Noise Reduction of Centrifugal Blower Using Particle Damping

Anand K. Mali, Tushar A. Jadhav

***Abstract*— Sound basically is what we hear, but in practical way at loud levels it is the disturbance from equilibrium. The Centrifugal Blower generates a large amount of noise which causes a lot of disturbance and mental imbalance to the people working nearby. Hence the objective is reduction of noise near the working environment of the blower. It can be accomplished using acoustic materials, enclosures, silencers and mufflers. Particle damping is also one of the techniques which have a huge scope in reducing noise in components. The principle behind particle damping technique is removal of vibrations by absorbing the energy by the particles. In this work axial hole of an appropriate diameter is drilled to the main shaft and partially filled with metal particles. The vibration response of the blower with and without particle damping arrangement is measured to understand particle damping effectiveness.**

Index Terms – Centrifugal Blower, Decibel (dB), Particle damping, Sound Pressure Level (SPL).

I. INTRODUCTION

Particle damping technique is a derivative of impact damping. Impact damping means a single mass in a cavity where as particle damping means a large amount of small particles filled in a cavity which does the same work as impact damper. Particle damper is a device which is used to control the vibrations by inserting small particles in the cavity that is attached to the main component with large vibration amplitude. Due to its various advantageous characteristics particle damping technique has found its way in various applications such as vibration and noise damping. The technique has a very scarce literature in the field of acoustics. In this work the technique of particle dampers is applied to reduce noise of the blower in order to avoid disturbances in the working environment. The main aim of the paper is to study the application of passive damping technique to reduce noise of the machine.

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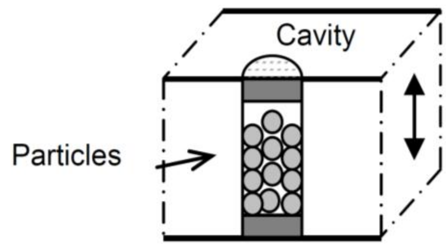

Fig 1. Schematic of particle damping

II. LITERATURE REVIEW

Particle damping technique has evolved with a lot of applications past many years. Xu, Wang and Chen explained the concept of particle damping for vibration and reduction of noise. The experimentation was carried out on a Desktop note processing machine [1]. Xu, Mao explained Passive control of centrifugal fan noise by using open-cell metal foam. Analytical and experimental work was done to find out the effect of the technique on the forward curved centrifugal fan [3]. Els explained damping of rotating beams using particle dampers. The main research objective of this study was to determine the performance parameters of particle dampers (PDs) under centrifugal loads. Xu, Wang and Chen explained particle damping for passive vibration suppression: numerical modeling with experimental verification. Physical models to take into account the shear frictional forces between particle layers and impacts of the particles with the containing holes. Zadjali, Ramesh kumar have studied the condition monitoring of centrifugal blower using vibration analysis. Vibration analysis is used to analyze the operating condition of Centrifugal Blower under various misalignment conditions [5]. Fowler, Flint and Olson have described the design methodology for particle damping. The study focused on the area of multiple- particle damping which results in new methods of characterization and prediction [7].

Ramji explained Aerodynamic and Aeroacoustic Analysis of Centrifugal Blower for Noise Reduction. The paper gives an idea about estimation of the aerodynamic and aeroacoustic parameters like pressure, velocity and noise of centrifugal blower for three different types of impellers namely forward, backward and radial by both experimental and numerical analysis [9].

III. THE CENTRIFUGAL BLOWER

From manufacturer's point of view, there is no basic distinction between fans and blowers [2]. However, in industry the term blower is usually used for high pressure devices most often used for conveying materials and products.

The particular blower used in the experimentation uses a 1 hp motor with maximum rotation speed of 3000 rpm. At full speed the blower produces an excessive noise of 93 dB measured at a distance of 1 m. the main aim is to reduce noise with cost efficient method.

IV. PARTICLE DAMPING TREATMENTS

From the various available dampers, particle damper have a huge potential to suppress large level of vibrations. The passive devices works with a very simple concept where particle are filled in the machines or are attached to the machines with the help of an auxiliary device. The treatment focuses on dissipation of the kinetic energy. The method basically is absorption and dissipation of energy via exchange of momentum between particles and vibratory walls [6]. It is effective in a high temperature zone [8]. In this work the damping treatment is carried out on the shaft of the blower. The method uses drilling of multiple holes axially in the shaft. The size of the particle is very less that the diameter of the hole. The holes are filled with steel particles. The diameter of particles is 1 mm.

Figure 2 and 3 shows the shaft of the blower without and with particle damping treatment applied on the centrifugal blower.

Fig 2. Shaft of the blower before drilling of holes.

Fig 3. Shaft of the blower after drilling of holes.

V. EXPERIMENTAL ANALYSIS

The implementation of particle damping treatment and the measurement of noise follows the basic crux of the experimental analysis. The noise measurement was carried out using a FFT analyzer. The readings were taken using survey method of noise measurement [10, 4]. The method is applied in those cases where one or several conditions (such as operating conditions, number or positioning of microphones) for an otherwise engineering type of measurement cannot be obtained.

The noise measurement was carried at different speeds and flow rates considering the packing factor by which the holes are filled with particles (i.e. 25% and 50%). The different speeds and corresponding flow rates used are as follows.

