

The Manufacturing Technology of Aluminum Foam Material and Some Special Equipments

Guang-Chun YAO, Hong-Jie LUO, Zhuo-Kun CAO

School of Materials and Metallurgy, Northeastern University, Shenyang, 110004, China

gcyao@mail.neu.edu.cn

Keywords: Aluminium foam, Properties, Application, High-speed Rail Train, Special Equipment.

Abstract. It was found that aluminum foam material have sound insulation and absorption, electromagnetic shielding, anti explosion, anti bullet penetration, special high strength sandwich plate.etc. So the aluminum foam material can be used to manufacture carrier deck, light-weight and quick mounting bridge, the littoral Combat Ship Deck, mine resistant floor of military vehicle , bulletproof composite armor, airborne buffer table for heavy equipment, light missile manhole covers, High-speed Rail train anti collision structure, High-speed Rail train sound barrier, safety school bus ,and so on. The performance of these equipment will be significantly improved by making use of foam aluminum material.

Introduction

Aluminum foam is a new material. Northeastern University has carried out engineering research work on the "863" high technology planning support of the Chinese Ministry of Science and Technology. Foam aluminum material specification has reached 800mm x 2000mm. Aluminum foam is a light-weight and multi functional materials, the density of $0.25\text{g/cm}^3 \sim 0.6\text{g/cm}^3$, the porosity of 78% ~ 90% . In addition, it also has the anti explosion, anti bullet penetration, sandwich plate high strength. Rely on these properties of aluminum foam, some equipment can be significantly improved the performance, such as manufacturing aircraft carrier deck, light quick mounting bridge, the Littoral Combat Ship Deck, mine resistant floor of military vehicle, bulletproof composite armor, airborne buffer table for heavy equipment, light missile manhole covers, High-speed Rail train anti collision structure, High-speed Rail train sound barrier, safety school bus ,and so on[1].

The Special Properties of Aluminum Foam

The Aluminum Tube Column Absorbing Energy by Filling Aluminum Foam

The stress strain curve of aluminum tube column filled with aluminum foam were measured and its drawing shown in figure .1. The initial aluminum feed tube is easy to pressure to collapse, not equilibrium deformation; aluminum foam has balance the deformation, strain rate is higher, but lower compression strength; aluminum tube filled with aluminum foam has high compressive strength, and can be steady deformation, deformation curved line in phase domain integral under the largest area, suction the highest energy,it is the best absorbing energy material[2]

The Electromagnetic Shielding Property of Aluminum Foam

The aluminum foam sheet with density of 0.32g/cm^3 , 0.40g/cm^3 , 0.74g/cm^3 were measured electromagnetic shielding effectiveness shown in Figure.2, when the electromagnetic wave frequency is below 200MH, the shielding rate of 90 dB, when the electromagnetic wave frequency 1000MH shielding rate is about 70 dB[3].

Anti Bullet Penetration Performance of Aluminum Foam

The armor penetration test structure on alumina ceramic plate/ aluminum foam,/Kevlar fiber board composite is shown in Figure. 3 Because the energy absorbing effect of aluminum foam, the

elastic impact area increases several times, that is, the projectile impact force on per unit area is reduced several times, thus blocking projectiles penetrating.

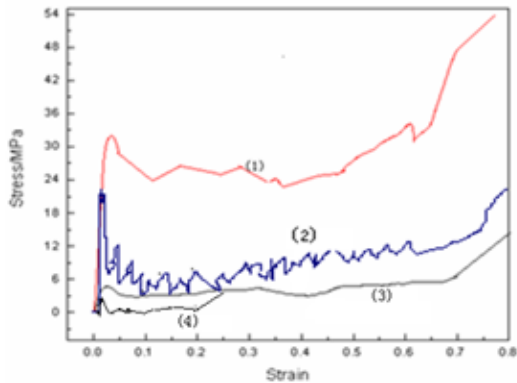


Fig.1 Packing aluminum foam stress strain curves
1)foam aluminum/aluminum tube 2)crushing tubes
3) aluminum foam 4) paper honeycomb

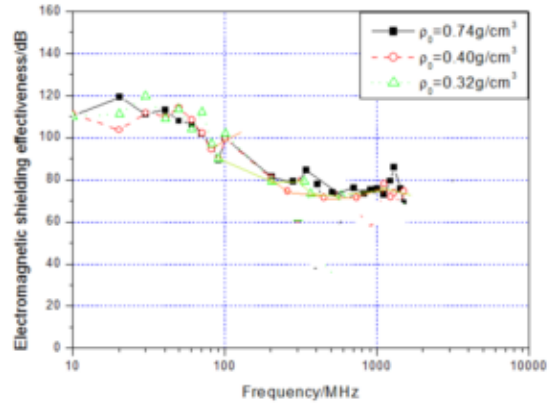


Fig .2 Foam aluminum electromagnetic Shielding effectiveness

Damping Properties of the Explosive Shock Wave in Aluminum Foam

The propagation attenuation curve drawing of blast shock wave in steel / aluminum foam / steel sandwich board is shown in Figure 4, the 520Mpa shock wave peak decay rapidly, close to 0, through 20mm thickness of aluminum foam[2].

