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Abstract - The paper deals with experimental investigation and comparative analysis of velocity measurements in ducted axial fan. Experiments were carried out to investigate the nature of velocity variations in a ducted axial fan at different throttle positions as a function of rotor speed employing both Pitot tube and Hot Wire Anemometer. Quantitative analyses of the magnitudes of velocity measured by a pitot tube as well as a hot wire anemometer are examined and various graphs have been plotted. The percentage errors of velocity level have been determined.

Keywords - *Hot Wire Anemometer, Velocity Measurements, Pressure rise, Rotor speed, Comparative Analysis, Pitot tube.*

I. INTRODUCTION

Mining fans and cooling tower fans normally employ axial blades and or required to work under adverse environmental conditions. They have to operate in a narrow band of speed and throttle positions in order to give best performance in terms of pressure rise, high efficiency and also stable condition. Since the range in which the fan has to operate under stable condition is very narrow, clear knowledge has to be obtained about the whole range of operating conditions if the fan has to be operated using active adaptive control devices. The performance of axial fan can be graphically represented as shown in figure 1.

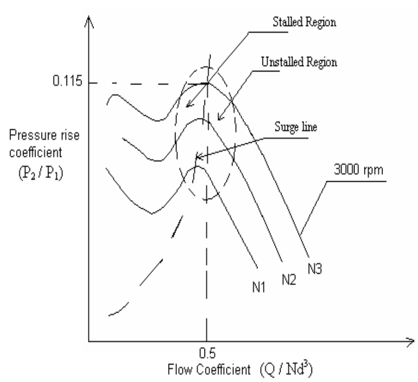

Fig: 1 Graphical representation of Axial Fan performance curve

II. TEST FACILITY AND INSTRUMENTATION

Experimental setup with the necessary instrumentation, fabrication as per the need, to examine the performance analysis in an industrial ducted axial fan is as shown in figures 2 to 6.

Fig: 2 Ducted Axial Fan Rig

Fig: 3 Side view of Ducted Axial Fan Rig

Fig: 4 Hot Wire Sensor Probe

Fig: 5 Velocity Measurement – Hot Wire Anemometer

Fig: 6 Velocity Measurements – Pitot Tube

A 2 HP Variable frequency 3-phase induction electrical drive is coupled to the electrical motor to derive variable speed ranges. Schematic representation of ducted fan setup is shown in fig. 7.

The flow enters the test duct through a bell mouth entry of cubic profile. The bell mouth performs two functions: it provides a smooth undisturbed flow into the duct and alsoserves the purpose of metering the flow rate. The bell mouth is made of fiber reinforced polyester with a smooth interna l finish. The motor is positioned inside a 381 mm diameter x457 mm length of fan casing. The aspect (L/D) ratio of the casing is 1.2. The hub with blades, set at the required angle is mounted on the extended shaft of the electric motor. The fan hub is made of two identical halves. The surface of the hub is made spherical so that the blade root portion with the same contour could be seated perfectly on this, thus avoiding any gap between these two mating parts. An outlet duct identical in every way with that at inlet is used at the down stream of the fan. A flow throttle is placed at the exit, having sufficient movement to present an exit area greater then that of the duct.

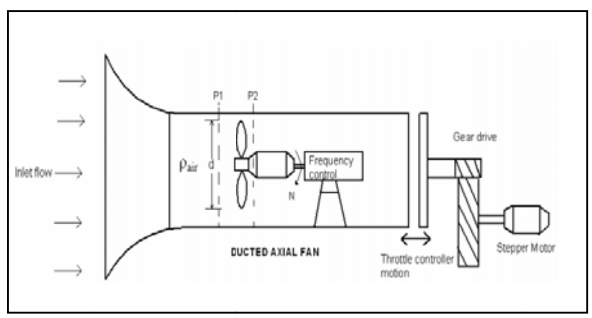

Fig: 7 Ducted Axial Fan – Schematic

III. COMPARATIVE ANALYSIS OF VELOCITY MEASUREMENTS

Experiments were carried out to examine the nature of velocity variations in a ducted axial fan at different throttle positions as a function of rotor speed employing both pitot tube and hot wire anemometer.

