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Effects of Volute Tongue Clearance and Rotational Speed on Performance of Centrifugal Blower

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ABSTRACT

In this paper, an experimental study has been carried out to study the effects of volute tongue clearance and rotational speed on performance of backward curved blades centrifugal blower. The experiments are performed in the wide range of rotational speeds varying from 1500, 2000, 2500 and 2800 rpm with different volute tongue clearance blowers of 6%, 8%, 10% and 12.5 % of impeller diameter are used for experimentations. The experiments are performed with respective Indian standard IS4894:1987. To study the performance parameters flow rate, total pressure, shaft power and efficiency of the blowers. The aim of many different experimental tests is to validate whether the effects of different volute tongue clearance modifications and impeller speed to blower performance and to find a good volute tongue clearance and impeller speed matching to increase the performance of centrifugal blower. The results show that the volute tongue clearance and impeller speed has a significant effect on the performance of centrifugal blower.

Keywords: Centrifugal Blower, Impeller Speed, Performance, Volute Tongue Clearance

I. INTRODUCTION

Centrifugal blowers are frequently used in many applications to produce high pressure. It correspondingly develops high-pressure ratios in small axial distance related to axial fans. They are commonly used in heating, ventilation, air conditioning systems and various other applications. Depending on the blade shape, centrifugal blowers can be classified into forward-curved, backward-curved, radial, and airfoil types. A blower is a device for moving air which utilizes a power driven the rotating impeller. A blower has at least one inlet opening and at least one outlet opening. The rotating impeller was transfers mechanical energy from the shaft toward the air stream. The energy in air appears in the form of air velocity and air pressure. It is important to note that all of the energy added to the air is added to power driven rotating impeller. When the air moves into the suction side of the impeller, the shape of the casing provides the necessary pressure to the flowing air. In centrifugal blower, the air was forced to the periphery and discharged into the volute [1]. The variations of the volute tongue clearance in order to decrease the pressure deviations in this region. Decreasing impeller-tongue clearance is mostly used method for centrifugal blower performance improvement [2]. Increase the gap between the tongue and the impeller, thus charge the tongue out of the region with reduce nonuniform flows [3].The volute tongues position has a significant effect on the performance. Large pressure variation is observed in the vicinity of volute tongue region and it decreases with increase in distance from the tongue [4-5]. The effect of volute tongue position on the circumferential pressure distribution was observed. The differences in flow pattern and flow reversal are larger when the radial gap is smaller and the blockage effect is reduced with increasing radial gap. Thus, the volute tongues position has a significant effect on the performance [6-7].

The modified tongue positions have affected to power consumption and the total efficiency of the fan [8-9]. The volute tongue clearance had a substantial effect on the performance of centrifugal fan [10- 12]. In the work reported here, an experimental study on the backward curved blades centrifugal blower performance has been performed and then, some different volute tongue

clearances, different impeller speed and their coupling effect to the performance of the backward curved blades centrifugal blower. The fundamental object of the present work is to offer a case study on the backward curved blades centrifugal blower performance. The second object is to appreciate whether the effects of different volute tongue clearance modifications to centrifugal blower performance are additive. And the additional object is to find a good matching between impeller speed and volute tongue clearance to increasing the performance of centrifugal blower.

II. METHODS AND MATERIAL

1. Centrifugal Blower Details

The four centrifugal blowers are used for the experimental measurement. The difference between the all this blower is only the casings with different volute tongue clearances the impeller is similar. Fig.1 shows the test centrifugal blower and Table I demonstration all dimensions of the test centrifugal blower. The different volute tongue clearance blowers are shown in Fig.2. For experimentation all four blower volute tongue clearance are 12.5%, 10%, 8% and 6% of impeller diameter and different speed of impeller are used. The blower is driving by an electric motor at different speed.

