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SOUND SPECTRUM MEASUREMENTS IN DUCTED AXIAL FAN UNDER STABLE CONDITION AT FREQUENCY RANGE 6000 TO 6600 HZ

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Abstract: Performance of axial fan is found to reduce drastically when instability is encountered during its operation. Performance of an axial fan is severely impaired by many factors mostly related to system instabilities due to rotating stall and surge phenomenon experienced during its operation. The present work involves measuring the sound spectrum measurements in ducted axial fan under stable condition at frequency range from 6000 to 6600 Hz. Objective of the experiment is to measure the frequency domain signal and study the sound Characteristics in ducted axial fan by using spectrum analyser. Different types of FFT signals have been measured under stable condition for the frequency range of 6000 Hz to 6600 Hz with respect to rotor speed and different graphs are plotted for ducted axial fan.

Keywords: Microphone, BNC connector, Data Acquisition System, LABVIEW, Spectrum Measurements, Throttle position, Rotor speed.

1. 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.

2. TEST FACILITY AND INSTRUMENTATION

Experimental setup, fabricated to create stall conditions and to introduce unstall conditions in an industrial ducted axial fan is as shown in figure 2 to figure 5.

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 figure 6.

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 also serves the purpose of metering the flow rate.

The bell mouth is made of fiber reinforced polyester with a smooth internal finish. The motor is positioned inside a 381 mm diameter x 457 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 than that of the duct.

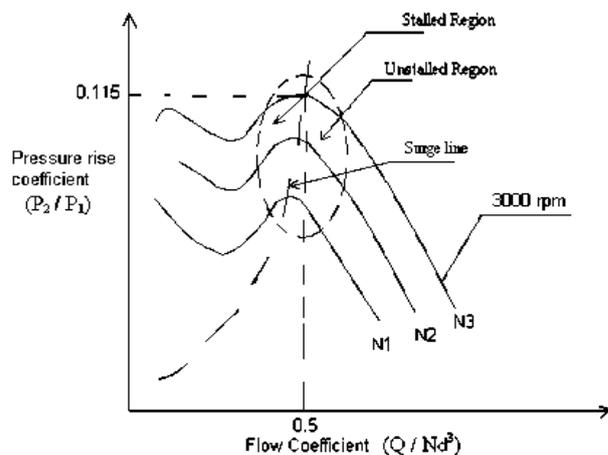


Fig: 1 Graphical representation of Axial Fan performance curve



Fig: 2 Ducted Axial Fan Rig



Fig: 3 Side View of Ducted Axial Fan Rig



Fig.4. Variable frequency Drive for speed control



Fig.5 Automatic Throttle controller

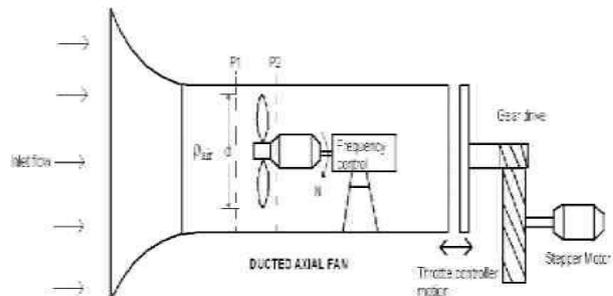


Fig: 6 Ducted Axial Fan – Schematic

3. BASIC SOUND SPECTRUM ANALYSER SYSTEM

Basic sound Spectrum analyzer schematic diagram consists of various components as shown in fig.7. microphone acquires the sound pressure fluctuation and converts them to an analog signal. BNC connector sends the signal to Data acquisition system. Data Acquisition system receive the signal from the BNC connector and sends to LABVIEW software. Once the amplitude of the signal has been measured, the computer system displays the measurement signal of spectrum through LABVIEW software.



Fig.7 Schematic diagram of Sound Spectrum Measurement

4. IV. SOUND SPECTRUM ANALYSER

Experimental setup of Spectrum analyzer consists of various components as shown in fig.8. Microphone acquires the sound signals, frequency range from 0 Hertz to 10000 Hz and measure the decibel range from 0 to 130 desibel. Microphone sensitivity is the ratio of of its electrical output to the sound pressure at the diaphragm of the microphone. Since a microphone output is usually measured in millivolts (mv) and sound pressure is measured in pascals. The unit of sensitivity of microphone is mv/Pa. microphone connects to BNC connector. BNC connector transmits the signal to DAQ system. DAQ card consists 2 channel input port to acquire the signal and send the signal to system achieve through LABVIEW software inbuilt with National Instruments noise and vibration acquisition system and 2 channel output port to receive the signal from the system and to make a active feedback control system in ducted axial fan.

