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Comparative Performance Analysis of Backward Inclined and Radial Impeller of the Centrifugal Blower

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Abstract - In this paper, the comparative performance analysis of backward inclined impeller with radial impeller on the performance of centrifugal blower has been investigated. The radial impeller manufactured in this work is of same dimensions as of backward inclined impeller of the centrifugal blower. with 280 mm outer diameter, 140 mm inner diameter with 12 number of blades. Performance parameters such as flow rate, total pressure, air power and blower efficiency are computed for backward inclined impeller as well as radial impeller of centrifugal blowers. The experimental facility was developed to test the blower according to IS: 4894-1987. The results indicated that backward inclined impeller of centrifugal blower has high efficiency as compared to radial impeller at different speeds. The performance of radial impeller was less as compared to backward inclined impeller of centrifugal blower in terms of flow rate, blower efficiency and total pressure.

***Key Words*:** Centrifugal blower, Backward inclined impeller, Radial impeller, Performance parameters

1.INTRODUCTION

THE centrifugal blowers are one of the types of mechanical or electro-mechanical turbo machinery. Primarily centrifugal blower performs function such as generating the specific quantity of air flow and build pressure of generated air flow to accommodate for the pressure drop. Rotating impellers in centrifugal blowers are used to give velocity to air or other gases. Centrifugal blower takes an air in inlet duct axially and accelerates it radially through outlet duct.

Centrifugal blowers are classified according to blade orientations, which includes backward, forward, and radial. Blowers can be single stage or multi-stage units. Electric motors are generally used to drive blowers; some of them are directly coupled to drive motors. Centrifugal blowers are broadly employed in turbomachines equipment in various types of modern and domestic life. Using the kinetic energy of the impeller or rotating the blades, for increasing the pressure of air or else gas stream that in turn moves them opposing the resistance which has been caused by dampers, ducts and even various other components. The centrifugal blowers provide air for ventilation and other industrial processing requirements.

Blowers produce pressure to move air opposing a resistance which is caused by dampers, ducts and other components. They use the kinetic energy of the impeller blades to increase the pressure of the supplied air. Hence their efficiency depends on the design of impeller blades. In current scenario, industries assign different design parameters and materials to each blade in order to obtain maximum performance from each blade. The need is an effective design for the impeller blades with same design parameters that gives an improved performance.[1] Main components of Blower are impeller which is having rotary motion, where energy is transfer and followed by stationary part casing, in which energy transformation takes place.[2]

2. LITERATURE REVIEW

V.S. Thangarasu. *et.al.* carried out the investigation of forward curved, backward curved and radial blade impellers of centrifugal blower. They found that the performance of centrifugal blower mainly depends on the design parameters of the impeller blades. He used backward curved, forward curved and radial blade for investigation. He concluded that Backward blade gave maximum efficiency of the centrifugal blower. With decrease in load the head developed in the blower decreases. [1] Dishant G. *et.al.* has experimentally studied the analysis of Backward, forward and radial curved vane of a centrifugal blower. They correlated the performance of centrifugal blower by experimental analysis. The results indicated that Backward blade at medium mass flow rate was most efficient impeller due to easy to manufacture.[2]

Vivek Brahmbhatt and Gaurav did improvement in performance of IND 25 Centrifugal Fan by Computational fluid dynamics, they used radial blade. They found that total efficiency in case of radial impeller by using computational fluid dynamics was 59% and by physical testing was 57%. The total efficiency in case of Backward impeller by using computational fluid dynamics was 78% and by physical testing was 75%. Thus, Backward impeller is highly efficient than Radial Impeller.[3] S.R. Patil. *et.al.* have studied the effect of different volute tongue clearances such as 6%, 8%, 10% and 12.5% of impeller diameter on the performance parameters of centrifugal blower. The results showed that as

volute tongue clearances decreases, total pressure and blower efficiency increases. [4]

