Measurement and Analysis of Acoustic Absorbing Coefficient of High-porosity Nickel Foam with Different Thickness

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Abstract. The noise problems have gradually become a major problem that affect the health of personnel and hinders industrial progress. Metal foam is one kind of the porous media, which could be applied as effective acoustic absorbing materials. In this study, an uncompressed pure material nickel foam with the various thickness of 20, 40, 60, 80, 100mm was used for acoustic experiments under the condition of the test signal wave frequency range of 100-2000Hz. The corresponding acoustic absorbing coefficient was measured by AWA6128A standing wave tube tester, and the corresponding analysis was carried out. It proves that nickel foam has high acoustic absorbing coefficient at high frequencies, and the parameters of nickel foam can be changed to meet the requirement of different acoustic absorbing properties.

1. Introduction

Nowadays, with the continuous development and progress of the industrial level, noise problems have gradually become a major problem that affects the health of personnel and hinders industrial progress. Therefore, the research on acoustic absorbing and noise reduction is very important. In order to solve this problem, the use of acoustic absorbing and noise reduction materials is one of the main methods. The available commercial acoustic absorbing materials could be generally divided into two categories: resonant acoustic absorbing materials and porous acoustic absorbing materials [1, 2]. Metal foam is one kind of porous media, which could be applied as effective acoustic absorbing materials. It has both metallic and porous structured properties, and can exhibit a high strength as well as thermal resistance compared with these polymer foams [3]. There are many merits for the nickel foams: the uniformed structure, controllable pore size, mature production technology, good work ability, and economy [4]. Metal foam has four main acoustic absorbing mechanisms: the viscous dissipation inside the foam metal, resonance dissipation between the foam metal and its composite materials, impedance matching in the composites, and elastic dissipation [5]. The use of nickel foam is of great market value, which is used in the noise reduction applications. Therefore, this research uses high-porosity nickel foam as experimental material for acoustic experiments. The experiment is divided into five groups, namely nickel foam cylindrical uncompressed pure materials with thicknesses of 20, 40, 60, 80, and 100mm. Acoustic absorbing experiment with the test signal frequency of 100-2000Hz on these five groups of materials are conducted, and the corresponding acoustic absorbing coefficient is analyzed.

2. Experimental Instruments and Experimental Materials

In this investigation, the AWA6128A standing wave tube acoustic absorbing coefficient tester is used, as shown in the Figure 1. The tester is controlled by the computer and it can calculate the calculation results. After starting, the microphone sensitivity calibration is performed as needed. Meanwhile, the
required measurement items can be selected after the calibration. According to the setting status, the instrument outputs the corresponding signal to the test sound source. The microphone receives the corresponding acoustic signal. After the amplification, A/D conversion, and the data processing by the computer, the calculated data or curve is displayed finally, and it can be printed as needed [6].

Figure 1. Schematic diagram of the standing wave tube test of the acoustic absorbing coefficient.

The material used in the experiment is high-porosity material nickel foam, which has a porosity of 95 and a pore-density of 40ppi. The basic unit of the experimental material is a cylindrical nickel foam with diameter of 96mm and a thickness of 20mm. The experiment is divided into five groups, each of which is 1 layer, 2 layers, 3 layers, 4 layers, and 5 layers, as shown in Figure 2.

Figure 2. Five groups of the nickel foam materials with the various thickness.

3. Results and Discussions

The five groups of experimental materials shown in Figure 2 were placed in the AWA6128A standing wave tube acoustic absorbing coefficient tester for the experiment. The acoustic absorbing coefficients of each group corresponding to the 100-2000 Hz were measured, and the wave frequency increased at an interval of 50 Hz each time. The corresponding acoustic absorbing coefficients are shown in the Figures 3-7, which correspond to the first to fifth groups respectively.
Figure 3. Acoustic absorbing coefficient of the nickel foam with the thickness of 20mm.

Figure 4. Acoustic absorbing coefficient of the nickel foam with the thickness of 40mm.

