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Vibration and Noise Reduction Optimization Design of Mine Chute with Foam Aluminum Laminated Structure

K. Yang*[a], J. Zou[a], J. Shen[b]

[a] *College of Mechanical Engineer and Automation, Liaoning University of Technology, Jinzhou, China*
[b] *College of Mechanical Engineering, Liaoning Technical University, Fuxin, China*

P A P E R I N F O

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A B S T R A C T

The mining chute is an important equipment in the process of coal transportation and coal screening preparation. During the working process, the mining chute generates a lot of vibration and noise because of constant friction and impact of gangue and coal blocks. In order to reduce the vibration and noise during the operation of the chute, a new type of foam aluminum laminated structure is used to manufacture the mining chute. According to the characteristic of chute, the laminated structure is optimized by taking the vibration amplitude as the objective function and the thickness of the steel plate and the foam aluminum core plate as the design variables. Then, the vibration and noise reduction performance of two types of chute are evaluated through experiments and finite element simulation method. Results show that use of foam aluminum laminate structure to manufacture the chute can obviously increase the damping ratio of the system, which can effectively reduce the vibration amplitude of the chute. The average sound insulation performance of foam aluminum laminated chute is better than prototype chute, especially in the middle and high frequency section, which can be reduced by about 7.1 dB on average in comparison with prototype chute. So, the foam aluminum laminated structure chute has a more significant sound insulation and vibration reduction effects than the prototype chute.

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NOMENCLATURE

A	Steady-state amplitude of vibration (m)
A_0	Equivalent static displacement (m)
F	Amplitude of exciting force (N)
k	System equivalent stiffness
w_c	Deflection of simply supported beam
$z(x)$	Cross section width
x	Height in x-axis direction
y	Width in y-axis direction
I_{zf}	Inertia moment of steel plate
I_{zp}	Inertia moment of foam aluminum plate
s	Thickness of foam aluminum plate (m)
t	Thickness of steel plate (m)
$(EI)_{\mathrm{eq}}$	Equivalent bending stiffness
E_f	Elastic module of Q235 (MPa)
E_p	Elastic module of foam aluminum (MPa)
m	Quality of foam aluminum chute panel (kg)
V_f	Volume of the Q235 steel plate (m^3)
V_0	Chute volume (m^3)
V_1	Volume in the height direction of the chute (m^3)
M	Bending moment of chute panel
t_0	Thickness of the prototype chute plate (m)
g	Gravity (m/s^2)

Greek Symbols

β	Vibration amplification factor
λ	Frequency ratio
ξ	Damping ratio
ϕ	Inclination angle of the chute panel
ρ_m	Density of coal
ρ_f	Density of the Q235 steel
ρ_p	Density of the foam aluminum
σ_f	Maximum stress of the prototype chute
σ_{ps}	Yield stress of foam aluminum
σ_{eq}	Maximum stress of the foam aluminum chute
σ_p	Maximum stress of the foam aluminum plate

*Corresponding Author Institutional Email: *yangkunwh@163.com* (K. Yang)

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V_p	Volume of the foam aluminum plate (m^3)
Q	Gravity of coal
F_t	Total pressure received by each chute panel

Subscripts

f,p	Inner and outer plate “f”, foam aluminum plate”p”

1. INTRODUCTION

The mining chute is an important equipment in the process of coal transportation and coal preparation plant screening and grading. It plays the role of reloading, distributing, concentrating, aliquoting and adjusting the process flow, so that the materials conveyed continuously run along the line specified in the process flow to achieve the purpose of continuous production [1-3]. The mining chute is constantly subjected to the friction and impact of vermiculite and lump coal in the work process, which will generate a lot of vibration and noise. The noise level can reach more than 100 dB, and the highest can reach 115 dB or more, which seriously endangers the health of workers. It also causes noise pollution to the surrounding environment [4].

The vibration and noise reduction of mine chutes has always been a problem in China. The structure of the traditional chute is generally manufactured by the method of welding the inner liner of the steel plate, and the inner lining plate is mainly made of cast iron, carbon steel and polymer materials. For ordinary cast iron liner, its wear resistance is poor and impact toughness is low; cast stone and polymer liner have good wear resistance but low toughness; carbon steel and stainless steel liner have high toughness but low wear resistance; rubber liner have good toughness and strong shock absorption performance, but easy to fall off and block, and the service life is low [5]. Therefore, there is an urgent need for a new material preparation chute to achieve the purpose of vibration and noise reduction, thereby improving the service life of the chute and reducing the noise during operation.