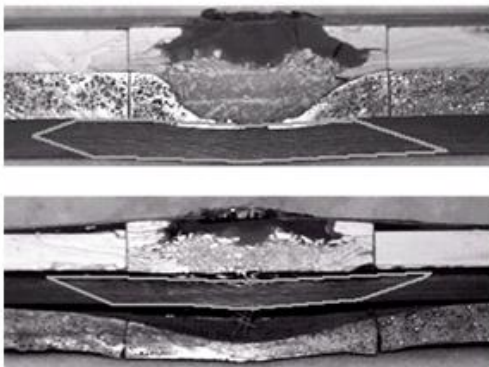


Fig. 3 Aluminum foam sandwich bullet proof Penetration effect

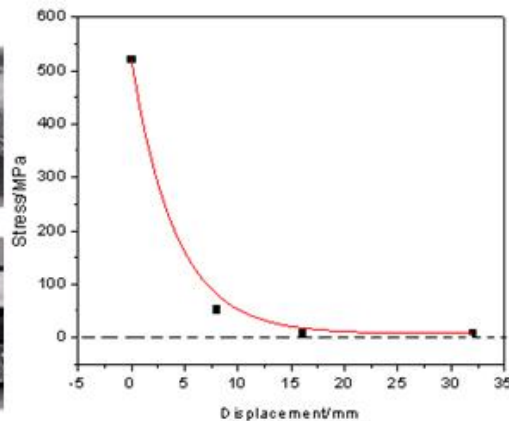


Fig. 4 Shock wave attenuation curve peak in aluminum foam

Load Strength Properties of Aluminum Foam Sandwich

The load strength of steel plate / aluminum foam aluminum sandwich panels was measured by three point flexural strength , it is shown in figure. 5. When the thickness of the aluminum foam is 10mm,its bending strength will be double than the two layers strength. It can be see that the bending strength increased with the increase of aluminum foam thickness[4].

The Typical Engineering Application of Aluminum Foam Material

Light Explosion Door

The existing explosion-proof door adopts reinforced concrete and steel plate structure, its total thickness is 300 ~ 400mm. Maximum antiknock ability of the explosion door is about 3Mpa, but its weight is 20 ~ 30 tons, so opening and closing difficulty. The light explosion-proof door structure made of aluminum foam as Figure .6 ,its panel are made of carbon steel plate of 5mm thickness and intermediate aluminum foam is about 100mm thickness. The antiknock ability of this kind of

explosion door reach more than 1000Mpa, but its weight reduce to several tons.

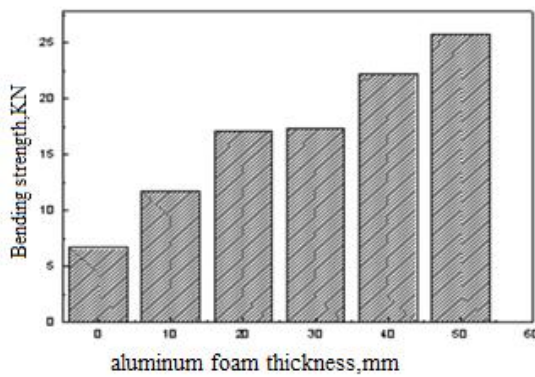


Fig.5 Bending strength of steel /aluminum foam /steel Sandwich plate(5mmthicksteelplate)

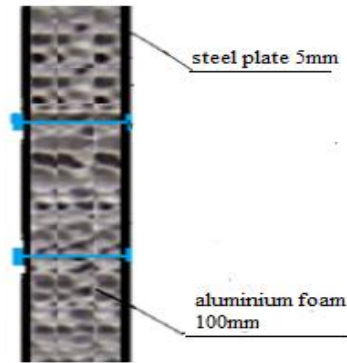


Fig .6 Light explosion door

Anti Crash Structure of High-speed Rail Train

There are serious security hidden danger of collision of high-speed trains, due to the trains without effective anti-collision structure. Using aluminum tube energy absorbing column filled aluminum foam made locomotive head anti-collision structure shown in Figure .7, anti collision structure between carriages shown in Figure 8, when the train speed is below 70Km, the anti collision structure can absorb all the impact energy, so that the train will buffer and stop, so as to ensure the life safety of the passengers.

