of the experimental setup [2]

Supply tank	1210*400*410 mm^3
Measuring tank	450*400*430 mm^3
Suction pipe	With vacuum gauge (60 mm)
Delivery pipe	With gate valve and pressure gauge (60 mm)
Capacity of motor	5 hp
Motor speed	1500 rpm variable
Capacity of Pump	5 hp
No of revolution of energy meter	10 flash
Transmission efficiency	80%
Area of measuring tank	(0.45*0.40) m^2
Inlet and outlet blade angles	170 and 260
Impeller inner and outer diameter	52 mm and 223 mm
Impeller thickness	24 mm
Number of blades	6

The impeller is housed in specially shaped chamber which has shape of Spiral casing. The liquid enters the impeller at its centre, technically known as the eye of the pump & discharge into the casing surrounding the impeller. To analyse the performance I am changing the impeller geometry by means of splitter blades attached to the impeller blades provided between two blades of impeller with different splitter blade length. The performance will be checked for both cases with and without splitter blades and result will be compare.

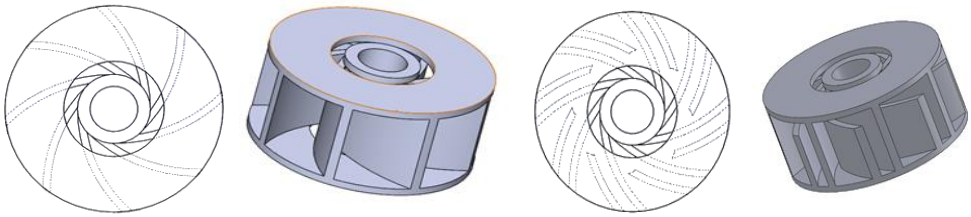

Fig.5 impeller without and with splitter blades with 2-D and 3-D diagram

VI. PROCEDURE

- Prime the pump with water.
- Start the motor.
- Note down the following readings.
- Vacuum gauge reading.
- Pressure gauge reading.
- Time required for 10 flash of energy meter.
- Measure the height in measuring tank for 5 sec.
- Vary the position of gate valve in delivery pipe.
- Repeat the above procedure for discharges.

VII. GOVERNING EQUATIONS

- Suction Head = H_s = (13.6/1000) × (H_s mm of Hg) m of H_2O
- Delivery Head = H_d = (P × 10) m of H_2O
- Total Head = H = (H_s+ H_d + 0.70) m of H_2O
- Power = I.P. = $\frac{3600 \times N}{C \times T}$ × Transmission Efficiency KW
- where, N= No. of flash counted = 10
- C = Meter counted = 6400
- T = Time in seconds
- Output Power = O.P.= $\frac{\rho g Q H}{1000}$
- where, = Density of water in Kg/m^3
- H = Total head in m
- Q = Discharge in m^3/s
- G = Gravitational Acceleration m/s^2
- Efficiency = η = $\frac{O.P.}{I.P.}$ × 100 %

DESIGN VARIATION OF IMPELLER

There are several variations on impeller like change in blade angle, diameter, number of blades, splitter blades length.

Table 2. Design variation of impeller

No	Cases	No of blades	No of splitter blades	Blade length	Splitter blade length
1	without splitter blades	4	0	L	0
2		5	0	L	0
3		6	0	L	0
4	with splitter blades	4	4	L	0.35L
5		4	4	L	0.50L
6		4	4	L	0.65L
7		5	5	L	0.35L
8		5	5	L	0.50L
9		5	5	L	0.65L
10		6	6	L	0.35L
11		6	6	L	0.50L
12		6	6	L	0.65L

RESULTS FOR WITHOUT SPLITTER BLADES FOR N=4,5,6

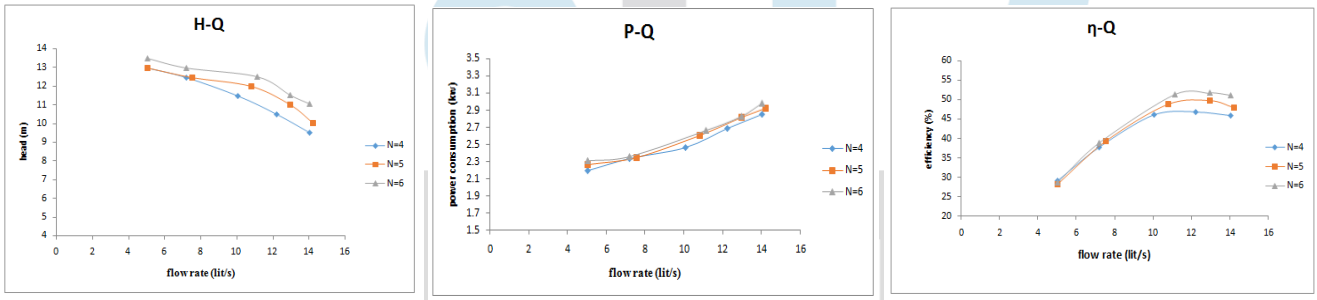

Fig.6. –H-Q, P-Q,η-Q for impeller without splitter blades for different blades number(4,5,6)