Foam aluminum is a new type of structural and functional porous material that has developed rapidly in recent years. It has light weight, high specific stiffness and high specific strength, high damping and sound absorption, sound insulation, heat insulation, flame retardant, vibration damping, absorbing impact energy, electromagnetic shielding and other physical properties [6-8]. The laminated board with foam aluminum as the core can not only have many excellent properties of the foamed aluminum material, but also can solve the disadvantage of low strength of the single foam aluminum plate. At present, foam aluminum laminate materials have been applied in many fields of automobile manufacturing, mechanical engineering, civil engineering, aviation and aerospace engineering [9-10]. In this study, a new type of mining chute with foam aluminum laminated structure is established. As we know, the main part of chute operation noise is the impact noise caused by the collision of the coal block and the metal plate in the chute. Reducing the vibration of structure is an effective way to reduce the noise. So, the laminated structure is designed by taking vibration amplitude as optimization objective, and the thickness of steel plate and foam aluminum core plate as design variables. And then, the vibration and noise insulation performance of two types of chute are studied by the method of experiment and finite element simulation. The research flowchart is shown in Figure 1.

2. FREE VIBRATION PRINCIPLE AND OPTIMIZATION DESIGN OF FOAM ALUMINUM CHUTE

2. 1. Prototype and Foam Aluminum Laminated Chute

In this study, a certain type of chute commonly used in coal mine was taken as an example; the shape and size are shown in Figure 2(a). This prototype chute is mainly used at the bottom of the vibration screen, and it is an additional transfer device for the purpose of centralizing the screened coal blocks. The size of the inlet and outlet parts depends on the requirements of the connected equipment. The width of the screen mesh is 600×600 mm, the drop from the bottom of the screen to the conveyor is 618 mm, and the conveyor width is 460 mm. Therefore, the cross section shape of the chute is square, the longitudinal section is a pyramid structure with the start side length of 600 mm, the end side length of 420 mm and the height of 468 mm. The thickness of steel plate on each side is 10 mm. The material of the prototype chute is Q235 steel plate, and its performance parameters are shown in Table 1.

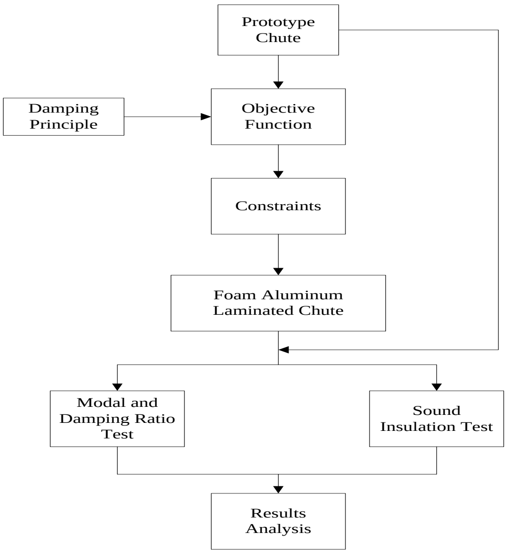
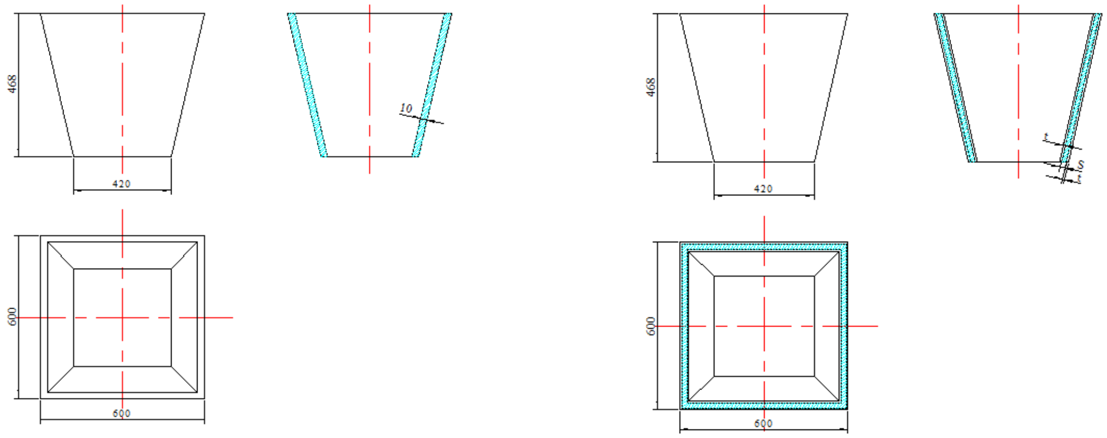


Figure 1. General framework of the study

TABLE 1. Material parameters

Material	Density/ (kg/m^3)	Elastic modulus/ GPa	Poisson's ratio	Yield strength/ MPa
Q235	7860	200	0.288	235
Foam aluminum	500	12	0.34	8.1

According to the prototype chute structure, the overall dimensions of the foam aluminum laminated chute are kept unchanged, but the original 10 mm thick steel plate is replaced by the thickness of the inner and outer steel plates *t* and the thickness of foam aluminum lamination plate *s*. The structural board is shown in Figure 2(b).



