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The Effect of Venturi Design on Jet Pump Performance

Mr. Brijesh R. Naik
Assistant professor
Department of Mechanical Engineering
Chhotubhai Gopalbhai Patel Institute of Technology, Uka Tarsadia University, Bardoli

Mr. Sagar M. Patel
PG Student
Department of Mechanical Engineering
Chhotubhai Gopalbhai Patel Institute of Technology, Uka Tarsadia University, Bardoli

Abstract

Jet pump is a type of mechanical device where the extra energy is provide by jet in mixing chamber. This jet is the fluid again circulate from diffuser exit to mixing chamber for better performance. This is also known as motive fluid. So the effects of change in geometrical parameter (Diffuser angle) on its performance were investigated. The set of experiment were carried out to study the effect of diffuser angle on the performance of jet pump. The performance of the jet pump is described by three sets of curves, Discharge vs. Head, Input power vs. Head, and Efficiency vs. Head. Changing the diffuser angle will affect jet pump behavior. Venturi diffuser angle was found to be an important geometrical parameter to characterize the maximum suction lift of the jet pump.

Keywords: Jet pump, diffuser angle, injector, mixing chamber, Area ratio

I. Introduction

Jet pumps mixing chamber is as shown in Figure 1 and 2. The main components of jet pump are nozzle, throat inlet, throat and diffuser. Nozzle is used to convert the high pressure energy of fluid into kinetic energy of fluid. The throat is used to accelerate the flow which is at low pressure from reservoir. Also a uniform mixture is developed in throat due to mixing of two fluids (Motive fluid and inlet fluid). The function of diffuser is to convert the combined energy (Pressure energy and Kinetic energy) into pressure energy only. So the pressure increase in the diffuser part of the pump lifts the mixture to the surface.

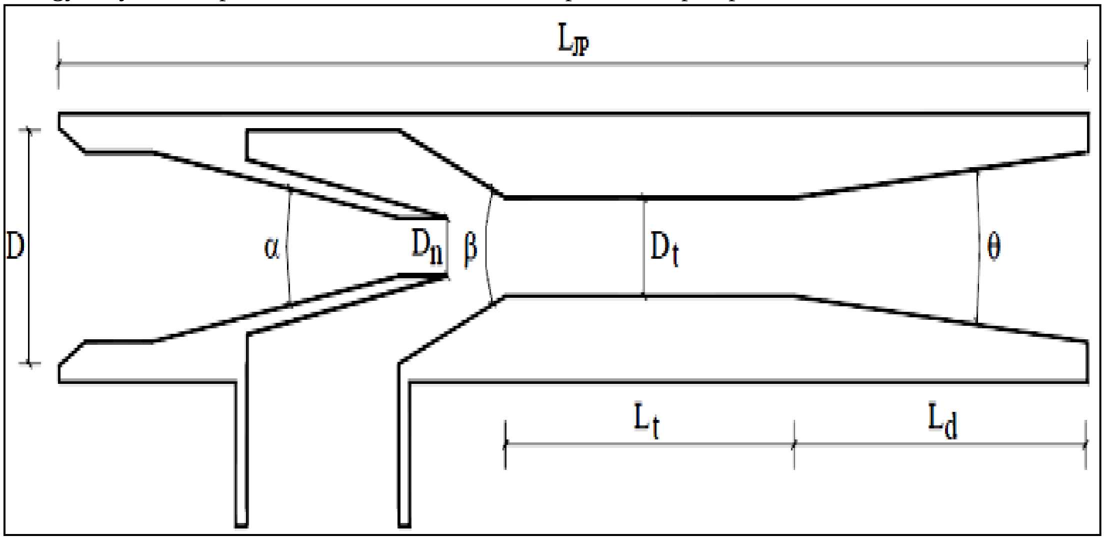


Fig. 1: Parameters of mixing chamber [02]

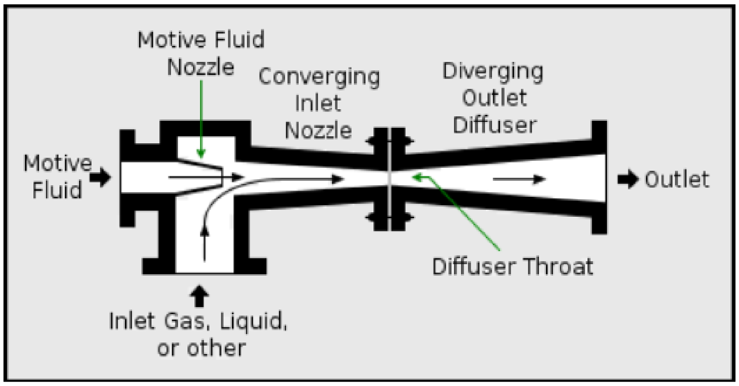


Fig. 2: Mixing Chamber [05]