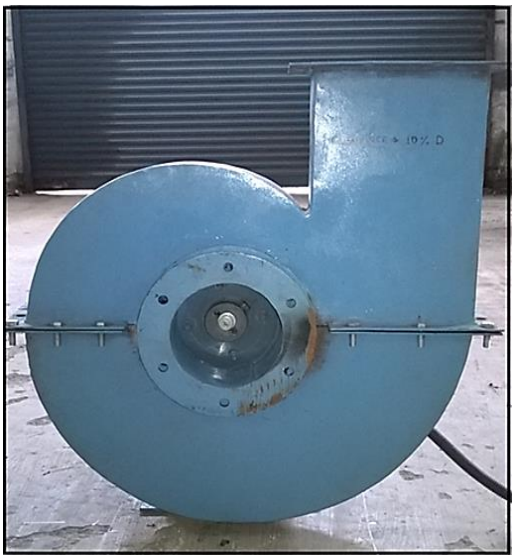

Figure 1. Test centrifugal blower

Figure 2. Casings with Different Volute Tongue Clearances

TABLE. I
CENTRIFUGAL BLOWER PARAMETER

Sr. No	Parameter	Unit	Values
1	Impeller Outlet Diameter	mm	280
2	Impeller Inlet Diameter	mm	140
3	Impeller Blade Number	-	12
4	Impeller Width	mm	20
5	Impeller Blade Angle	deg	30
6	Casing Width	mm	65
7	Volute Tongue Radius	mm	14
8	Casing Inlet Diameter	mm	125
9	Casing Outlet B×L	mm	65×185

2. Experimentation

In this study, four centrifugal blowers were tested according to Indian standard IS4894:1987. The test setup contains of a centrifugal blower of backward curved type, a test inlet duct and delivery duct. The blower is driven by an AC three-phase electric motor. The inlet duct has 125 mm in diameter and 552 mm in length and delivery duct has 200 mm in length. The flow rate can be varied by orifice plate in the inlet duct during experiments. The test setup is assembled and the experiments conducted in accordance with IS4894:1987. Fig.3 shows a test setup equipped with the measuring devices. The flow rate over the blower is calculated by the static pressure measured by the U-tube manometer at section 'A' of the inlet duct. The static pressures at the blower inlet are measured over four taps equally distributed on the circumference of the inlet duct at section 'B' and the outlet total pressure measured at the outlet of the blower for calculating the blower total

pressure. The distance from the static taps at blower inlet duct is 130 mm. The three phase variable auto-transformer is used to varying the speed of blower. The rotation speed of the blower is measured by a hand-held tachometer. The input power required to drive the impeller is measured using an ammeter and voltmeter. From experimental calculation data the blower total efficiency is calculated by using following equation,

$$\eta_{\text{Total}} = \frac{2.725\times10^{-3}\times Q\times P_t}{P_{sh}}$$

Where, P_t the blower total pressure, Q is the blower volume flow rate. In this study, the uncertainty in the flow rate and the pressure measurements is ±2.5%. Moreover, the fan input power obtained is within ±2%. The rotational speed variation during the test is controlled within ±1%. The maximum uncertainties for different instruments are as follows,

Tachometer: ± 0.05 % (± 10 rpm)
Ammeter: ± 0.01 % (± 0.01 Amp)
U-tube manometer: ± 1 mm of H_2O

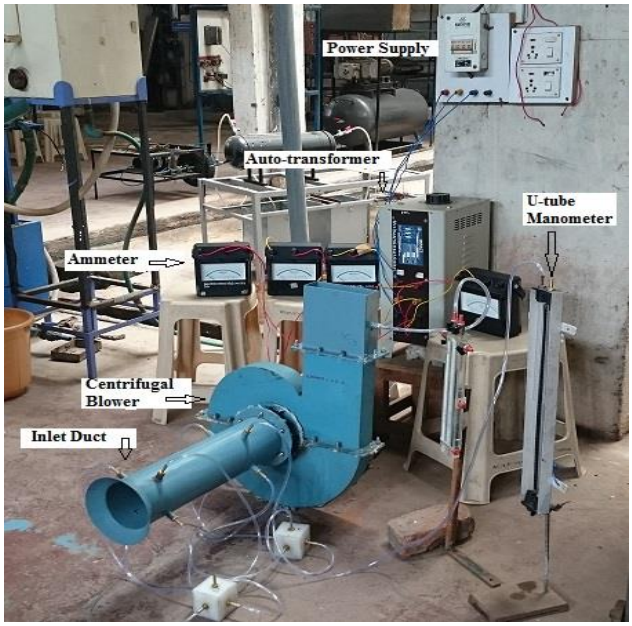

Figure 3. Actual test setup

III. RESULTS AND DISCUSSION

In the present study, the effects of modifications of volute tongue clearance were studied on the entire four blowers i.e. 12.5%, 10%, 8% and 6% volute tongue clearance blowers at four different speeds e.g. 2800, 2500, 2000 and 1500 rpm. The experimental measured results are shown in two plots, where the x-axes are volume flow rate and the y-axes is total pressure. The modifications of volute tongue clearance have affected on the total pressure, efficiency and shaft power of centrifugal blower. For different volute tongue clearances, the increasing volume flow rate the variation in total pressure is shown in Fig.4 at 2800 rpm.