(a) Prototype chute

(b) Foam aluminum chute

Figure 2. Chute structure size

2. 2. Principle of Free Vibration During the operation of foam aluminum chute, the chute panel is forced to vibrate by the continuous impact of materials. The steady-state amplitude of forced vibration which is the product of equivalent static displacement A_0 and the vibration amplification factor β [11-13], can be expressed as follows:

$$A=A_0*\beta=\frac{F}{k\sqrt{(1-\lambda^2)^2+(2\xi\lambda)^2}} \tag{1}$$

where $A_0 = F/k$ is the equivalent static displacement, F is the amplitude of the exciting force, 387 N, k is the system equivalent stiffness, $\lambda = \omega/\omega_n$ is the frequency ratio, ω is the minimum excitation frequency, 500 Hz, $\omega_n = \sqrt{k/m}$ is the natural frequency of the system, m is the system quality, $\xi = c/c_0$ is the damping ratio and $c_0 = 2\sqrt{km}$ is the critical damping. The relationship of the amplification factor β, the frequency ratio λ and the damping ratio ξ are shown in Figure 3.

According to Equation (1), if the exciting force F is fixed, the amplitude of the system is affected by the spring coefficient k, the frequency ratio λ, and the damping ratio ξ. According to Figure 2, in order to reduce the amplitude of the system, the natural frequency of the system should be much smaller than the excitation frequency or increase the damping ratio ξ of the system.

According to the literature [14], the damping ratio of the open-cell foam aluminum laminate structure is 0.03 to 0.06. So, the damping ratio of laminated plate can be set as 0.04 initially.

The way to reduce the natural frequency of the system is to increase the mass of the system m or reduce the system equivalent stiffness k. But reducing the stiffness of the system also increases the equivalent static displacement of the system, which may cause the amplitude of the system to increase, so the design parameters require system considerations.

2. 3. Optimization Design of Foam Aluminum Chute The optimization purpose is to minimize the vibration amplitude of the foam aluminum chute, through

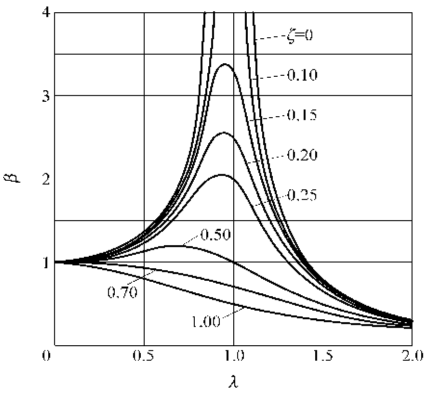


Figure 3. Magnification factor curve

determining the thickness of foam aluminum plate *s* and the thickness of steel plate *t*. So, the objective function is min *A(s, t)*.
In order to calculate the inertia moment of the chute panel, the coordinate system as shown in Figure 4 is established.

According to Figure 4, the cross-section width $z(x)$ of the panel is linearly changed along the height in x-axis direction, and it is satisfied as:

$$z(x) = 5x/13 + 0.42 \tag{2}$$

The inertia moment of a section of any foamed aluminum laminated structural panel can be divided into three parts, the inertia moment of the inner and outer steel plates I_{zf}, and the inertia moment of the aluminum foam plate I_{zp}. And the inner and outer steel plates have the same moment of inertia. Because of continuous variation of the foam aluminum layer and the cross-section of the panel, the total moment of inertia on the x-axis can be expressed as follows:

$$I_{zf} = \int_{-t/2}^{t/2} (y + \frac{t}{2} + \frac{s}{2})^2 (\frac{5}{13}x + 0.42) dy \tag{3}$$

$$I_{zp} = \int_{-s/2}^{s/2} y^2 (\frac{5}{13}x + 0.42) dy \tag{4}$$

Equations (3) and (4) are the total moments of inertia on the x-axis. The average moment of inertia is also divided by the height of the panel in the x-axis direction. Therefore, the equivalent bending stiffness of the foam aluminum chute panel can be determined:

$$\begin{aligned}(EI)_{eq} &= [2E_f I_{zf} \int_0^{0.168} dx + E_p I_{zp} / \int_0^{0.468} dx] = \\ &[2E_f \int_0^{0.168} \int_{-t/2}^{t/2} (y + \frac{t}{2} + \frac{s}{2})^2 (\frac{5}{13}x + 0.42) dydx + \\ &E_p \int_0^{0.468} \int_{-s/2}^{s/2} y^2 (\frac{5}{13}x + 0.42) dydx] / \int_0^{0.468} dx\end{aligned} \tag{5}$$

where E_f and E_p are the elastic module of Q235 and foam aluminum, respectively.