TABLE 1
DIFFERENT SPEED AND CORRESPONDING FLOWRATES

Speed (RPM)	Flowrate (m^3/s)
3000	0.148
2900	0.145
2800	0.142
2700	0.138
2600	0.135

VI. RESULTS AND DISCUSSIONS

In order to assess the effect of particle damper treatment noise measurement was carried out at different speeds and different flow rates of the blower. The results showed a substantial decrease in noise by decreasing the speed and by changing the packing factor by which the particles are to be filled inside the blower. The averaged results using survey method is as follows.

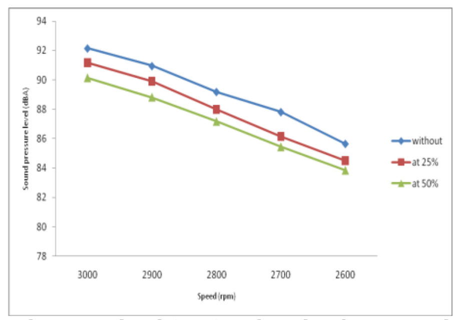

Fig 4. Sound pressure level (SPL) with and without particle damping treatments at different speeds.

From figure 4 it is interpreted that when the shaft holes are filled with 25% of particles the maximum noise reduction is by 3 dB and when the shaft holes are filled with 50% of particles there is a gradual decrease in noise by 2 dB.
From the graph of Sound pressure level vs. frequency at 3000 rpm speed, detailed sound analysis is observed.

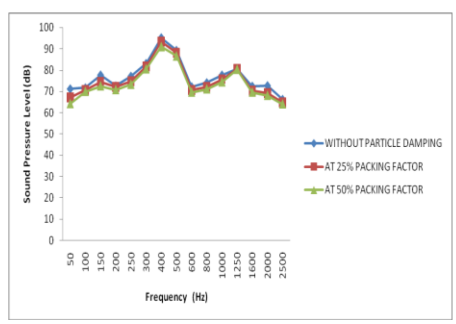

Fig 5. Sound pressure level (SPL) with and without particle damping treatments at 3000 rpm

From figure 5, the sound pressure level at various spectral values is depicted. The particle material is efficient in providing a highly striking damping effect in the frequency range of 50 – 2500 Hz.

Figure 6, 7, 8 and 9 shows the sound pressure values at different spectral value at different speeds i.e., 2900, 2800, 2700, 2600 rpm respectively. The observations show a substantial decrease in noise at different packing factor.

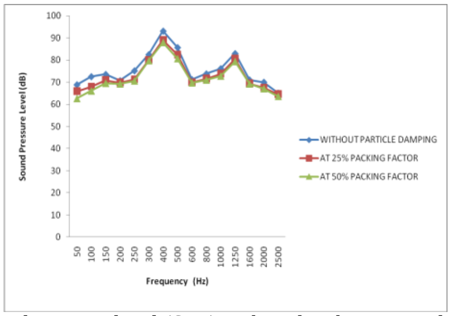

Fig 6. Sound pressure level (SPL) with and without particle damping treatments at 2900 rpm

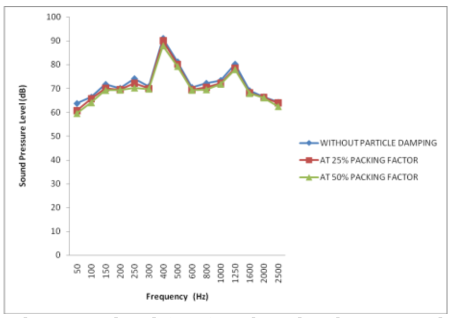

Fig 7. Sound pressure level (SPL) with and without particle damping treatments at 2800 rpm

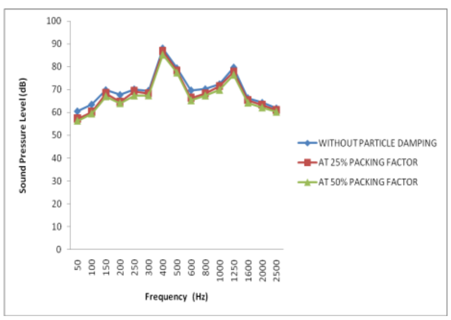

Fig 8. Sound pressure level (SPL) with and without particle damping treatments at 2700 rpm

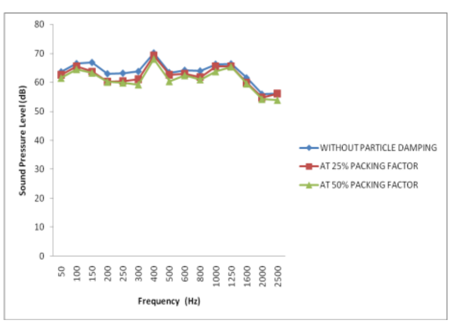

Fig 9. Sound pressure level (SPL) with and without particle damping treatments at 2600 rpm

VII. CONCLUSION

In order to study effect of particle damper on the noise of a centrifugal blower, full factorial experimental analysis has been performed. Readings were taken at different speeds and flow rates to analyze the effects of these parameters on noise of the blower. Considering the experimental analysis it is seen that there is a substantial reduction of noise for different speeds and flow rate. The noise is reduced by maximum 3 dB when 25% of shaft holes are filled with particles. The noise is reduced by maximum 2 dB when 50% of shaft holes are filled with particles. Considering the research done in particle damping, it can be said that a lot of applications can be carried forward with this technique.

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