RESULTS FOR WITH DIFFERENT LENGTH SPLITTER BLADES FOR N=4

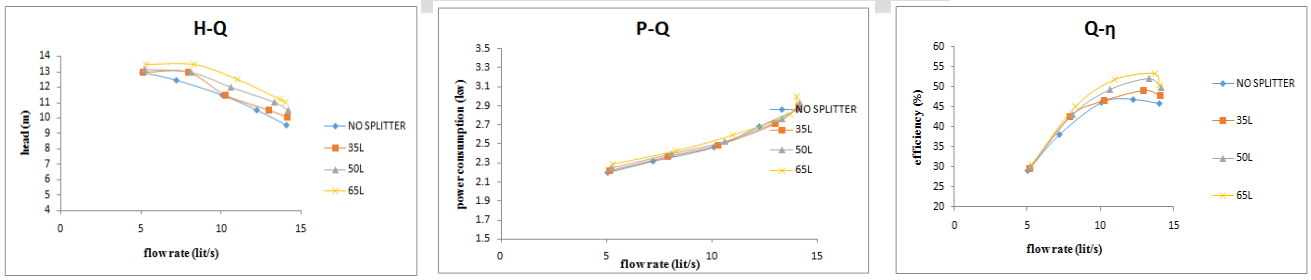

Fig.7. –H-Q, P-Q,η-Q for impeller with different splitter blades for N=4

RESULTS FOR WITH DIFFERENT LENGTH SPLITTER BLADES FOR N=5

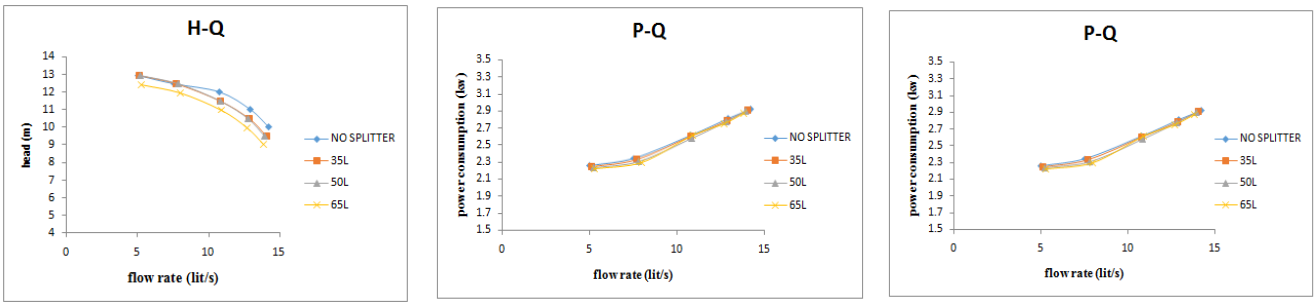

Fig.8. –H-Q, P-Q,η-Q for impeller with different splitter blades for N=5

RESULTS FOR WITH DIFFERENT LENGTH SPLITTER BLADES FOR N=6

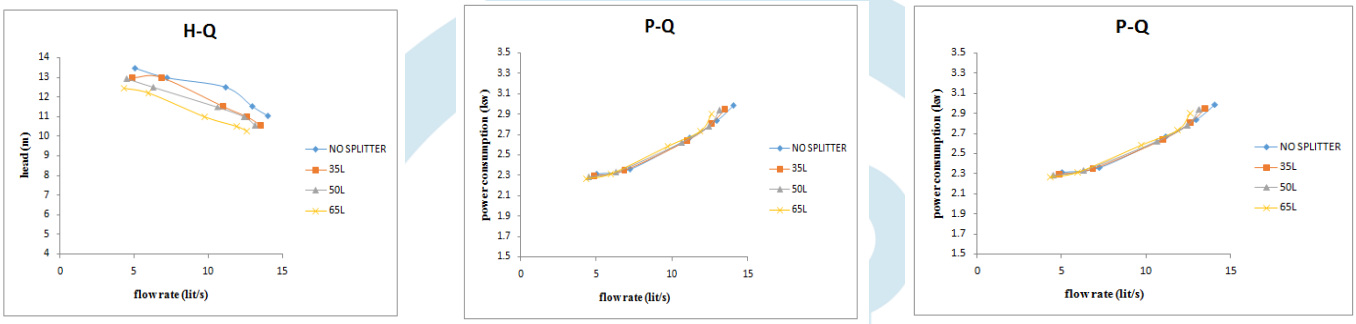

Fig.9. –H-Q, P-Q,η-Q for impeller with different splitter blades for N=6

VII. CONCLUSION AND FUTURE SCOPE

CONCLUSION

- The characteristics like flow rate against head, power consumption and efficiency are obtained experimentally for different number of blades of impeller and also with different splitter blade lengths.
- Head, power consumption and efficiency increases as number of blades on impeller (N=4, 5, 6) increases. By adding splitter blades, head and efficiency decreases with increasing splitter blades lengths in impeller with higher number of blades (N=5,6).
- Splitter blades have no positive effect at higher number of blades but power consumption decreases. Splitter blades have positive effect when there is blade number is less (N=4).
- Efficiency and head increases with splitter blades length increment. The best efficiency point is obtained at 13.7 lit/s flow-rate which is 52.71%. Increase in efficiency is 6.54% and increase in head is 6.08%. Thus splitter blades are useful when number of blades on impeller is less.

FUTURE SCOPE

- Further research can be done by means of putting splitter blades at different outlet blade angles also providing microgrooves on impeller.

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