The quality of the foam aluminum chute panel is:

$$m = [2V_f \rho_f + V_p \rho_p] = 0.468 \times [(0.6 + 0.42) t \rho_f + \frac{(0.6 + 0.42)}{2} s \rho_p] \tag{6}$$

where V_f and V_p are the volume of the Q235 steel plate and the foam aluminum plate, respectively and ρ_f and ρ_p are the density of Q235 steel and the foam aluminum, respectively.

$$\begin{aligned}k &= \frac{F}{w_c} = \frac{48(E\bar{I})_{eq}}{l^3} = 48[2E_f \int_0^{0.468} \int_{-t/2}^{t/2} (y + \frac{t+s}{2})^2 (\frac{5}{13}x + 0.42) dydx + \\ &E_p \int_0^{0.468} \int_{-s/2}^{s/2} y^2 (\frac{5}{13}x + 0.42) dydx] / [(\int_0^{0.468} dx)^4]\end{aligned} \tag{7}$$

Using Equations (1), (6) and (7), the optimization objective function can be expressed as follow:

$$\begin{aligned}&\min A(s,t) = 387 / \{[2.4 \cdot 10^{11} s^3 + 8 \cdot 10^{12} t (3s^2 + \\ &6st + 4t^2) - 3140^2 (3750t + 119.3s)]^2 + \\ &251^2 [2.4 \cdot 10^{11} s^3 + 8 \cdot 10^{12} t (3s^2 + 6st + 4t^2)](3750t + 119.3s)\}^{0.5}\end{aligned} \tag{8}$$

In order to improve the static performance of foam aluminum chute, the maximum static stress of the foam aluminum chute should be smaller than the maximum stress of the prototype chute. So, this relationship can be expressed as follow:

$$\begin{aligned}&\sigma_{eq} = \frac{M(s + 2t)}{2(2I_{zf} + I_{zp})} < \sigma_f = \frac{Mt_0}{2I_z} \Rightarrow \\ &(s/2 + t) - [2s^3 + (3s^2 + 6st + 4t^2)t] \times 10^4 < 0\end{aligned} \tag{9}$$

where σ_{eq}, σ_f are the maximum stress of the foam aluminum chute and the prototype chute, respectively, M is the bending moment received from the chute panel and t_0 is the thickness of the prototype chute steel plate.

In order to prevent the pores of the foam aluminum from being crushed and to reduce the damping, the maximum stress of the foam aluminum plate should be less than its yield stress.

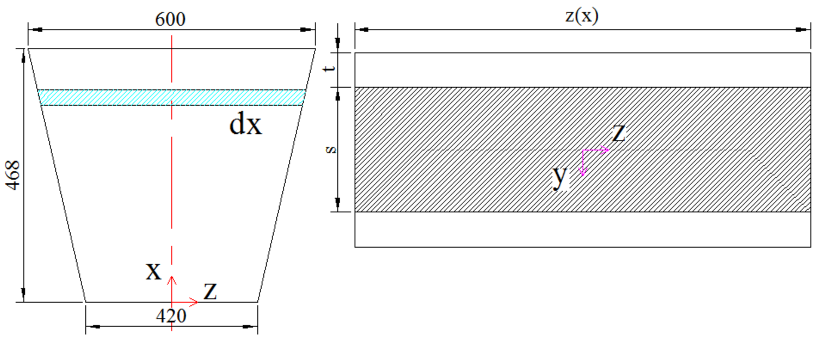


Figure 4. Panel height and width

According to the analysis, the force model of the chute panel can be considered as the force model of the simply supported beam with variable cross section, and its system equivalent stiffness *k* satisfies the equation as follow:

$$\begin{aligned} &\sigma_p = \frac{Ms}{2(2I_{zf}+I_{zp})} < \sigma_{ps} = 8.1\times10^6\,\mathrm{Pa} \Rightarrow \\ &\frac{49.8s}{17s^3+34t(3s^3+6st+4t^2)} - 8.1\times10^6 < 0 \end{aligned} \tag{10}$$

where σ_{ps} is the yield stress of foam aluminum.

