Effect of magnetic properties of metal foam on magnetic field

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This paper investigates the magnetic properties of metal foams experimentally. A set of test rig, including the coils, the magnetic core, is developed. The effects of metal foams with different materials and thickness on the magnetic field are studied. The results show that, as for the same thickness of metal foams, if the relative magnetic permeability of materials is bigger, the magnetic density flux in the gap will be bigger; to the metal foams with the magnetic permeability, the difference of thickness will have effect on the magnetic field, and with the increasing of relative magnetic permeability, the effect of thickness will be more obvious, which provide the experimental data for the research on magnetic characteristics of metal foams.

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1. Introduction

Metal foams, as one of the most important smart materials, have the adjustable permeability, high porosity, small density, large specific surface area, etc. They are widely used in vibration isolation buffer, catalyst carrier, sewage treatment and other fields. In recent years, with the development of material preparation technology and processing technology, the quality of metal foam has been improved greatly, which expand the application fields of metal foam, and become the hot research in the field of materials.

At present, many researchers mainly focused on the mechanical properties of metal foam and its preparation process, etc., In 2001, John Banhart [1] improved the preparation technology of metal foam and manufactured the metal foam the high performance, besides, the application field of metal foam is also studied. For the mechanical properties of metal foam, in 2004, Liu Peisheng [2] studied the deformation under the action of external force and the parameters. However, for the electromagnetic properties of metal foam, as well as its structural parameters, including the porosity, thickness and so on, the influence of them on the magnetic field is seldom. In 1996, by electromagnetic computing method, Huang Fuxiang et al. [3] studied the electromagnetic shielding performance of metal foam, and the effect of porosity of metal foam on the electromagnetic shielding is obtained for; In 2007, Li Kaihua et al. [4] studied using porous foam metal nickel electrodeposition method of the structure and magnetic, but for the type, structure parameters of porous foam metal (including porosity and thickness, etc.) for the research on the effects of magnetic field intensity.

A set of testing device, including the energized coil, the upper and lower poles, etc., is built up. The effect of metal foams with the different thickness and materials on the magnetic field was investigated experimentally. The results show that the larger magnetic conductivity of metal foams on the same thickness, the larger magnetic induction intensity will be obtained in the gap. And for the same magnetic conductivity of metal foam, the change of the thickness will have effect on the magnetic field obviously, the greater magnetic permeability, the more obvious influence on the magnetic field.

2. Magnetic properties of metal foams

Metal foam used in the test, is manufactured by the method of metal electrodepositing, the model is domestic plastic foam, the manufacturing process is shown in Fig. 1.

According to the production process of the Fig. 1, the structure of metal foam is as shown in Fig. 2, in which a) the original figure, b) is the figure under the microscopic observation of view (SEM) [5].

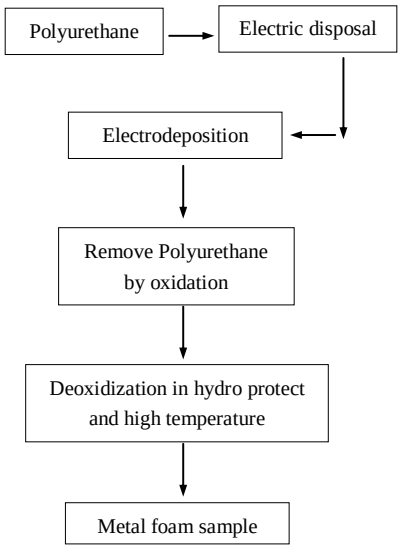
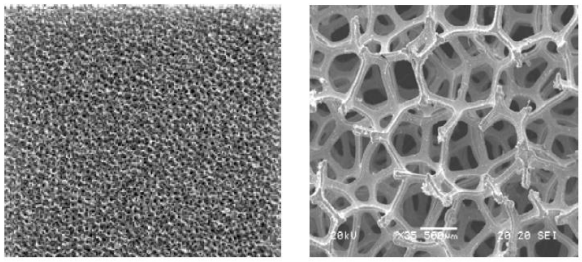


Fig. 1. The production process of metal foam.

The cross structure of metal foam mesh is shown in Fig. 2 b), by changing the processing current, the different materials and PU foam model, the different hardness, material and aperture of the metal foam will be obtained. Fig. 2 shows that the obtained metal foam has the 3d mesh uniform structure; the porosity test is 85%.



a) Metal foam b) SEM figure

Fig. 2. Metal foam and SEM figure.

The magnetic permeability of metal foam is tested by the vibrating sample magnetometer; the test of material is made of metal foam iron and copper, the relative permeability as shown in Fig. 3. Fig. 3 shows that, as to the nonmagnetic metal foam copper, the relative permeability is 1; the initial relative magnetic permeability of metal foam iron is about 2.55.

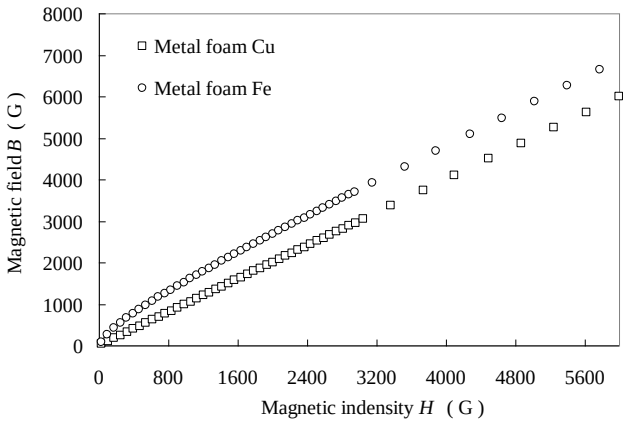


Fig. 3. The relative magnetic permeability of metal foam.

