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Effect of Pressure and Speed on the Volumetric Efficiency and Discharge of the Centrifugal Pump

Dr. R.K. Mehta[1], Er. Mahendra Rai[2], Er. R.J. Singh[3]

Dean, MCAET, Ambedkar Nagar, Uttar Pradesh, India[1]

Associate Professor (Dept. of SWCE), MCAET, Ambedkar Nagar, Uttar Pradesh, India[2]

Associate Professor (Dept. of FMPE), MCAET, Ambedkar Nagar, Uttar Pradesh, India[3]

Abstract: The experiment conducted at Mahamaya College of Agricultural Engineering & Technology, Ambedkarnagar (U.P.). The pump tested for analysis performance is equipped with 2HP three phase induction electric motor with 1440rpm.The discharge was measured with stop watch having 1/100sec. least count. The pump was tested for three different speed of 242 rpm, 285 rpm and 344 rpm with five different pressure are 1.5 kg/ cm^2, 5.7 kg/cm^2,10.3kg/cm^2, 15kg/cm^2 and 24kg/cm .A pressure gauge having capacity 0-35kg/cm was used to record all pipe pressure used for this testing. The pulley with minimum diameter 6.25cm was fitted in motor shaft a V(twin) belt the electric connection was energized. The result based on the experimental observation revealed that the efficiency increased when pressure is increased. At speed 344 rpm the efficiency is observed 90% and at same speed the volumetric efficiency is 77%for lowest pressure 1.5kg/cm and volumetric efficiency is 95% for highest pressure 24kg/cm^2.The pressure and average discharge indicate that as pressure increases the discharge increases and which almost linear.

Keywords: Discharge, Efficiency, Volumetric efficiency, Pressure, rpm, Static head and Pressure head.

I. INTRODUCTION

Centrifugal pump is a hydraulic machine which converts the mechanical energy into hydraulic energy. It works on the principle of centrifugal force. It is used at a place where relatively small amount of water is to be delivered at high pressure. Centrifugal pump functioning by means of revolution of impeller. The capacity of centrifugal pump depends on the size of impeller. Centrifugal pump is operated by electric motor or diesel engine. Irrigation schemes which required this because high output levels can be more easily attained and controlled. Centrifugal pump developed high head and higher capacity as compared to other types of pump. A centrifugal pump induces from low level to high level. A centrifugal pump convert rotational energy to energy in moving fluid which passing through impeller. The fluid is gaining both velocity and pressure. The capacity of centrifugal pump depends upon pump design, impeller diameter and pump speed. The actual flow rate achieved is directly dependent on the total dynamic head, it must work against. However, scientific information such as efficiency discharge, head relationship and other characteristics of the pumps are lacking which becomes very difficult to recommends a pump for specific purpose. Keeping this view, study on evaluation of volumetric efficiency, pressure discharge relationship and speed-power-discharge was undertaken under laboratory conditions.

II. MATERIALS AND METHODS

The experiment was conducted at Mahamaya College of Agricultural Engineering and Technology, Ambedkar Nagar (U.P.). The pump tested for analysis performance is equipped with 2HP, three phase induction electric motor with 1440 rpm. The water source was a hose measuring 4.12x3.25x1.23. The suction pipe used wasG.I.20 mm pipe. The delivery pipe was high density flexible reinforced rubber pipe to withstand sufficient pressure (up to 25 kg/cm^2). The discharge was measured with stop watch having 1/100sec.least count. The discharge was collected in a cylindrical vessel of 69.91 liter capacity. The pump was tested for three different speed of 242 rpm, 285 rpm and 344 rpm along with different pressures of 1.5kg/cm^2,5.7kg/cm^2,10.3kg/cm^2,15 kg/cm^2 and 24kg/cm^2.The centrifugal pump used or tested was designed with advanced engineering techniques to fulfill the most exacting requirements of contemporary users. The pressure variation was measured with a pressure gauge having 0-35 kg/cm^2. The pressure head was converted into static head with conversion factor 1kg/cm^2 =10 meter. The pulley with minimum diameter 6.25 cm. was fitted in motor shaft a V-(twin) belt the electric connection was energized. The pump started taken revolutions and discharge, suction pipe air after few second when whole air of the suction pipe was out of the flexible delivery pipe. The pressure was fitted to the delivery pipe with the help of spitted clip having nuts and bolts at the both end was restarted and discharge was