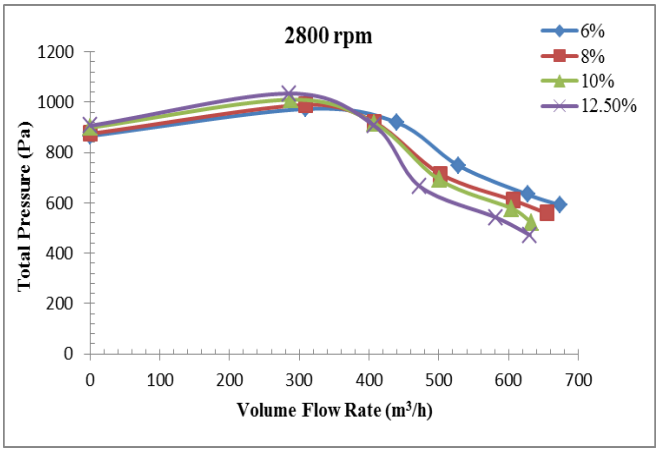

Figure 4. Effect of volume flow rate on total pressure at 2800 rpm

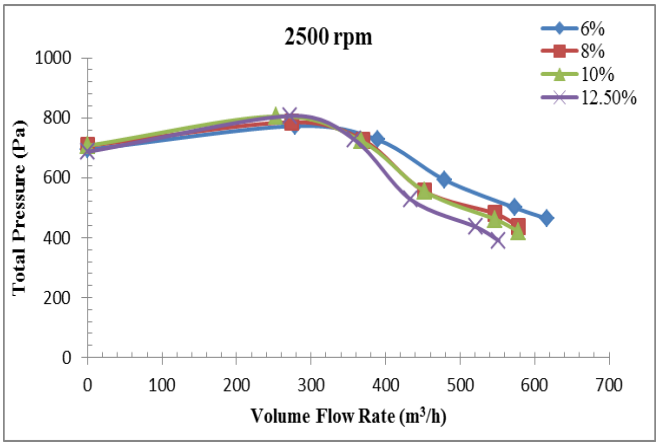

Figure 5. Effect of volume flow rate on total pressure at 2500 rpm

For different volute tongue clearances, the increasing volume flow rate the variation in total pressure was shown in Fig.5at 2500 rpm. The total pressure is increased when the volute tongue clearance is decreased. For different volute tongue clearances, the increasing volume flow rate the variation in total pressure was shown in Fig.6 at 2000 rpm. For different volute tongue clearances, the increasing volume flow rate the variation in total pressure was shown in Fig.7at 1500 rpm. The

total pressure is increased when the volute tongue clearance is decreased.