In order to prevent the material transportation from being affected, the thickness of the foam aluminum panel can not be increased too much and the thickness of inner and outer panel cannot exceed 5 mm. So, the thickness of the two types panel should satisfy the following conditions:

$$\left.\begin{matrix} 0\le t\le 0.005 \\ 0\le s\le 0.02 \end{matrix}\right\} \tag{11}$$

According to the established optimization objective function (Equation (8)) and Constraints (9), (10) and (11), the optimized thickness of the steel plate and foam aluminum is obtained 4.912 mm and 2.6341 mm by using the fmincon function in MATLAB [15,16]. Taking into account the thickness specification of the steel plate, the thickness of the steel plate is set as 5 mm. The thickness of foam aluminum plate is set as 2.6 mm, because of the difficulty in processing the foam aluminum material and that the thickness has a large influence on the natural frequency of the system.

3. STATIC SIMULATION ANALYSIS OF CHUTE

3. 1. Finite Element Model

Based on the size of prototype and optimization results, the three-dimensional models of the two types of chutes are created using Pro/E software. The relevant material performance parameters are given in Table 1. Every panel of the chute is mainly subjected to the pressure of the coal block under the condition of full loading, and its force analysis is shown in Figure 5. According to the actual situation at full load, the total pressure received by each chute panel can be calculated by Equation (12).

$$F_t = Q\cos\phi = \rho_m \cdot (V_0 - V_1)\cdot g\cdot\cos\phi \tag{12}$$

where V_0 is the chute volume, V_1 is the volume in the height direction of the chute discharge port, *g* is the acceleration of gravity, ρ_m is the density of coal and ϕ is the inclination angle of the chute panel.

Bringing the relevant data into Equation (12), the calculated pressure on the chute panel is 155.352 N. According to the working condition of the chute, the fixed constraints are added to the four entrance vertices of the chute, and the y-axis and z-axis direction constraints are also added to the four exit vertices of the chute.

3. 2. Result Analysis

The equivalent stress and strain analysis results of the two types of structural chutes obtained by ANSYS software are shown in Figures 6 and 7.

The main data of simulation results are listed in Table 2 for the convenience of comparison.

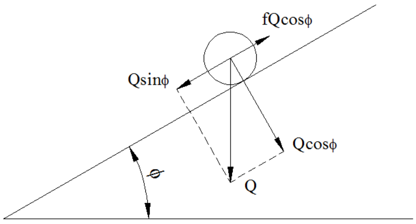
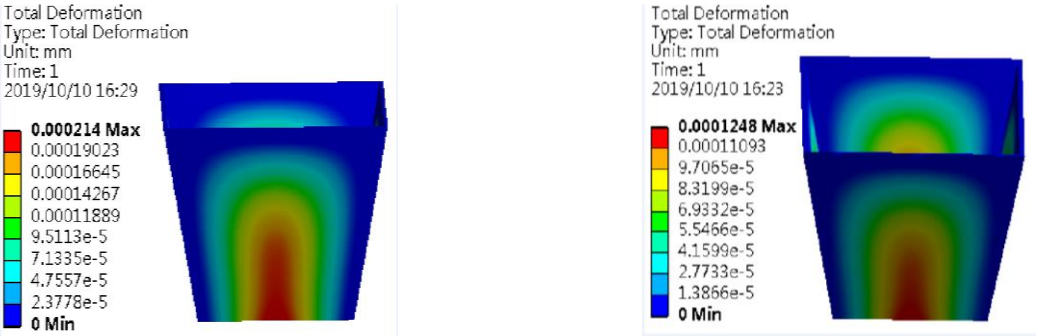
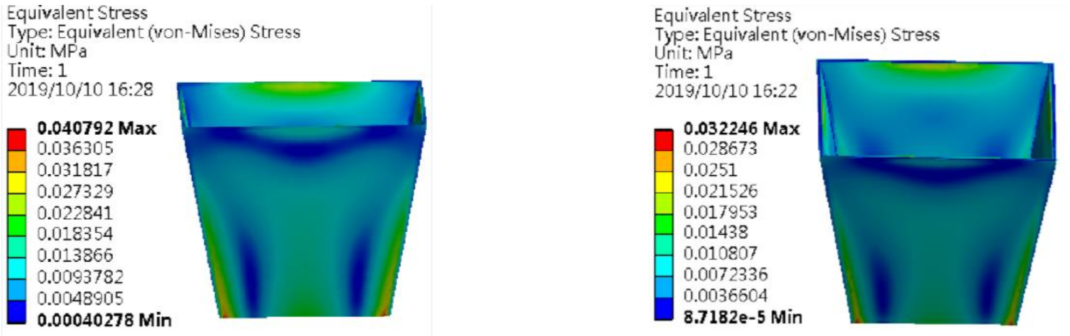