5. SOUND SPECTRUM MEASUREMENTS

Experiments were carried out to examine the nature of sound pressure variations in a ducted axial fan under stable condition for the frequency range from 6000 hz to 6600 hz at particular throttle position and varying the rotor speed from 2400 rpm to 3600 rpm by using spectrum analyzer. In an axial fan setup, eight number of fan blades have been transferred the energy to fluid. In a single rotation, aerofoil section of blades transfers the energy through lift force of blade. Lift force of N across the fan blade area gives the pressure rise to the fluid. It makes a single rotation of blade; sound pressure amplitude value will rise in a ducted axial fan at eight times. For a same rotation, blockage factor between each blade decrease the sound pressure amplitude. For every arithmetic progression of blade pass through the fluid and transfer the energy to the fluid simultaneously, sound pressure will rise and down takes place. A variation in sound pressure amplitude of air at throttling positions of 6 cm when the rotor rotates at 2400 rpm is shown in fig.9. Maximum sound pressure amplitude is found to be 62 decibels and the Minimum sound pressure amplitude is found to be 44 decibels at stable conditions which is attributable to combinatorial effects of blockage in mass flow, rotating stall, periodic vibration due to air flow and excitation of fan blade. A variation in sound pressure amplitude of air at throttling positions of 6 cm when the rotor rotates at 2700 rpm is shown in fig.10. Maximum sound pressure amplitude is found to be 55 decibels and the Minimum sound pressure amplitude is found to be 40 decibels at stable conditions.

A variation in sound pressure amplitude of air at throttling positions of 6 cm when the rotor rotates at 3000 rpm is shown in fig.11. Maximum sound pressure amplitude is found to be 70 decibels and the Minimum sound pressure amplitude is found to be 57.5 decibels at stable conditions. A variation in sound pressure amplitude of air at throttling positions of 6 cm when the rotor rotates at 3300 rpm is shown in fig.12. Maximum sound pressure amplitude is found to be 67.5 decibels and the Minimum sound pressure amplitude is found to be 47.5 decibels at stable conditions.

A variation in sound pressure amplitude of air at throttling positions of 6 cm when the rotor rotates at 3600 rpm is shown in fig.13. Maximum sound pressure amplitude is found to be 75 decibels and the Minimum sound pressure amplitude is found to be 50 decibels at stable conditions.