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collected in the measuring tank, simultaneously stop watch was used to record the time. Pump efficiency was computed by WHP (Watt Horsepower) and SHP (Shaft Horse Power) Watt Horse Power is the theoretical horse power required for pumping. It is the head and capacity of the pump expressed in terms of horse power. The volumetric efficiency of the pump isratio of actual flow rate delivered to the theoretical discharge flow rate, which is computed by using equation:

$$Volumetric\ efficiency\ (\eta_v) = \frac{Actual\ flow\ rate\ produced\ by\ pump}{Theoretical\ flow\ rate\ produced\ by\ pump} * 100$$

$$\text{Mechanical } efficiency\ (\eta_m) = \frac{Theoretical\ power\ that\ must\ be\ delivered\ to\ pump}{Actual\ power\ delivered\ to\ pump} * 100$$

$$\text{Overall efficiency of centrifugal pump } (\eta_o) = \eta_v * \eta_m$$

Where, η_v = $Volumetric\ efficiency$
η_m = Mechanical $efficiency$
η_o = Overall efficiency
and WHP is calculated by using formulae-

$$\text{WHP} = \frac{\text{Discharge (liter / sec.)} * \text{Total dynamic head (m)}}{75}$$

Table 1. Pressure – Discharge – Volumetric Efficiency relationship in centrifugal pump

S.No.	Pressure (kg/cm^2)	Discharge(lit/sec)	Actual Value (m^3)	Theoretical Volume (m^3)	Volumetric efficiency (%)
		Speed 242 rpm			
1.	1.5	0.13	0.00013		43
2	5.7	0.18	0.00018		60
3.	10.3	0.21	0.00021	0.00030	70
4.	15	0.25	0.00025		83
5	24	0.27	0.00027		90
		Speed285 rpm			
1.	1.5	0.14	0.00014		42
2.	5.7	0.21	0.00021		63
3.	10.3	0.24	0.00024	0.00033	72
4.	15	0.28	0.00028		84
5.	24	0.30	0.00030		90
		Speed 344rpm			
1.	1.5	0.37	0.00037		77
2.	5.7	0.39	0.00039		81
3.	10.3	0.41	0.00041	0.00048	85
4.	15	0.44	0.00044		91
5.	24	0.46	0.00046		95

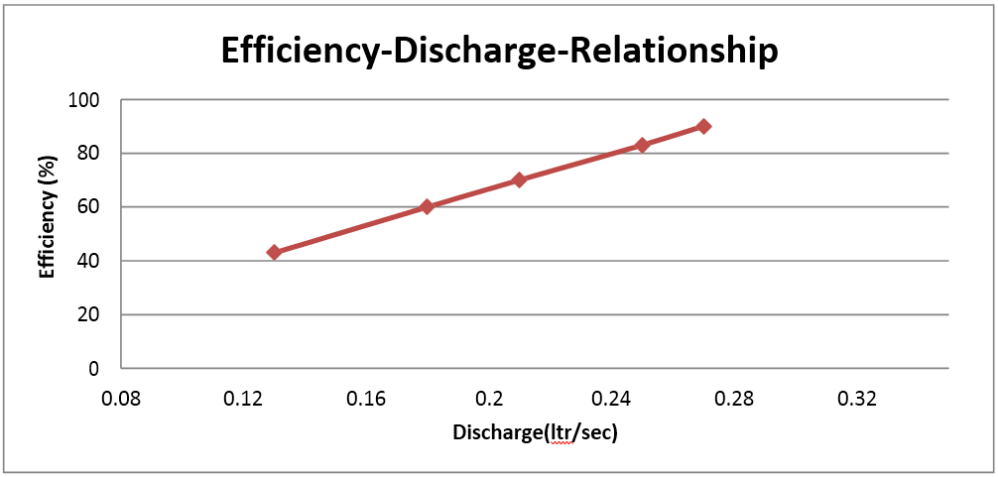

Fig.1 Efficiency-Discharge relationship of centrifugal pump tested, speed: 242rpm.