Figure 5. Chute stress analysis



(a) Prototype chute (b) Foam aluminum chute

Figure 6. Equivalent strain of the two types of chute



(a) Prototype chute (b) Foam aluminum chute

Figure 7. Equivalent stress of the two types of chute

TABLE 2. Simulation results of the chute

Category	Prototype	Foam aluminum
Maximum deformation/m	21.4×10^{-5}	12.48×10^{-5}
Maximum stress/MPa	0.0407	0.0322

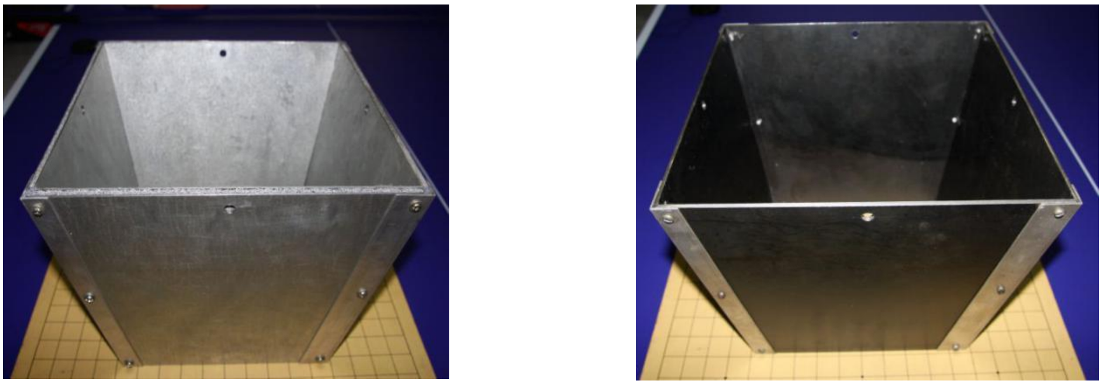
According to Table 2, the maximum strain of the foam aluminum chute is reduced by 41.68% compared with the prototype chute, and the maximum stress is also reduced by 20.88%, which proves that the designed foam aluminum chute has better static characteristics than the prototype chute.

4. MODAL EXPERIMENT

The impact noise caused by the impact of the coal block and the metal plate in the chute is the main part of the chute noise. That is the sound energy radiated by the free vibration which gradually attenuates after the structure impacted by the impact force. So, it is necessary to study the vibration characteristics of the chute structure. According to the shape and size of the two types of chutes, the test specimen is prepared according to the ratio of 1:1. The foam aluminum layer of laminated structure chute specimen is bonded with epoxy resin adhesive between other panels. The prepared test specimens of the foam aluminum chute and the prototype chute are shown in Figure 8.

The test system is mainly composed of excitation system, acceleration sensor, measurement and analysis system, as shown in Figure 9. The measurement and analysis system use the DH5922N dynamic signal test produced by Jiangsu Donghua Testing Technology Co., Ltd. During the test, the test piece is suspended with soft rope to achieve the approximation of free condition. In order to minimize the influence of suspension, the connection point of the suspended test piece shall be selected at or close to the node with as many modes as possible. So, the middle points of the 4 sides at the inlet are selected as the suspension point.

During the experiment, the hammer stroke is used as the excitation signal, and the single-point excitation method is used while hammer striking. The acceleration sensor is used to detect the response signal by multi-point picking, which is to measure the response signals of all nodes on each panel at one time. The measured excitation signal and response signal are amplified by the amplifier, then are inputted into the analysis system for analysis to obtain the response function of each response point.



(a) Foam aluminum chute (b) Prototype chute

Figure 8. Test specimens of the two types of chute

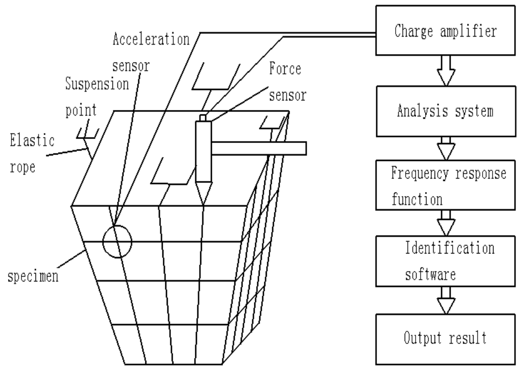


Figure 9. Schematic representation of modal analysis system

And then the response function is subjected to modal recognition processing by special recognition software. The final output is the experimental modal results of the chute. The experimental environment is shown in Figure 10.