A. Specification of experiment:

Table – 1

Area of measuring tank (A)	**280×360 mm^2**
Sump tank	**900×550×450 mm^2**
Energy meter constant (N)	**3000 rev/k watt hr.**
Level difference between vacuum gauge & pressure gauge (X)	**350 mm.**
Pump	**Lubi make, 42m head, 900 lph, 2800 rpm, 1 hp**
Pressure gauge	**2.1 kg/cm^2**
Vacuum gauge	**0 - 760 mm hg**

B. Nomenclature [02], [03]:

Table – 2

D = Nominal diameter of nozzle	***α = Nozzle angle***
D_n = Nozzle outlet diameter	***ß = Throat inlet angle***
E_C = Energy meter constant	***H = Total head***
R = Area ratio$(Dn/Dt)^2$	***IP = Input power***
V = Vacuum gauge reading	***OP = Output power***
G = Pressure gauge reading	***L_t = Throat length***
L_{jp} = Total jet pump length	***L_b = Diffuser length***
W= Equivalent weight of water	***θ = Diffuser angle***
D_t = Throat diameter	***Q = Actual discharge***

Fig. 3: Different types of diffuser

II. Experimental Procedure

1) Ensure the 4.5^0 diffuser was assembled into the jet pump.
2) Start unit with fully open delivery valve.
3) Set flow regulating valve.
4) Note down pressure gauge reading.
5) Note down time taken for "y" m rise in the collection tank.
6) Note down time taken for "N" revolutions in the energy meter.
7) Tabulate the above observations for different flow regulating valve openings.
8) Repeat step (1) to (7) for 5^0 and 5.5^0 diffuser.

III. Result and Discussion

In this study three venturi of diffuser lengths (L_d) of 110, 100 and 148 mm were tested, having diffuser angles (θ_d) of 4.5º, 5º, and 5.5º respectively With the throat diameter of 10 mm and the same nozzle to throat area ratio(R) 0.25 [04]. Jet pump was tested on the test rig. Reading was taken at different discharge pressure. Table 1 shows the observations of 4.5º diffuser at different discharge pressure. Similar observations of 5º and 5.5º diffuser are shown in table 2 & 3.

Table – 3
Data collected for 4.5º diffuser angle with area ratio(R) 0.25

Sr. No.	Pressure Gauge (G)	Vacuum Gauge (V)	Time for 10 rev(sec)	Time for 10 cm rise (sec)	Discharge Q (m3/s) 10^{-4}	Head (m)	BP (w)	IP (w)	Efficiency (%)
1	0	650	9.42	17	5.93	9.19	53.45	1.27	41.96
2	0.5	600	9.4	17.32	5.82	13.51	77.13	1.27	60.42
3	0.7	550	9.16	17.84	5.65	14.83	82.20	1.31	62.74
4	0.9	500	9.02	18	5.60	16.15	88.72	1.33	66.68
5	1.1	400	9	18.19	5.54	16.79	91.27	1.33	68.45
6	1.5	250	8.9	18.26	5.52	18.75	101.5	1.34	75.30

Table – 4
Data collected for 5º diffuser angle with area ratio(R) 0.25

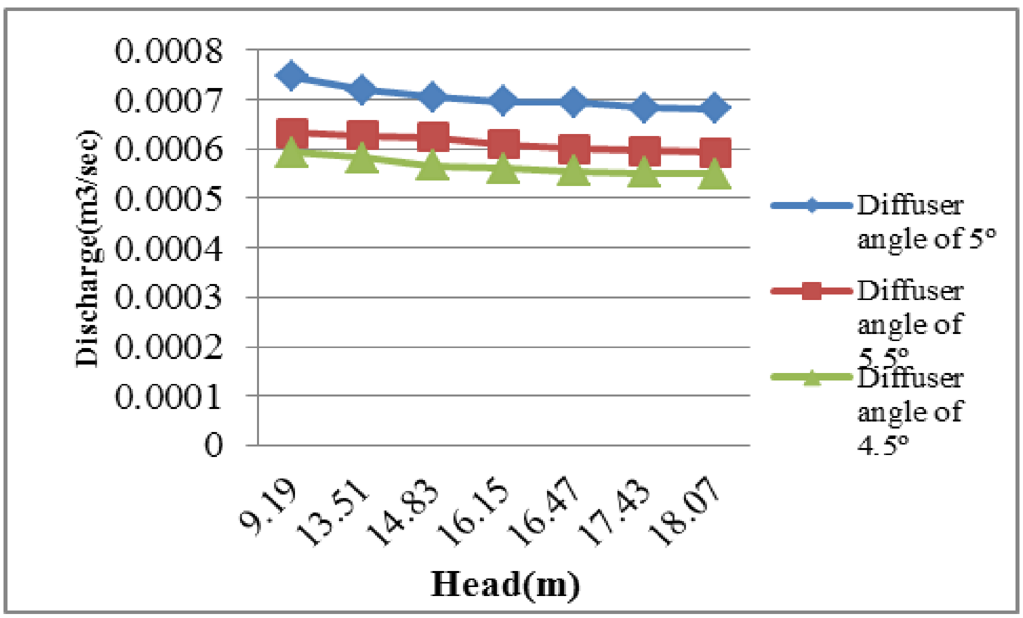
Sr. No.	Pressure Gauge (G)	Vacuum Gauge (V)	Time for 10 rev(sec)	Time for 10 cm rise (sec)	Discharge Q (m3/s) 10^{-4}	Head (m)	BP (w)	IP (w)	Efficiency (%)
1	0	650	8.76	13.5	7.747	9.19	67.314	1.36	49.139
2	0.5	600	8.71	14	7.200	13.51	95.423	1.37	69.261
3	0.7	550	8.63	14.3	7.050	14.83	102.54	1.39	73.750
4	0.9	500	8.50	14.5	6.950	16.15	110.13	1.41	78.013
5	1	450	8.30	14.5	6.930	16.47	112.01	1.44	78.501
6	1.5	200	8.20	14.8	6.810	18.07	120.73	1.46	82.500