The Sound Barrier Made of Aluminum Foam on High-speed Rail Line

The sound barrier of High-speed Rail line at present is a counterfeit product, its sound absorb box is of 140mm thickness, suitable for the frequency of 100 ~ 200Hz of low frequency noise, does not have the sound absorption and noise reduction function, but High-speed Rail line noise is high frequency (frequency of 1000 ~ 2000Hz). The aluminum foam sound box is made of 10~15mm thickness foam aluminum sound absorption board and the folded type galvanized steel partition board at the middle, its cavity is 0 ~ 30mm. The backplane is made of 1mm thick galvanized plate , as shown in figure 10. This kind of sound barrier to adapt the frequency of High-speed Rail noise of 500Hz ~ 2000Hz, can be more than 20 dB noise reduced.

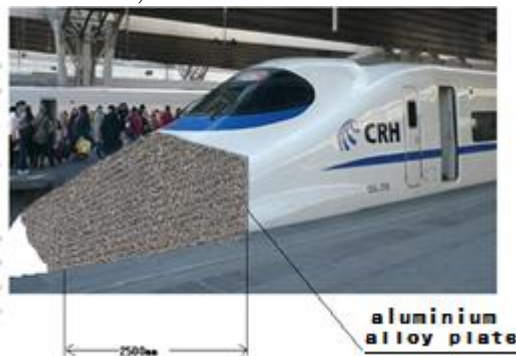


Fig.7 The head protection structure of high-speed Train locomotive



Fig.8.Anti collision structure between carriages

Aluminum Foam Sandwich Flight Deck of Aircraft Carrier

When the plane landed on the aircraft carrier flight deck, due to the rebound effect ,can not easily be arrested by the cable attachment, resulting in some aircraft cannot stop on the deck. Using aluminum foam sandwich flight deck (Figure 9), the plane bounce height is reduced by more than 50%, ensuring plane smooth glide, increasing the chance to be the arrested by cable attachment. In addition, the blast resistance and anti missile combat ability will significantly improved.

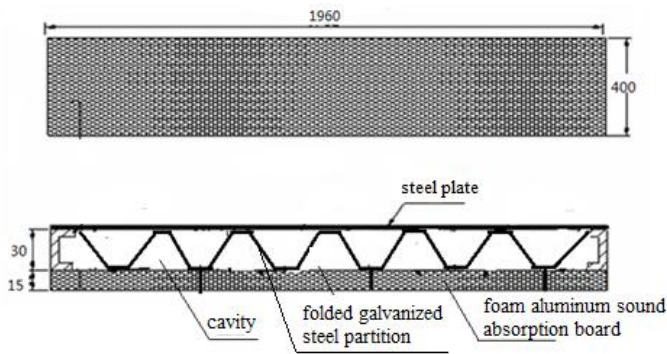


Fig.9 Sound absorption box structure of aluminum foam sound barrier

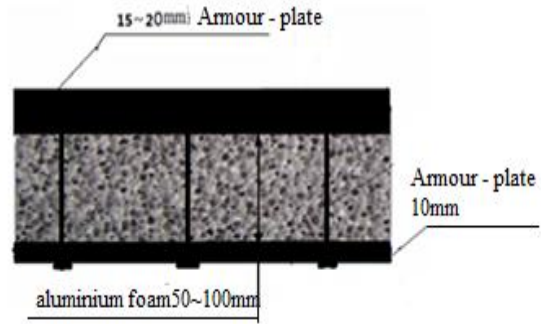


Fig. 10 Aluminum foam sandwich flight deck of aircraft carrier

Quick Mounting Large Span Bridge Made of Aluminum Foam

In wartime, the armored forces need quick mounting support bridge to across the river and ditch. The quick mounting support bridge at home and abroad is made of steel, its maximum length is 53 meters. The 70 meters long bridge can be manufacture by aluminum foam materials, as shown in Figure. 11.