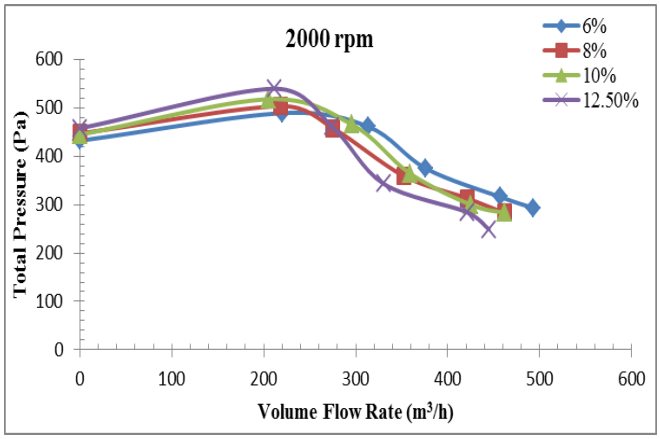

Figure 6. Effect of volume flow rate on total pressure at 2000 rpm

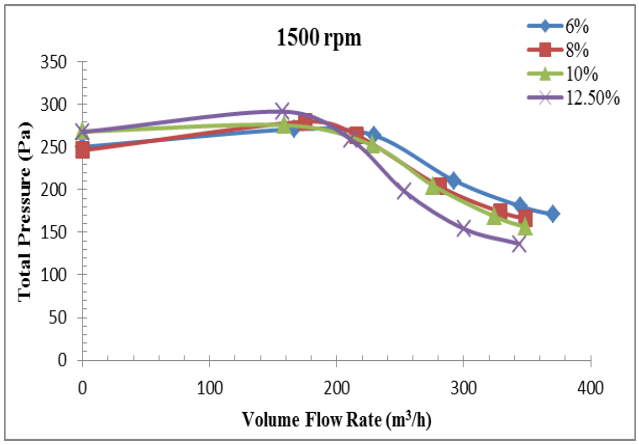

Figure 7. Effect of volume flow rate on total pressure at 1500 rpm

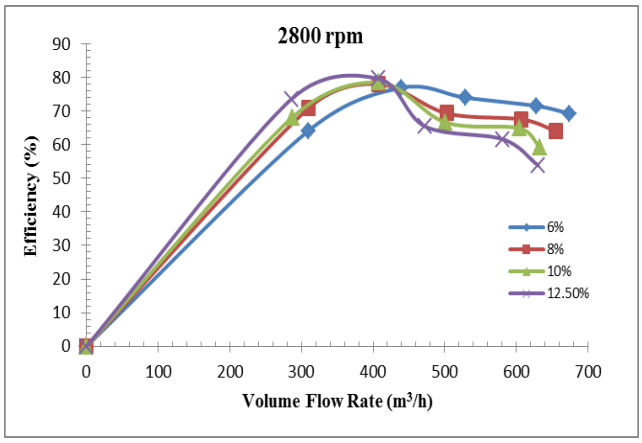

Figure 8. Effect of volume flow rate on efficiency at 2800 rpm

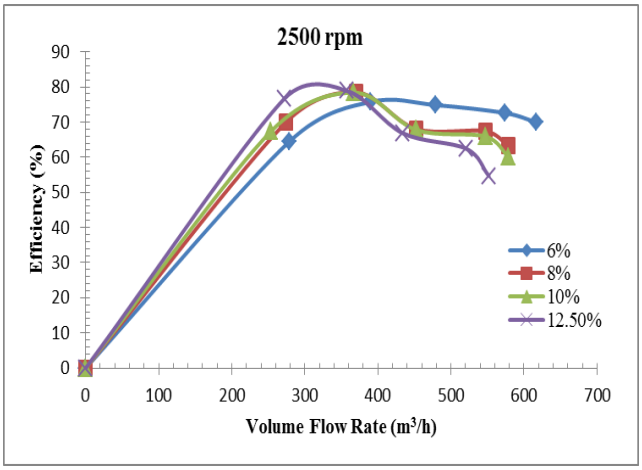

Figure 9. Effect of volume flow rate on efficiency at 2500 rpm

For different volute tongue clearances, the increasing volume flow rate the variation in efficiency is shown in Fig.8 to Fig.11 at different impeller speed, 2800, 2500, 2000 and 1500 rpm. As volume flow rate is greater than Q_1 = 420 m^3/h the efficiency is increased when the volute tongue clearance is decreased the total pressure, volume flow rate and efficiency were increased as the volute tongues clearance was decreases. The operating point of the blower was shifted as the impeller speed varied. The impeller speed is varied from 2800 rpm to 1500 rpm the total pressure, volume flow rate and shaft power are decreases. The efficiency remains same only the operating point of the blower was shifted as the impeller speed varied.