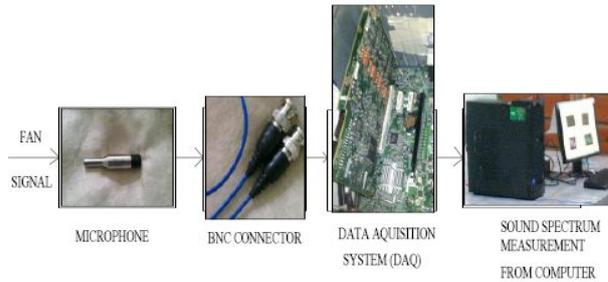


Fig.8 Experimental Rig for sound Spectrum Analyzer

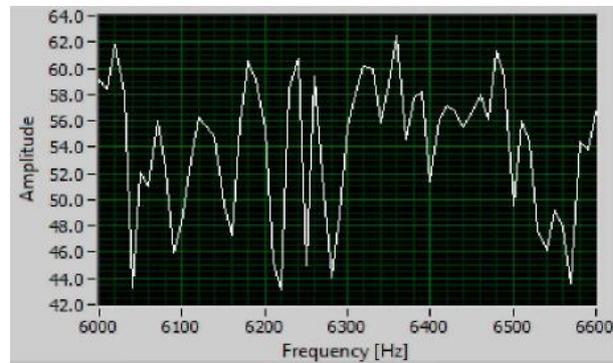


Fig.9 Rotor Speed 2400 Rpm , Throttle Position 6 cm

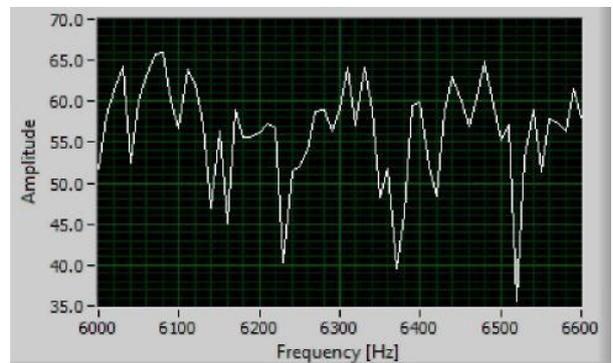


Fig.10 Rotor Speed 2700 Rpm, Throttle Position 6 cm

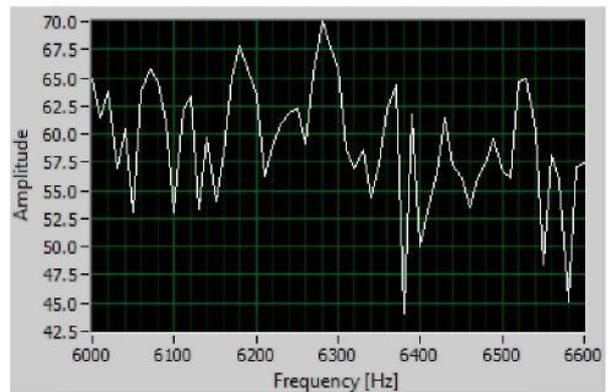


Fig.11 Rotor Speed 3000 Rpm, Throttle Position 6cm

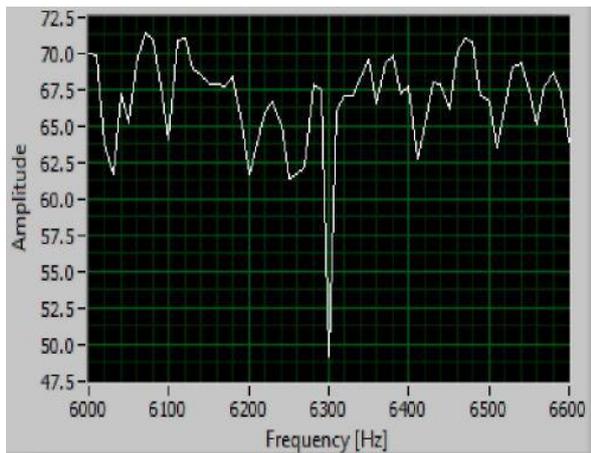


Fig.12 Rotor Speed 3300 Rpm, Throttle Position 6cm

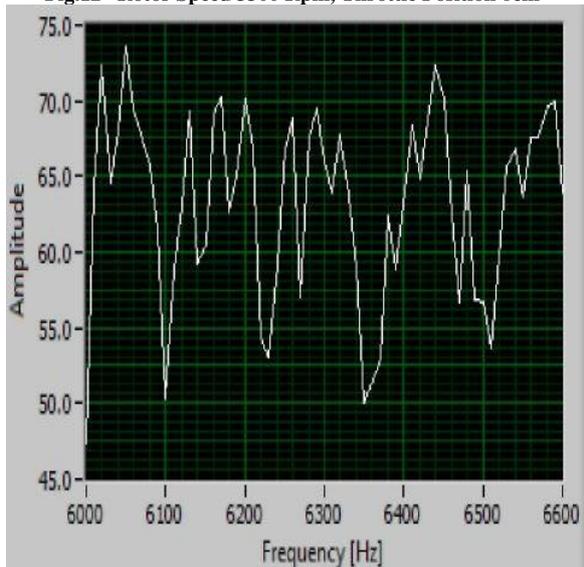


Fig.13 Rotor Speed 3600 Rpm, Throttle Position 6 cm

6. CONCLUSIONS

In this paper, an attempt has been made to measure the sound spectrum in frequency domain for the frequency range from 6000 hz to 6600 hz under stable condition with respect to rotor speeds in ducted axial fan by using spectrum analyzer. It is useful to examine the characteristics of stall in ducted axial fan. Further, this work can be extended by working on the mathematical model of sound spectrum study in ducted axial fan. The results so far discussed,



indicate that sound spectrum measurements in ducted axial fan is very promising.

7. ACKNOWLEDGMENT

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NOMENCLATURE

v_w = Whirl velocity in m/s N = Tip speed of the blades in rpm p = Pressure rise across the fan in N/m^2
 d = Diameter of the blade in m ρ_{air} = Density of air in kg/m^3
 L_p = Sound Pressure Level in db BPF = Blade passing frequency in Hz L_N = Normalized Sound Level in db

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