3. The effect of metal foam on the magnetic field intensity

In order to investigate the effect of the different parameters of metal foam on the magnetic field, a test rig is designed and manufactured, as shown in Fig. 4.

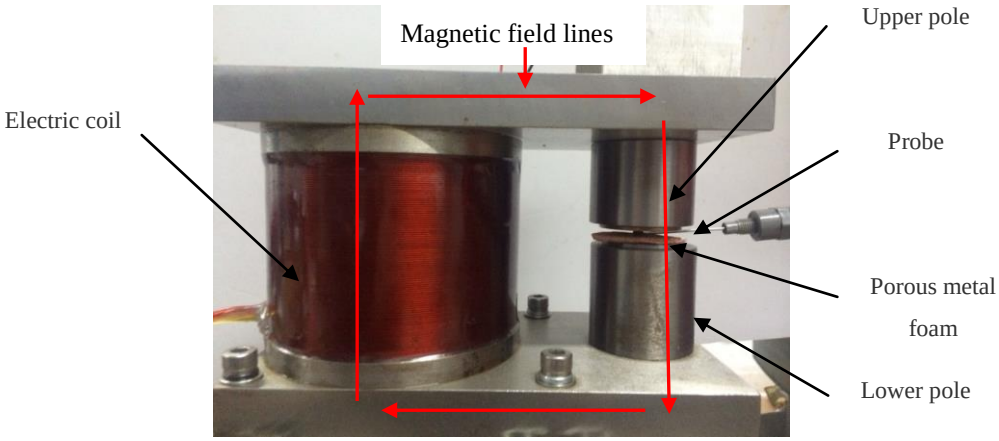


Fig. 4. Test rig.

The turns of copper coils is 4200, here, the current in the coil can be adjusted by the external power source, the probe of tesla meter is fixed on the surface of metal foam, which will be used to gather the magnetic field, and the air gap is 10 mm (not contacted with the metal foam, the whole magnetic circuit of materials of 20# steel. The metal foams with different thickness and different materials are sticked on the lower pole, by changing the current, the magnetic field intensity will be obtained, as shown in Fig. 5 and Fig. 6.

According to the Fig. 5 and Fig. 6, the main conclusions are as follows:

1) Fig. 5 shows that, for the metal foam with the same thickness, when the metal foam iron, used, the magnetic induction intensity in the gap is the largest, for another metal foam copper, the magnetic induction intensity will be stable, which is mainly related to the relative magnetic permeability of metal foam.

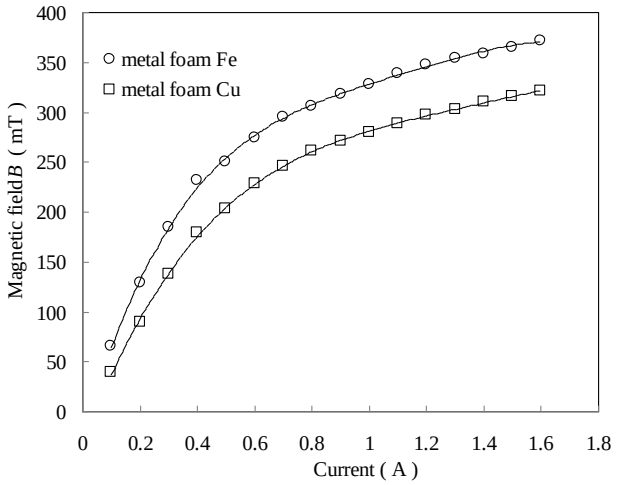


Fig. 5. The influence of materials on the magnetic field (thickness: 5.34 mm).

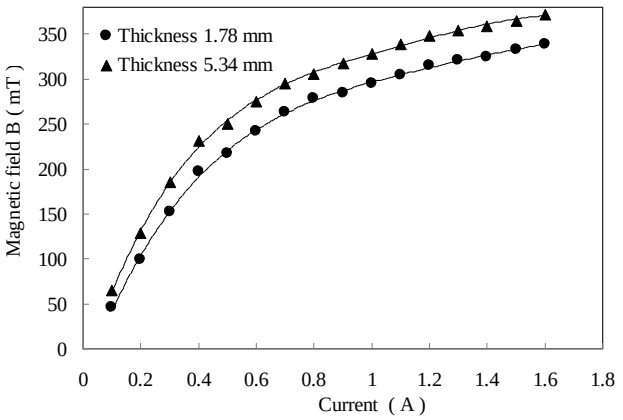


Fig. 6. The influence of thickness to magnetic field (porous metal foam iron).

2) Fig. 6 shows that, for the same magnetic permeability metal foam, for example, the iron, when the thickness increased, the magnetic induction intensity in the gap will be increased, under the condition of the thickness increased three times, the magnetic induction intensity will increases about 20%.

4. Conclusions

This paper investigated the influence of metal foam with the different parameters on the magnetic field experimentally. Experimental results show that for the magnetic metal foam, the change of the thickness will affect the magnetic induction intensity in the gap. The greater magnetic permeability, the effect on the gap will be more obvious; to the non-magnetic conductivity of metal foam, the effect of thickness on the magnetic field can be ignored. Therefore, in order to increase the magnetic induction intensity in the gap, the thickness of metal foam with magnetic conductivity can be adopted. The results provide the experimental basis for the research of metal foam.

Acknowledgments

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