Venkatratnam dirisala. did performance investigation of a centrifugal pump by using computational fluid dynamics. They did computational fluid dynamics at five different flow rates and at different speeds and also different number of blades of centrifugal pump. From results they obtained optimum efficiency for 32 kg/sec for 7 blades at 2000 rpm rotational speed, the best efficiency was obtained for 7 number of blades and best head obtained was for 6 number of blades. [5] R. Haridas *et.al.* Investigated and predicted the effects and performance of a radial fan impeller on ANSYS using Nylon66 and White Acrylic material properties. The investigation was done in Ansys. They Compared with straight inlet and bend inlet after optimization, they found the pressure coefficient error and efficiency error are about 0.5% and 0.4%, respectively. Acceleration can effectively suppress the inlet flow distortion. [6].

Zar chi Thaung *et.al.* carried out the numerical study on flow characteristics of radial tipped impeller of centrifugal fan. Their primary objective was to examine the flow characteristics which were in the centrifugal fan in variable inlet parameters employing the numerical analysis. After generating numerical model and complex internal flow fields were investigated by using ANSYS-CFX 15. After matching the theoretical results and Simulation results, it showed it was feasible to use the industrial requirement for Fume Extraction fan of texturizing machine. Complex internal flow fields were investigated by using Ansys -Cfx 15.0. [7] Krishna Kumar Yadav *et.al.* conducted a study on optimization on the design of radial flow pump impeller using computational fluid dynamics. They concluded that the performance of radial flow pump by increasing the number of blades. Impeller which had eight number of blades gave optimal efficiency. They noticed that the overall efficiency of the pump was increased by 2.23% at optimum value.[8].

P. Naveen Kumar and S. Sahaya Rubinson investigated the backward inclined radial blade impeller using Ansys and even stress distribution on them, they even worked on reducing the thickness of the blade and decreasing the number of blades of the fan impeller. It was concluded from the results that the stress and deformation of the 8 mm thick with 10 blades was more or less similar to 9 mm thickness of 12 blades. The weight and cost of the impeller was reduced. [9] Sharad Chaudhary and Santosh Kansal did performance analysis of backward curved Centrifugal fan When they compared the theoretical and CFD based performance curves. They found that after increasing blade angle results increase in static pressure and accompanied by increase in total head of fan. Static pressure decreases when blade angle increases. At the angle of 54º maximum static pressure of the fan was observed.[10]

3. DETAILS OF CENTRIFUGAL BLOWER

Centrifugal blower is specified according to IS: 4894-1987. The dimensions of radial impeller are same with respect to backward inclined impeller of centrifugal blower. In this paper the parameters of backward inclined impeller of centrifugal blower are given in Table I.

Table -1: Parameters of Backward inclined impellers of Centrifugal blower

Sr. No.	Parameters	
1	Impeller outlet diameter (mm)	280
2	Impeller inlet diameter (mm)	140
3	No. of blades	12
4	Impeller blade type	Backward inclined
5	Inlet duct diameter (mm)	130
6	Inlet duct length (mm)	552.5
7	Motor speed	2800 rpm
8	Impeller width (mm)	20
9	Casing width (mm)	65
10	Casing inlet diameter (mm)	130
11	Casing outlet BxL(mm)	65*186
12	Effective flow area (m^2)	0.01227

4. DETAILS OF RADIAL IMPELLER OF CENTRIFUGAL BLOWER

The backward inclined impeller and radial impeller used for comparative performance analysis of a centrifugal blower are shown in Fig.1. and Fig.2.