The first 5 natural frequencies measured in the experiment and finite element simulation results of the two structural chutes are shown in Table 3. The first 5 natural frequencies of the foam aluminum laminated chute are higher than original chute. The maximum relative error of the natural frequencies obtained by the two methods is less than 3.85%, and the minimum increase of damping ratio of foam aluminum chute is 6.54 % (first order) and the maximum increase is 89.55% (third order). It is proved that the foam aluminum chute can increase the damping ratio of the system and play a role of vibration reduction, as well as reducing the impact noise of the chute.

5. SOUND INSULATION EXPERIMENT

The foam aluminum laminated structure has also a good noise reduction performance. It is necessary to compare the sound insulation performance of the two structural chutes by experiment.

5. 1. Experimental Equipment and Composition

The purpose of this test is to measure the sound insulation of two different structure chutes. The amount of sound insulation can be expressed by three methods, including the sound pressure level, sound intensity level and sound power level. In this test, the method of measuring the sound pressure level is used. The experimental system mainly consists of AWA5680 multi-function sound level meter and analog sound source.

A special sound spectrum generating software is used to simulate the noise source by computer and sound reinforcement equipment. The noise generated by the analog sound source can directly read the sound pressure value on the instrument. During the experiment, there are three conditions to measure the sound pressure value of the noise source, such as without a chute, a prototype chute, and a foam aluminum laminated structure chute. And then, the measurement results can be compared and analyzed. The test system is shown in Figure 11.

5. 2. Experiment Method In this study, the sound insulation performance is represented by the average sound insulation of six octaves with center frequencies of125, 250, 500, 1000, 2000, and 4000 Hz commonly used in engineering. In order to reduce the influence of

Figure 10. Experimental site

TABLE 3. First 5 natural frequencies and damping ratios

Order	Prototype			Aluminum foam		
	Experimental frequency/Hz	Simulation frequency/Hz	Damping ratio/%	Experimental frequency/Hz	Simulation frequency/Hz	Damping ratio/%
1	295.257	301.59	5.351	196.615	200.45	5.701
2	401.886	411.41	3.247	277.538	282.91	4.823
3	397.262	413.07	0.134	278.895	285.30	0.254
4	590.681	310.46	3.083	403.976	413.94	5.140
5	638.933	657.00	3.565	412.668	421.00	5.685

Figure 11. Sound test system

the sound diffraction during the experiment, a foam plate with thickness of 10 mm is added to the upper opening part of the chute specimen.

The noise measurement test is carried out when the laboratory is relatively quiet, and both the room wall and the ground are noise reflection surfaces. According to the size of the chute specimen, the noise source is placed in the middle position of the chute and 0.3 m from the ground. And the sound level meter is placed 1 m outside the chute specimen at a height of 0.3 m from the ground.

5. 3. Experiment Results Analysis

The test results are shown in Figure 12. The three curves in the figure are the equal curve of bare test, prototype structure and foam aluminum laminated structure.

It can be seen from Figure 11 that the sound pressure level fluctuates greatly with the change of the frequency under the pure tone of the same loudness level, and the equal sound curve is divided into two parts. The first part is the frequency range of 125~1000 Hz. In this frequency range, the measured sound pressure level of the two structure chutes increases with the increasing of the frequency, and tends to stabilize after reaching a certain degree. The second part is the frequency range of 1000~4000 Hz. In this range, the sound pressure level of two kinds of structure chutes decreases with the increasing of frequency, which indicates that the two structural chutes have better sound insulation effect on higher frequency noise. However, due to the small space in the test room, the echo of the room, the resonance of the desktop and the interference of the external environment during the test can have a certain impact on the experimental results.