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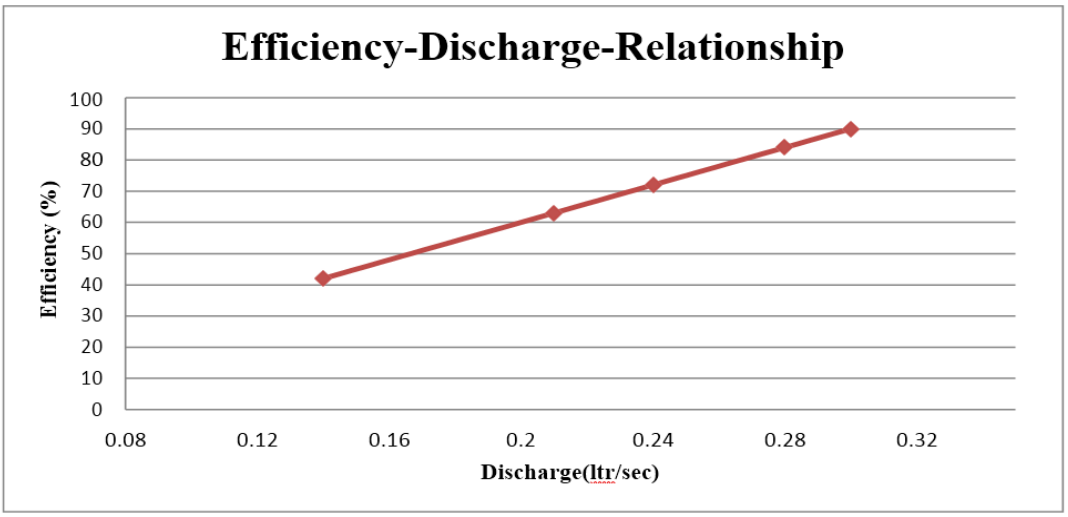

Fig.2 Efficiency-Discharge relationship of centrifugal pump tested, speed: 285rpm

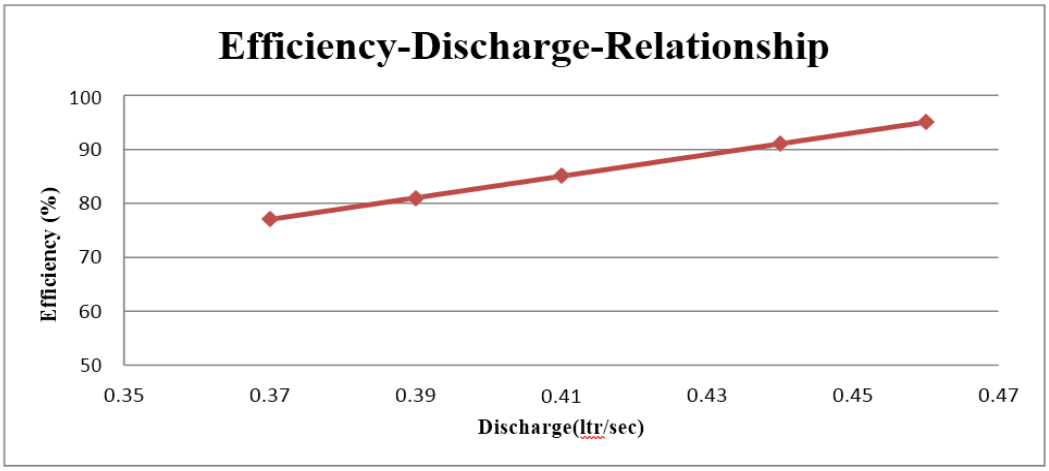

Fig.3 Efficiency-Discharge relationship of centrifugal pump tested, speed: 344 rpm

Table 2. Power, Pressure, Discharge and Efficiency for different speeds of centrifugal pump.

S.N.	Power, Watt	Pressure (kg/cm^2)	Discharge (l/sec)	Efficiency (%)
		Speed, 242rpm		
1.	56.15	1.5	0.27	
2.	261.98	5.7	0.25	
3.	352.46	10.3	0.21	70
4.	499.43	15	0.18	
5.	506.16	24	0.13	
		Speed ,285 rpm		
1.	61.78	1.5	0.30	
2.	251.73	5.7	0.28	
3.	377.19	10.3	0.24	70.2
4.	472.9	15	0.21	
5.	564.04	24	0.14	
		Speed ,344 rpm		
1.	83.31	1.5	0.46	
2.	362.22	5.7	0.44	
3.	678.71	10.3	0.41	85.8
4.	997.93	15	0.39	
5	1356.21	24	0.37	