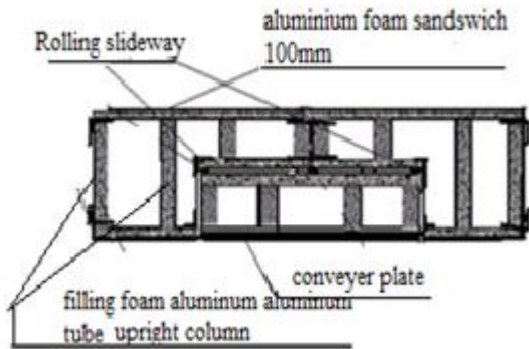


Fig.11 Aluminum foam quick mounting large span bridge

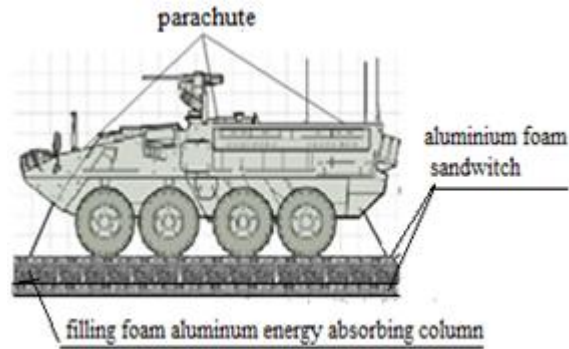


Fig.12 Aluminum foam heavy equipment airborne buffer table

Heavy Equipment Airborne Buffer Table Made of Aluminum Foam

Russian airborne 20 tons of equipment adopt 4 meters high big balloon, do not stable when landing. Using the filling foam aluminum aluminum tube energy absorbing column, the heavy equipment airborne buffer pad can be made as shown in Figure. 12 its height is about 500mm, 20 tons of equipment can be dropped, to ensure the smooth landing and safety equipment.

Light Missile Manhole Cover

The missile manhole cover made of reinforced concrete materials, its weight reach to more than 600 tons, very heavy, opening and closing difficulty. The new missile manhole cover made of armor plate and aluminum foam(Figure.13), can make anti explosion strength more than 10000Mpa, the anti armor piercing capability than the original cover, and its weight be reduced to 1/6.

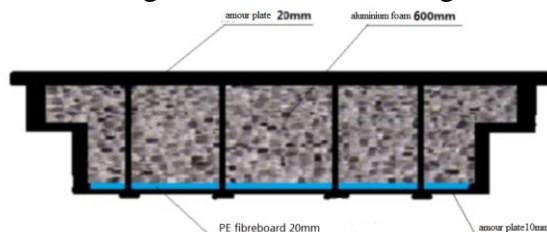


Fig.13 Aluminium foam missile manhole cover

Safety School Bus Made by Aluminum Foam

Before and after the safety school bus(Figure.14) anti-collision beam is made by using aluminum tube absorption column filled with aluminum foam, its surface made of 1 ~ 2mm thick steel plate. The anti-collision beam can absorb most of the impact energy when the school bus collision. The body upright column and cross beam are made of square steel tube filled with aluminum foam, its ability of anti rollover will be increased doubled.



Fig. 14 Safety school bus made by aluminum foam

The Aluminum Foam Sound Barrier on Highway

Aluminum foam sound barrier was build in Shneyang, aluminium foam absorption board is 800mmx 2000mm, its cavity 70mm, the noise can be decreased 20dB.

The Aluminum Foam Sound Boarding

The aluminum foam / aluminum panel(20mmthickness) sound boarding installation was build in basement floor rooftop of a building in a Shenyang, The average reduction of noise is 26 db.



Fig.15 Aluminium foam sound barrier in shenyang

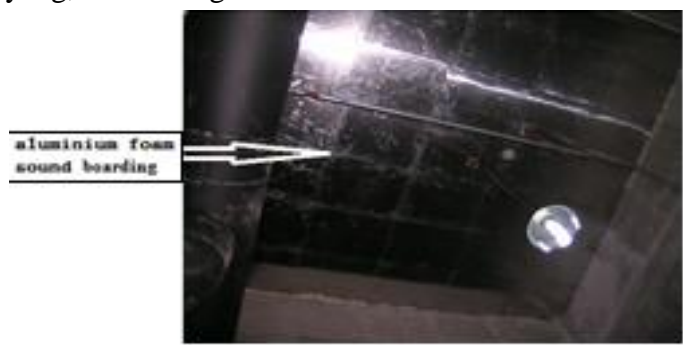


Fig.16 Aluminium foam sound boaring

Summary

Aluminum foam is a multifunctional and multipurpose engineering materials, it can be used in engineering, High-speed Rail trains, buildings, cars and some military equipment, their performance will be significantly improved.

References

- [1] Yao Guangchun etc., Aluminium Foam Mterial, Science Press, China, 8, 2014.
- [2]liu Huan, Study on properties of the impact absorption and wave damping of aluminum foam,Doctoral Dissertation of Northeastern University, 11, 2014.
- [3]Yu Haijun, Research on acoustic, mechanical and other properties of closed-cell aluminum foam,

Doctoral Dissertation of Northeastern University, june,2 007.

[4]Song Binna, Study on mechanical properties of aluminum foam sandwich panels, Doctoral Dissertation of Northeastern University,, September, 2013.