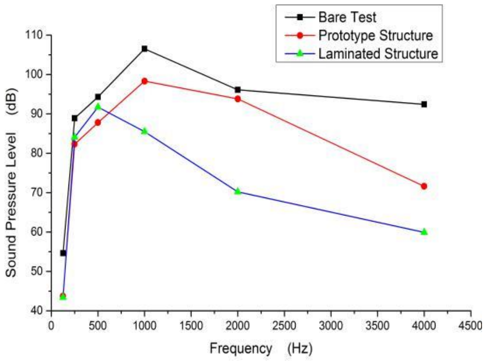


Figure 12. Relationship between frequency and noise

By comparing the results of the three sets of tests, it can be found that both of the foam aluminum laminated structure chute and the prototype structure chute have different degrees of sound insulation effect. In the frequency range of 125-500 Hz, the average sound insulation of the prototype chute is 6.6 dB, and the average sound insulation of the laminated structure chute is 3.7 dB. The foam aluminum laminated structure is 2.9 dB smaller than the prototype. In the frequency range of 1000~4000Hz, the average sound insulation of the foam aluminum laminated structure chute is 26.5dB, and the average sound insulation of the prototype chute is 10.4 dB. The sound insulation of the foam aluminum laminated structure chute is 16.1 dB larger than the sound insulation of the prototype chute. However, from the average sound insulation of six octaves, the sound insulation effect of the foam aluminum laminated structure chute is better than that of the prototype chute, and the average sound insulation is increased by about 7.1 dB. It can be seen that the foam aluminum laminated structure chute has a more significant function of noise reduction effect than the prototype chute.

6. CONCLUSIONS

In this paper, a new type of foam aluminum laminate materials is used to design the mining chute, which has been commonly applied in many fields. And in order to reduce the vibration as more as possible and not to affect the working efficiency of the chute, the structure parameters of the chute are optimized. According to the established optimization objective function and constraints, the optimized thickness of the steel plate and foam aluminum plate is 4.912 mm and 2.6341 mm by using the fmincon function in MATLAB. Taking the difficulty of processing, the foam aluminum material and the thickness which has a large influence on the natural frequency of system into account, the thickness of the steel plate and the foam aluminum plate is set as 5 mm and 2.6 mm, respectively.

In order to verify if the stiffness and strength of the foam aluminum laminated structure chute can meet the working requirements, the static properties of the two types of structure chute are numerically calculated. According to the stress distribution and deformation of the two structural chutes under external load, the equivalent stress and strain is reduced by 41.68% and 20.88% compared with the prototype chute, respectively. This shows that the foam aluminum laminated structure chute has better static mechanical properties.

Through experiments, it can be found that the foam aluminum chute can increase the damping ratio of the system. The minimum increase of damping ratio of foam aluminum chute is 6.54% (first order) and the maximum increase is 89.55% (third order) compared with prototype chute. Both of the foam aluminum laminated chute and the prototype chute have different degrees of sound insulation. However, the average sound insulation performance of foam aluminum laminated chute is better than the prototype chute, especially in the middle and high frequency section. The average sound pressure level can be reduced by about 7.1 dB. It can be seen that the foam aluminum laminated structure chute has a more significant sound insulation and vibration reduction effect than the prototype chute. The superiority of the foam aluminum laminated structure provides a new way to improve the vibration and noise reduction performance of the mining chute. But we only take the vibration amplitude as the objective function, without considering the purchase and processing cost of materials. Thus, it is necessary to carry out a multi-objective optimization design in the future.

7. REFERENCES

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Persian Abstract

مجرای سرریز (ناودان) معدن یکی از تجهیزات مهم در فرآیند حمل و نقل ذغال سنگ و غربالگری آن است. در طی فرایند کار، ناودان معدن به دلیل اصطکاک مداوم و اثر کلوخه و بلوک‌های ذغال سنگ، لرزش و سر و صدای زیادی ایجاد می کند. به منظور کاهش لرزش و سر و صدا از ناودان در حین کار، از نوع جدیدی از سازه روکش شده آلومینیومی فوم برای ساخت ناودان معدن استفاده می‌شود. با توجه به ویژگی‌های ناودان، ساختار چند لایه با بهره‌گیری از دامنه ارتعاش به عنوان تابع هدف و ضخامت صفحه فولادی و صفحه اصلی آلومینیوم فوم به عنوان متغیرهای طراحی، طراحی شده است. سپس عملکرد لرزش و کاهش سر و صدا در دو نوع ناودان از طریق آزمایشات و روش شبیه سازی عنصر محدود ارزیابی می‌شود. نتایج نشان می‌دهد که استفاده از سازه ورقه ورقه آلومینیومی فوم برای تولید ناودان می‌تواند موجب افزایش نسبت کاهش میرایی سیستم شود، که در نتیجه می‌تواند به طور موثری دامنه ارتعاش ناودان را کاهش دهد. متوسط عملکرد عایق صوتی فوم آلومینیومی نسبت به نمونه اولیه بهتر است، خصوصاً در بخش فرکانس میانی و بالا، که می‌تواند به طور متوسط در حدود ۷.۱ دسی‌بل در مقایسه با نمونه اولیه کاهش یابد. بنابراین، ناودان سازه‌ای با روکش آلومینیوم فوم دارای خاصیت عایق صوتی قابل توجهی نسبت به نمونه اولیه است و موجب کاهش لرزش می‌شود.