CERTAIN INVESTIGATIONS ON

MEASUREMENT OF SOUND ABSORPTION

COEFFICIENT USING A LOW COST

IMPEDANCE TUBE OPTIMIZED WITH

DIGITAL TECHNIQUES

ABSTRACT

The automobile industry is growing rapidly, with its players introducing new features like performance, aesthetics, comfort and safety every other day. Mobiltech that includes technical textiles for automobile applications is applied intelligently as about 48 square meters of it is used in an average vehicle. To combat the irritation caused due to engine noise and noise from outside, a part of technical textiles is used to absorb them. As these materials are cheaper and have low specific gravity, they are preferred over other methods, for this application. Again, the choice of materials used for sound absorption is based on their sound absorbing property. To measure this property, impedance tube apparatus is widely employed.

Research on impedance tubes have been widely carried out for the past many years. Commercially available impedance tube setup is priced on the higher side and hence not affordable by many researchers/customers who are in need of studying the absorption behaviour of the textile material. A consequence of this study is the proposed low cost impedance tube as given in this thesis. An already developed impedance tube is modified using various latest techniques to improve the efficiency of the tube at lower cost. The impedance tube originally designed to measure sound absorption coefficient using standing wave ratio method is modified to measure the parameter using transfer function method.

The impedance tube experimental setup consists of a sound source. The sound source is realized using a function generator connected to a loudspeaker. This enables the generation of sound at varying frequencies. A sinusoidal signal is generated using the function generator and is amplified using a power amplifier circuit. This amplified signal is fed to the loudspeaker present at one end of the impedance tube. The textile sample to be tested is prepared based on the dimension of the tube and mounted on the end opposite to the loudspeaker. Two microphones are used to capture the sound waves reflected from the sample The captured signal is amplified and stabilized using an amplifier circuit and sent to the recording device. The recording device used in this work is a personal computer system and an oscilloscope. A spectrum analyzer is also used to analyse the frequency response of the signal.

With detailed literature study, five textile samples have been chosen to test the performance of the impedance tube. The calculated data from the tube is validated by comparing it with a standard B&K tube available in the market. Deviations are found in the developed tube in terms of the sound absorption coefficient value. On detailed study, the error is found to be random error and to overcome this, certain modifications are proposed in this thesis.

Reduction of errors is first approached by treating the signals acquired from the microphone. As these signals are prone to noise, digital filters are designed and the signals are treated. Use of digital filters avoids the need for expensive hardware modifications. Three types of digital filters namely, low pass, band pass and Least Mean Square filters are investigated. The digital filters are realized using MATLAB environment. The sound waves captured using microphone is processed using the digital filters to remove any noise available in the signal. The efficiency of the system is found to increase with reduction in noise. Furthermore LMS filters are found to reduce noise to the maximum extent, with minimum error value.

To optimize the system further, error reduction algorithms are designed based on artificial intelligence techniques. Two algorithms namely, artificial neural networks and

particle swarm optimization are used to reduce errors in the measured sound absorption coefficient. In the research problem undertaken, three types of neural networks namely feed-forward back propagation network (FF BPN), radial basis function network (RBF) and probabilistic neural network (PNN) are considered. Neural networks require sufficient training dataset and hence the input data set is expanded by making large number of measurements at intermediate frequencies other than the measured frequencies. A comparison of the three techniques reveals that PNN performs better and reduces the error significantly. It is also observed that PNN generates sound absorption coefficient values nearest to the ones obtained from standard tube for all the tested samples.

To better the performance of the impedance tube, a particle swarm optimization based error reduction algorithm is developed. The implementation of the algorithm improves the efficiency of the system by reducing the error in the impedance tube. With the implementation of software based digital techniques, the sound absorption coefficient values obtained is found to be in the same trend line compared with the commercially available tube. This feature of the proposed research can be used to analyze the textile samples at intermediate stages of research and development. Overall, a significant improvement has been made in the field of low cost instrumentation and measurement, contributing to industrial needs.