The variations in inlet velocity of air in ducted axial fan as a function of throttling positions for different rotor speeds is shown in fig.8. Its magnitude is found to be low in stall region, which is around 4 to 8 m/s when the throttle position is between 1 to 3 centimetre from the casing. However, when the throttle position is increased from stall region to unstalled region, the maximum velocity is found to be 16 m/s at a rotor speed of 3600 rpm.

Fig.8 shows the analysis of velocity measurement carried out with hot wire anemometer, when the rotor speed is varied between 2400 – 3600 rpm for different throttle positions. Hot wire probe measurements are found to be more reliable in their operation with respect to range, precision and accuracy.

The variations in inlet velocity of air in ducted axial fan as a function of throttling positions for different rotor speeds is shown in fig.9. Its magnitude is found to be low in stall region, which is around 4 to 10 m/s when the throttle position is between 0.001 to 0.004 meter from the casing. However, when the throttle position is increased from stall region to unstalled region, the maximum velocity is found to be 17m/s at a rotor speed of 3600 rpm.

Quantitative analyses of the magnitudes of velocity measured by a pitot tube as well as hot wire anemometer are graphically represented in figs.10 to 12. The magnitudes of pressures measured with a pressure hot wire sensor are found to be low in comparison with those measured with the help of a pitot tube, though their trends remain to be similar (Fig.12). An error magnitude in pressure measurement for different throttle positions when the rotor speed is varied from 2700 – 3600 rpm is shown in fig.13.

The error percentage appears to be on the lower side in case of measurements made with a pitot tube in comparison with those made on a hot wire anemometer, probably due to improper calibration of the former. Further, it has also been found that error level percentages are medium with the pressure measurements made with a pitot tube