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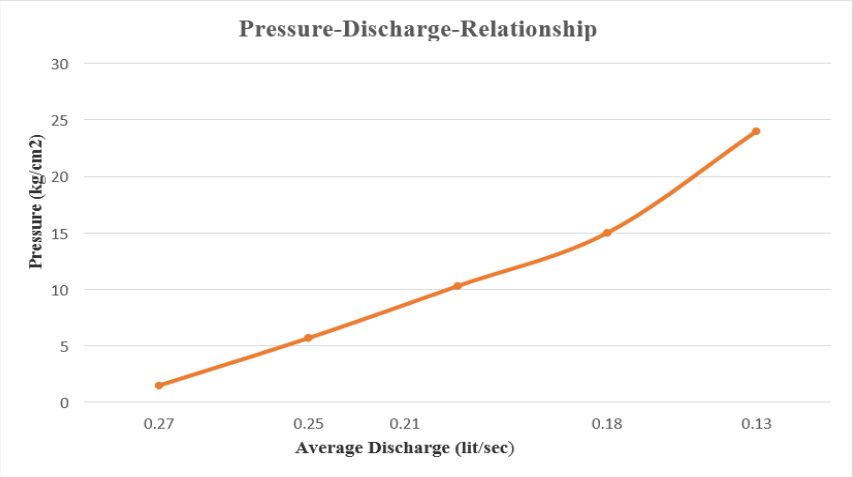