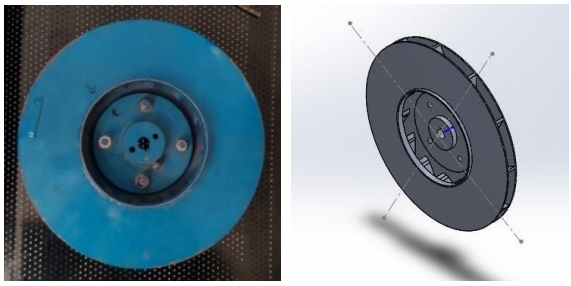

Fig -1: Backward inclined impeller of centrifugal blower

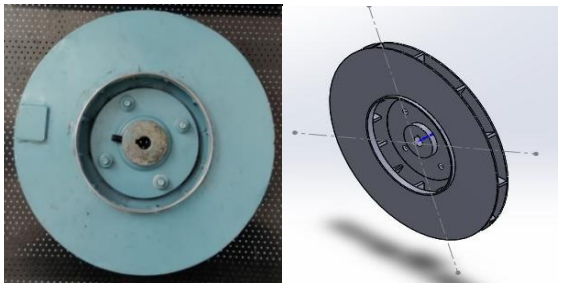

Fig -2: Radial impeller of centrifugal blower

The shape of the radial impeller is same as that of backward inclined impeller only blades will be straight in case of radial impeller of blower.

5. EXPERIMENTATION

Manufacturing of radial impeller with respect to backward inclined impeller was done. Experimentation was carried out on backward inclined as well as radial impeller of centrifugal blower. An experimental setup for comparative analysis of both the impellers of the centrifugal blower was according to IS:4894-1987

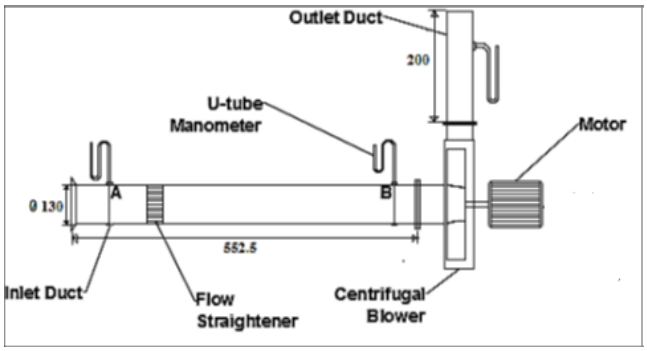

Fig -3: Experimental setup

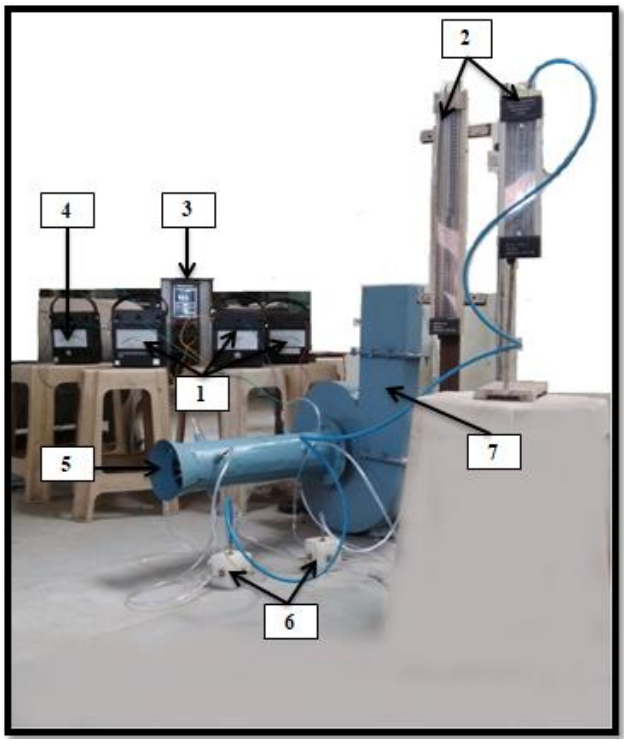

Fig -4: Photograph of the experimental setup

1: Ammeters, 2: U-tube manometers, 3: Dimmer-stat, 4: Voltmeter, 5: Inlet duct with straighteners of 24 mm diameter, 6: four way inlet one way outlet valves, 7: Centrifugal blower

A three-phase electric motor of 0.5 HP drives the centrifugal blower. The output of four-way inlet and one way outlet valve is connected to one limb of the manometer. The experimental setup is shown in Fig.3. U-tube manometer was connected at section A of the inlet duct through four side tappings to measure static pressure which is used to calculate flow rate as shown in Fig.3. At section B, measurement of average static pressures was done by using U-tube manometer. It was also connected at the outlet of the blower to calculate outlet total pressure. Dimmer-stat was used to vary voltage from zero to rated value of 415 V; hence rated rpm of motor is achieved. Current and voltage measurements were done by analogue ammeters and voltmeter respectively. Photograph of experimental setup of blower is shown in Fig.4.