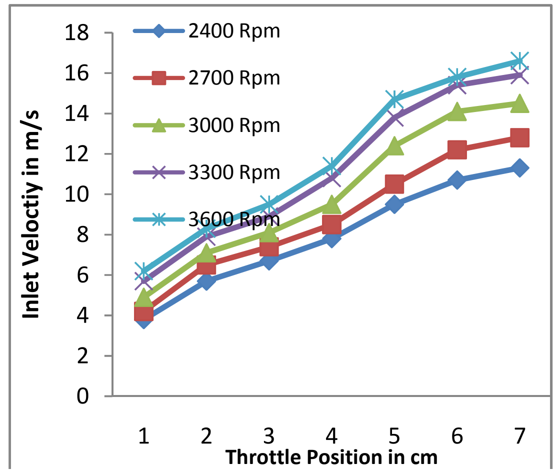

Fig: 8 Hot wire Anemometer Reading at different Rotor Speeds

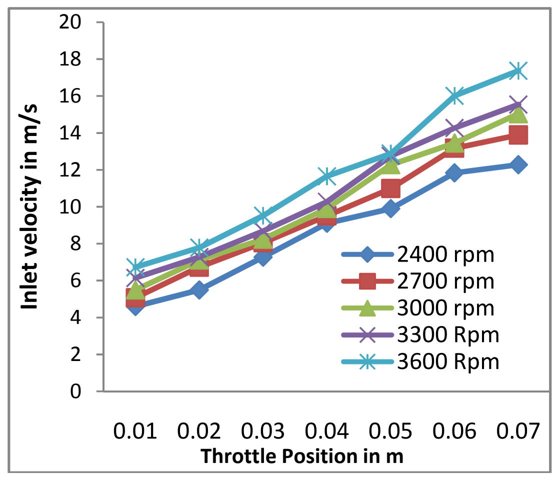

Fig: 9 Pitot tube reading at different Rotor Speeds

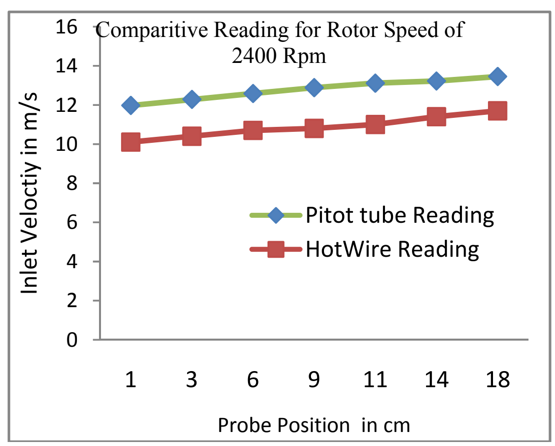

Fig: 10 Comparison Reading (Hot Wire Anemometer Vs Pitot tube)

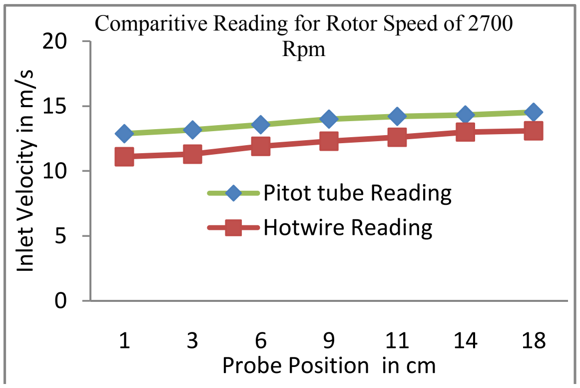

Fig: 11 Hot Wire Anemometer Vs Pitot tube Comparison Results

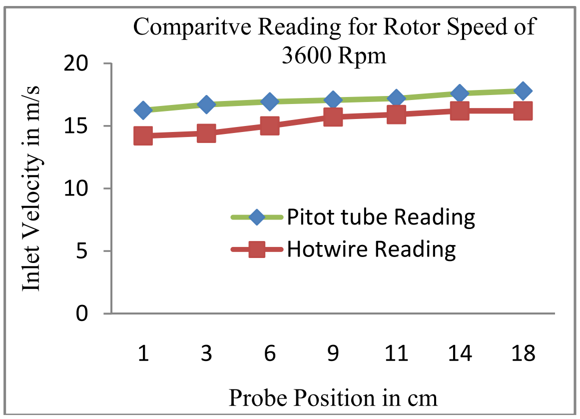

Fig: 12 Hotwire Anemometer Vs Pitot tube Reading Comparison

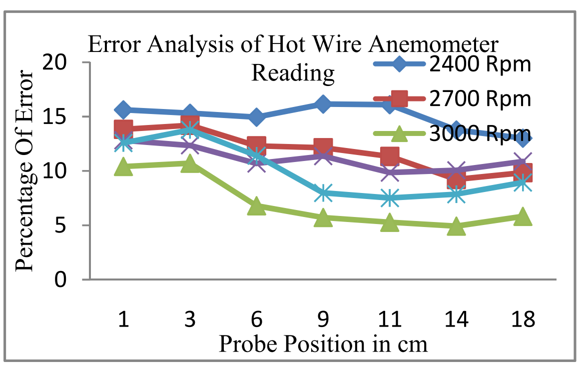

Fig: 13 Percentage of error with different Rotor Speeds

IV. CONCLUSIONS

In this paper, an attempt has been made to analyse the comparative study of velocity measurements in ducted axial fan. It is useful to precisely predict the operating regime of an axial fan in order to run the same in a stable condition. Further, this work can be extended by working on the flow modeling of dynamic stall and control in ducted axial fan. The results so far discussed, indicate that comparative analysis of velocity measurements in ducted axial fan is very promising.

V. ACKNOWLEDGMENT

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NOMENCLATURE

P_2 / P_1 = Pressure rise coefficient

V/U = Flow coefficient

N = Tip speed of the blades in rpm

Q = Flow discharge in m^3/s

$P_2 - P_1$ = Pressure rise in N/m^2

d = Diameter of the blade in m

ρ_{air} = Density of air in kg/m^3

η = Efficiency of fan

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