Fig 4. Pressure-Discharge relationship of centrifugal pump tested, speed: 242rpm

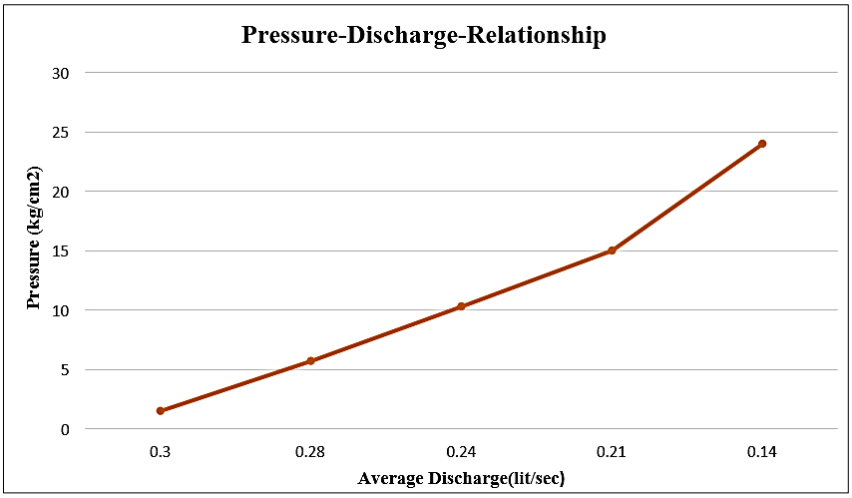

Fig 5. Pressure-Discharge relationship of centrifugal pump tested, speed: 285rpm

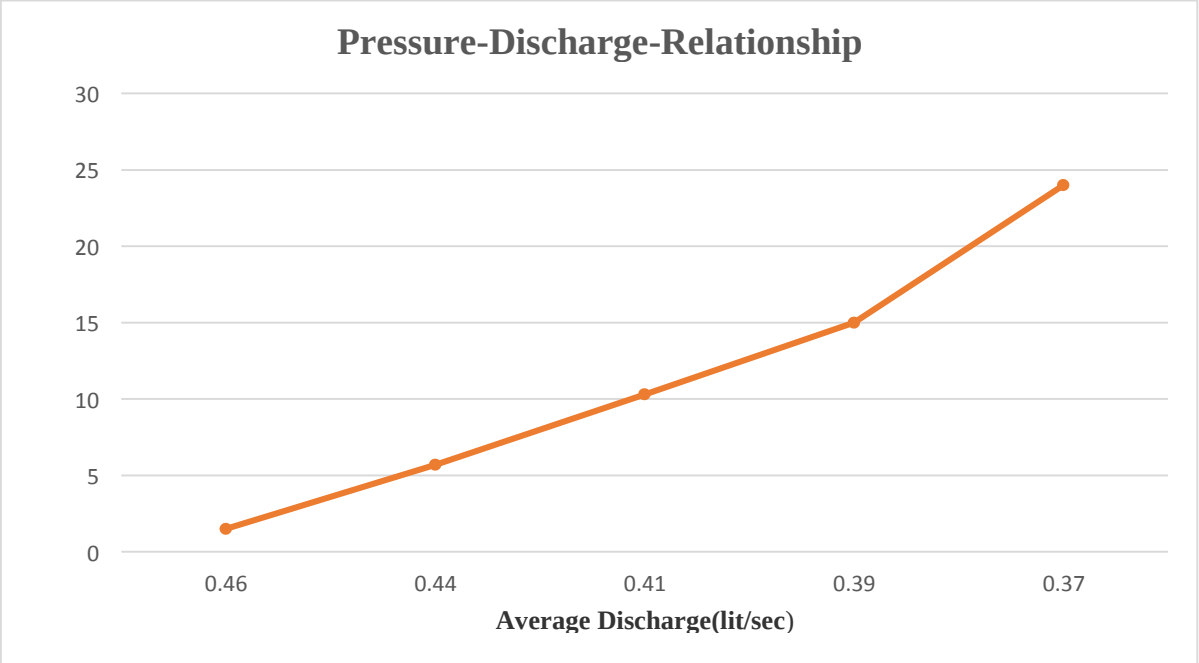

Fig 6. Pressure-Discharge relationship of centrifugal pump tested, speed: 344rpm

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III. RESULTS AND DISCUSSION

The experiment was conducted on effect of pressure and speed on the volumetric efficiency and discharge of centrifugal pump in terms of volumetric efficiency, pressure discharge relationship and speed- power- discharge relationship. The pump was tested for three different speed of 242 rpm, 285 rpm and 344 rpm with five different pressures i.e.1.5kg/cm^2, 5.7kg/cm^2,10.3kg/cm^2,15kg/cm^{2}and 24 kg /cm^2.The results revealed that if pressure increased at different speed the discharge rate increased as well as volumetric efficiency is also increased. At speed 242 rpm the volumetric efficiency is 43% at pressure 1.5 kg/cm^2 while at pressure 24kg/cm^2 the volumetric efficiency is 90 %. Similar trend obtained in case of speed 285 rpm and 344 rpm. Discharge at pressure 1.5 kg/cm^2 is 0.13 l/sec. whereas at pressure 24 kg/cm^2 the discharge is 0.27 l/sec. at speed 242 rpm, similarly at pressure 1.5 kg/cm^2 the discharge is 0.37 l/sec. and at pressure 24 kg/cm^2 the discharge is 0.46 l/sec. Similarly results revealed that if power (Watt) increases discharge is also increased. At speed 242 rpm and power 506.16 watt the pump

Efficiency is 70 %, at speed 285 rpm and power 564.04 the pump efficiency is 70.2 % and at speed 344 rpm and power 1356.21 watt the pump efficiency is 85.8 %. Hence, the increased trend was found in relationship of increase in pressure and its corresponding discharge. The power consumption was increased with the increase of pressure and a linear relationship was found between the power required and of pressure build up while the discharge followed decreasing trend.

IV. SUMMARY AND CONCLUSION

The experiment was conducted to determine the effect of pressure and speed on the volumetric efficiency and discharge of centrifugal pump. The pump was tested for three different speed i.e. 242 rpm, 285 rpm and 344 rpm with five different pressures i.e. 1.5 kg/cm^2, 5.7 kg/cm^2, 10.3 kg/cm^2, 15 kg/cm^2 and 24 kg/cm^2. The variable parameters namely pump speed and pressure were taken out to determine efficiency, discharge and power of centrifugal pump. The results revealed that-

1. The volumetric efficiency of the pump increases with increase of delivery head.

At speed 242 rpm, at low pressure of 1.5 kg/cm^2 the volumetric efficiency is 43%. where as at high pressure of 24 kg/cm^2 the volumetric efficiency is 90 %.

- At speed 285 rpm, at low pressure of 1.5 kg/cm^2 the volumetric efficiency is 42%, where as at high pressure of 24 kg/cm^2 the volumetric efficiency is 90%.
- At speed 344 rpm, at low pressure of 1.5 kg/cm^2 the volumetric efficiency is 77%, where as at high pressure of 24 kg/cm^2 the volumetric efficiency is 95%.

2. The average volumetric efficiency for three different pump speedare-

- At speed 242 rpm the average volumetric efficiency is 70 % for power 56.15 -506.16Watt and pressure 1.5 -24 kg/cm^2.
- At speed 285 rpm the average volumetric efficiency is 70.2 % for power 61.78 -564.04 Watt and pressure 1.5 – 24 kg/cm^2.
- At speed 344 rpm the average volumetric efficiency is 85.8 % for power 83.31.-1356...21Watt and pressure 1.5 -24 kg/cm^2.

3. The increase trend was found in relationship of the increase in pressure and its corresponding discharge.
4. The power consumption was increased with increase of pressure and a linear relation was found between the power required and of pressure build up, while the discharge followed decreasing trend.

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