6. RESULTS AND DISCUSSION

The results obtained from comparative analysis of backward inclined and radial impeller of centrifugal blowers are given in Table II, III, and IV. The performance parameters such as flow rate, total pressure, air power and blower efficiency of backward inclined impeller of centrifugal blower and radial impeller of centrifugal blower, were calculated at different speeds. It can be seen from the results that flow rate

is maximum in backward inclined impeller of centrifugal blower when it was compared with radial impeller at different speeds.

The flow rate occurred to be minimum in radial impeller of centrifugal blower at different speeds, total pressure is less in case of radial impeller of centrifugal blower as compared to backward inclined impeller of centrifugal blower at different speeds, efficiency is found to be more in case of backward inclined impeller of centrifugal blower at different speeds.

The highest efficiency achieved by backward inclined impeller to be 55.30 % at a speed of 2800 rpm. From results of backward inclined and radial impeller of centrifugal blower performance curve are plotted by considering the different speeds of centrifugal blower as a baseline. The Fig.5. to Fig.8. shows, the performance curves of backward inclined as well as radial impeller of centrifugal blowers for flow rate, total pressure, air power and blower efficiency at different speeds respectively.

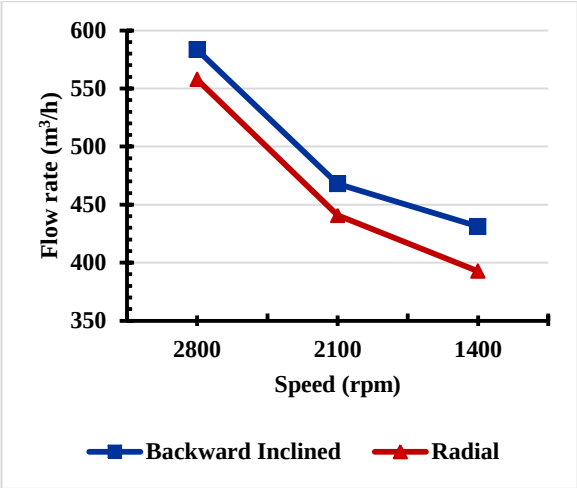

Fig -5: Flow rate of backward inclined and radial impeller blower at different speeds

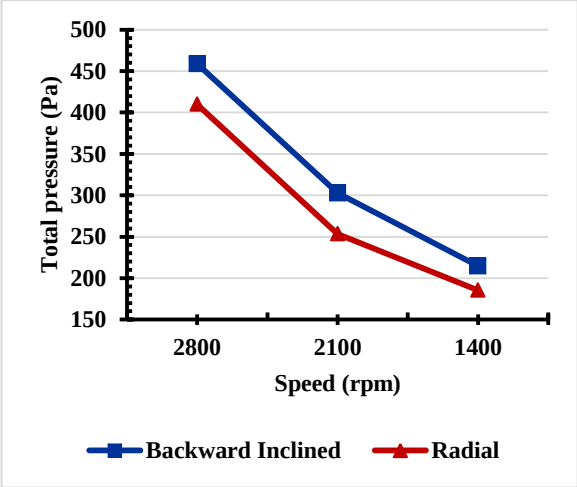

Fig -6: Total pressure of backward inclined and radial impeller blower at different speeds