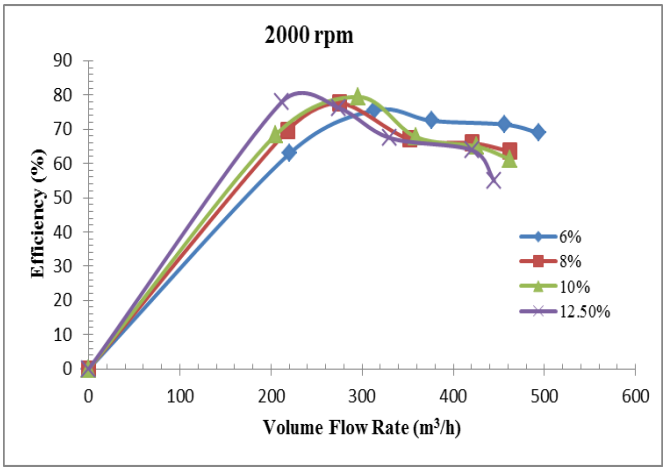

Figure 10. Effect of volume flow rate on efficiency at 2000 rpm

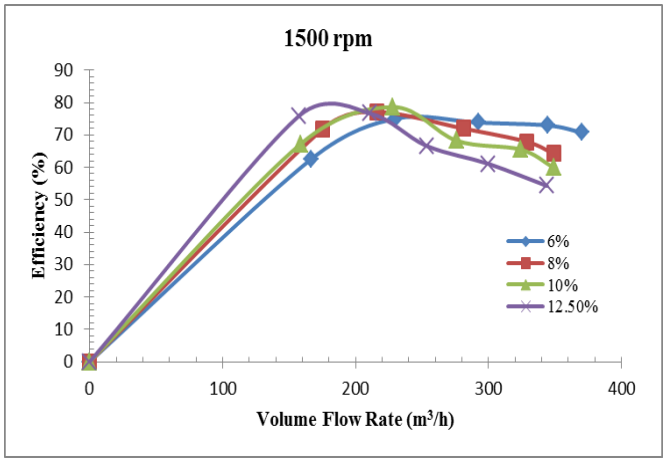

Figure 11. Effect of volume flow rate on efficiency at 1500 rpm

Table II to Table V summarized the change in blower performance when the volute tongues clearance was varied from12.5 % to 6% of impeller diameter. At different impeller speed, 2800, 2500, 2000 and 1500 rpm, the blower was operating at full discharge condition.

TABLE.II

INFLUENCE OF VOLUTE TONGUE CLEARANCE UPON BLOWER PERFORMANCE AT FULL DISCHARGE AND AT 2800 RPM

t_c/d (%)	Q (m^3/h)	P_t (Pa)	P_{sh} (Kw)	η_t (%)
12.5	630.4469	472.7425	0.1536	53.8735
10	632.5968	522.0660	0.1576	59.3010
8	654.7344	558.6915	0.1583	64.1811
6	673.8414	591.2284	0.1595	69.3729

TABLE.III

INFLUENCE OF VOLUTE TONGUE CLEARANCE UPON BLOWER PERFORMANCE AT FULL DISCHARGE AND AT 2500 RPM

t_c/d (%)	Q (m^3/h)	P_t (Pa)	P_{sh} (Kw)	η_t (%)
12.5	551.8543	390.2524	0.1093	54.6924
10	578.7608	419.4676	0.1122	60.0786
8	578.9030	434.9731	0.1106	63.2537
6	617.0228	463.2954	0.1135	69.9343

TABLE.IV

INFLUENCE OF VOLUTE TONGUE CLEARANCE UPON BLOWER PERFORMANCE AT FULL DISCHARGE AND AT 2000 RPM

t_c/d (%)	Q (m^3/h)	P_t (Pa)	P_{sh} (Kw)	η_t (%)
12.5	444.9192	248.7590	0.0560	54.8968
10	461.6914	282.9865	0.05919	61.3145
8	461.9453	282.9865	0.0570	63.5577
6	493.4948	292.5811	0.0581	69.9906

TABLE.V

INFLUENCE OF VOLUTE TONGUE CLEARANCE UPON BLOWER PERFORMANCE AT FULL DISCHARGE AND AT 1500 RPM

t_c/d (%)	Q (m^3/h)	P_t (Pa)	P_{sh} (Kw)	η_t (%)
12.5	344.0233	136.4810	0.0240	54.2846
10	346.0059	156.1010	0.0252	59.9458
8	349.9710	165.9111	0.0250	64.2261
6	370.3988	170.7084	0.0248	70.7500

IV. CONCLUSION

The present paper experimentally studies the effect of modification of volute tongues clearance and different rotational speed of impeller on centrifugal blower performance. Experiments of the original blower and modified blowers are conducted and the results are compared. As the volute tongues clearance decreases from 12.5% to 6% of impeller diameter, the total pressure, volume flow rate and efficiency has significantly increased at full discharge condition. The operating point of the blower was shifted as the impeller speed varied. The impeller speed is varied from 2800 rpm to 1500 rpm the total pressure, volume flow rate, shaft power and efficiency are decreases. Therefore all the modified blowers satisfy the fan law and it gives higher level of performance at 2800 rpm. The modified volute tongues clearances, increases the total pressure and efficiency of blower because the reverse airflow at the region near blower volute tongue are effectively reduced.

NOMENCLATURE

P_t	Total pressure (Pa)
t_c	Volute tongue clearance (mm)
d	Impeller diameter (mm)
P_{sh}	Shaft power (kW)
η	Efficiency (%)

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