Table – 5
Data collected for 5.5º diffuser angle with area ratio(R) 0.25

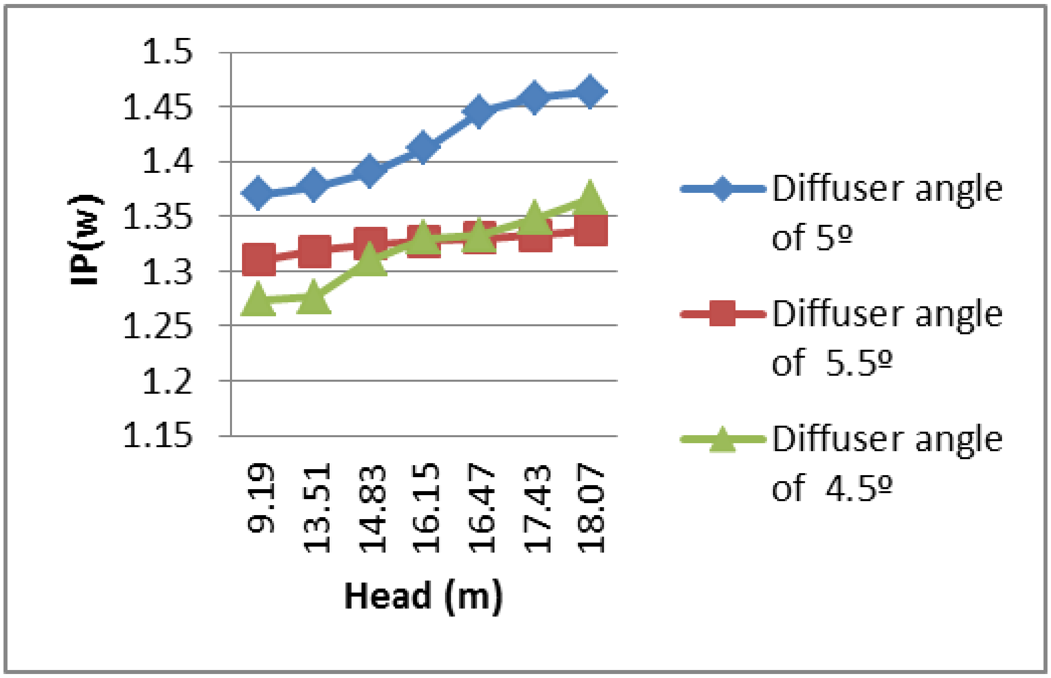
Sr. No.	Pressure Gauge (G)	Vacuum Gauge (V)	Time for 10 rev(sec)	Time for 10 cm rise (sec)	Discharge Q (m3/s) 10^{-4}	Head (m)	BP (w)	IP (w)	Efficiency (%)
1	0	650	9.16	15.93	6.33	9.19	57.04	1.31	43.54
2	0.5	600	9.1	16.09	6.26	13.51	83.02	1.31	62.96
3	0.7	550	9.06	16.16	6.24	14.83	90.74	1.32	68.51
4	0.9	470	9.04	16.53	6.10	15.74	94.17	1.32	70.94
5	1.1	400	9.02	16.8	6.00	16.79	98.82	1.33	74.28
6	1.5	250	9	16.9	5.96	18.75	109.7	1.33	82.28

A centrifugal jet pump operated at constant speed delivers any capacity from zero to maximum depending on the head, design and suction condition. So pump performance is most commonly shows by means of plotted curves which are graphical representation of pump's performance. Characteristic pump curves present the average results obtained from testing several pumps of the same design under standardized test condition.