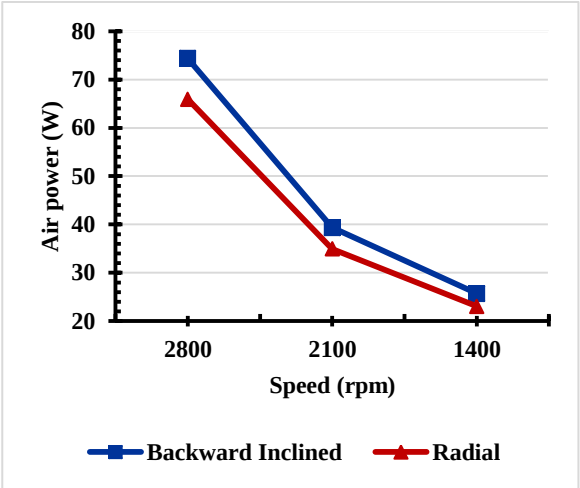

Fig -7: Air power of backward inclined and radial impeller blower at different speeds

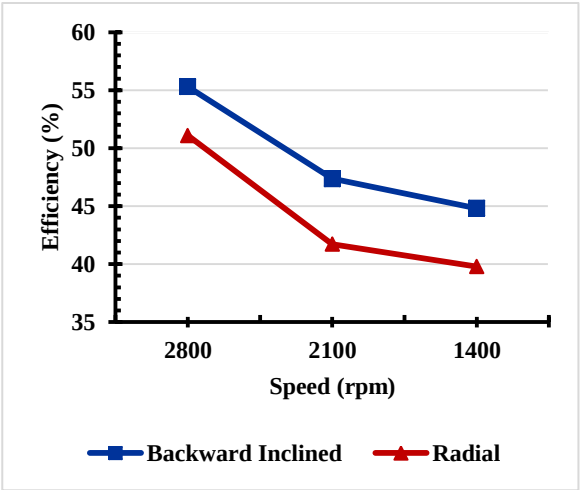

Fig -8: Efficiency of backward inclined and radial impeller blower at different speeds

Comparison in results of backward inclined impeller with radial impeller of centrifugal blower at different speeds of are given in Table II, III and Table IV respectively. The deviations occurred between results of backward inclined impeller and radial impeller are within 4.21 % in terms of efficiency at a speed of 2800 rpm, hence it is found that backward inclined impeller has high efficiency as compared to radial impeller at same speed and also at different speeds.

Table -2: Comparison in results of Backward inclined impeller and Radial impeller of Centrifugal blower at a speed of 2800 RPM

Performance parameters	Backward inclined impeller results	Radial impeller results	Deviation (%)
Flow rate (m^3/h)	583.4	557.79	4.60
Total pressure (Pa)	458.77	409.93	11.91
Air power (W)	74.35	65.91	12.80
Efficiency (%)	55.30	51.09	4.21

Table -3: Comparison in results of Backward inclined impeller and Radial impeller of Centrifugal blower at a speed of 2100 RPM

Performance parameters	Backward inclined impeller results	Radial impeller results	Deviation (%)
Flow rate (m^3/h)	467.95	440.72	6.17
Total pressure (Pa)	302.64	253.38	19.44
Air power (W)	39.34	34.96	12.52
Efficiency (%)	47.37	41.73	5.64

Table -4: Comparison in results of Backward inclined impeller and Radial impeller of Centrifugal blower at a speed of 1400 RPM

Performance parameters	Backward inclined impeller results	Radial impeller results	Deviation (%)
Flow rate (m^3/h)	431.10	392.73	9.77
Total pressure (Pa)	214.56	185.34	15.76
Air power (W)	25.69	23.05	11.45
Efficiency (%)	44.82	39.79	5.03

7. CONCLUSIONS

The comparative performance analysis of both the backward inclined impeller and radial impeller of centrifugal blower was performed for various performance parameters such as flow rate, total pressure, air power and efficiency, the following conclusions are drawn at different speeds.

The performance of centrifugal blower relies on the type of blades. From the performance curve it is clearly seen that the performance parameters such as flow rate, total pressure, air power and efficiency were more in backward inclined impeller as compared to radial impeller at different speeds. The backward inclined impeller is more efficient as compared to radial impeller at different speeds of the centrifugal blower.

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