Figure 5. Acoustic absorbing coefficient of the nickel foam with the thickness of 60mm.
Figure 6. Acoustic absorbing coefficient of the nickel foam with the thickness of 80mm.

Figure 7. Acoustic absorbing coefficient of the nickel foam with the thickness of 100mm.

From the experimental data, it can be found that for the nickel foam with a thickness of 20mm, the average acoustic absorbing coefficient corresponding to frequency range of 100-500Hz is 8.6%, the average acoustic absorbing coefficient corresponding to 500-1000Hz is 9.8%, the average acoustic absorbing coefficient corresponding to 1000-1500Hz is 13.6%, and the average acoustic absorbing coefficient corresponding to 1500-2000Hz is 17.1%; for the foam nickel with the thickness of 40mm, the average acoustic absorbing coefficient corresponding to 100-500Hz is 12.2%, and the average acoustic absorbing coefficient corresponding to the 500-1000Hz is 18.5%, 1000-1500Hz corresponds to average acoustic absorbing coefficient of 29.6%, 1500-2000Hz corresponds to an average acoustic absorbing coefficient of 39.8%; for the foam nickel with a thickness of 60mm, 100-500Hz corresponds to an average acoustic absorbing coefficient of 15.9%, the average acoustic absorbing coefficient corresponding to the 500-1000Hz is 32.1%, the average acoustic absorbing coefficient corresponding to 1000-1500Hz is 49.1%, and the average acoustic absorbing coefficient corresponding to 1500-2000Hz is 55.2%; for nickel foam with a thickness of 80 mm, the 100-500 Hz corresponds to average acoustic absorbing coefficient of 22.3%, the average acoustic absorbing coefficient corresponding to 500-1000Hz is 46.9%, average acoustic absorbing coefficient corresponding to the frequency range of 1000-1500Hz is 59.6%, and average acoustic absorbing coefficient corresponding to 1500-2000Hz is 58.3%; for thickness 100mm nickel foam, average acoustic absorbing coefficient corresponding to the 100-500Hz is 28.9%, the average acoustic absorbing coefficient corresponding to the 500-1000Hz is 58.7%, the average acoustic absorbing coefficient corresponding to the 1000-1500Hz is 62.6%, and the average acoustic absorbing coefficient corresponding to the 1500-2000Hz is 64.8%.
4. Conclusions
Through the above analysis, it is not difficult to see that the acoustic absorbing effect of high-porosity nickel foam at the high frequency range is still relatively good. As the thickness increases, the acoustic absorbing coefficient increases significantly at the beginning, and after increasing to a certain value, the increase is significantly reduced. It tends to fluctuate, and as the frequency continues to increase, there is a continuing upward trend.

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References
[1] Yang X C, Bai P F, Shen X M, To S, Chen L, Zhang X N, Yin Q 2019 Optimal design and experimental validation of sound absorbing multilayer microperforated panel with constraint conditions Applied Acoustics 146 334-344.
[2] Shen X M, Bai P F, Chen L, To S, Yang F, Zhang X N, Yin Q 2020 Development of thin sound absorber by parameter optimization of multilayer compressed porous metal with rear cavity Applied Acoustics 159 107071.
[3] Bai P F, Yang X C, Shen X M, Zhang X N, Li Z Z, Yin Q, Jiang G L, Yang F 2019 Sound absorption performance of the acoustic absorber fabricated by compression and microperforation of the porous metal Materials & Design 167 107637.
[4] Yang X C, Chen L, Shen X M, Bai P F, To S, Zhang X N, Li Z Z 2019 Optimization of geometric parameters of the standardized multilayer microperforated panel with finite dimension Noise Control Engineering Journal 67(3) 197-209.
[5] Duan H Q, Shen X M, Yin Q, Yang F, Bai P F, Zhang X N, Pan M 2020 Modeling and optimization of sound absorption coefficient of microperforated compressed porous metal panel absorber Applied Acoustics 166 107322.
[6] Yang X C, Peng K, Shen X M, Zhang X N, Bai P F, Xu P J 2017 Geometrical and dimensional optimization of sound absorbing porous copper with cavity Materials & Design 131 297-306.