The results obtained by performing the experiments are shown in Table 1, 2 and 3. With this result characteristic curves obtained in graph 1, graph 2 and graph 3. Graph 1 shows the Head vs. Discharge characteristics curve of the jet pump in graph 1. Head and discharge are inversely proportional for the selected range of head in this experiment which is in between from 9 m to 18 m of water.



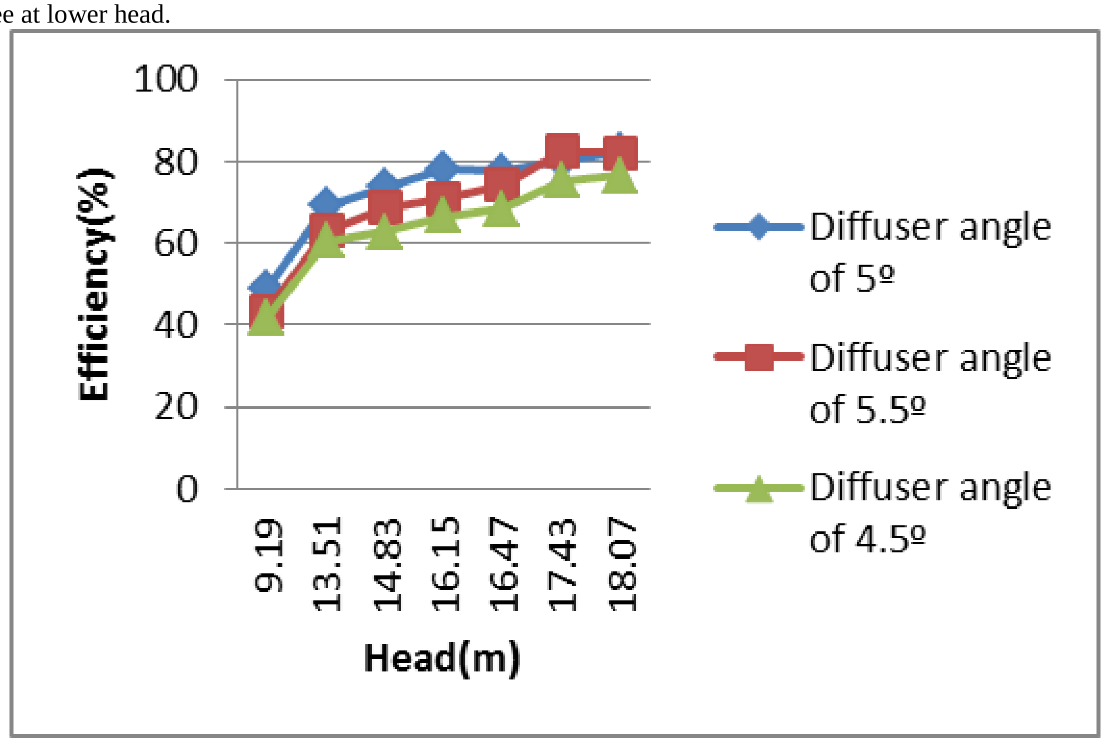
Graph 1: Discharge v/s Head



Graph 5: Input power v/s head

Graph 2 shows the head vs. input power characteristics of the centrifugal jet pump. Power requirement is less for lowest diffuser angle at lower head. But power requirement is lowest for highest diffuser angle at higher head.

Graph 3 shows the head vs. efficiency characteristics of the centrifugal jet pump. Diffuser angle of 50 is the most efficient amongst three at lower head.



Graph 3: Head V/s Efficiency

The diffuser converts kinetic energy into potential energy. The length and angle of diffuser is difficult to quantify without experiments. The efficiency increases also with increasing the mass flow rate. The highest values of efficiency are 82.5 % for diffuser angle of 5^0 as shown in graph 3. It is also clear that the diffuser angle of 5^0 gives the best performance compared to diffuser angle of 4.5^0 and 5.5^0 which gives the lower efficiency. This may be because the jet pump with diffuser angle of 5^0 draws more driving fluid than that with diffuser angle of 4.5^0 and 5.5^0 for the same discharge pressure.

IV. CONCLUSION

Changing the diffuser angle will also effect on the jet pump behaviour? The venturi of diffuser angle of 5º gives the highest efficiency while the venturi with diffuser angle 4.5º gives the lowest efficiency. The highest value of efficiency at 18.5 meter head is 82.5% for diffuser angle of 5º, while 4.5º gives 75.30 % respectively.

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