



Review

Research process on property and application of metal porous materials



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ABSTRACT

This paper describes the mechanical properties, biological properties, permeability and strength and corrosion resistance of the metal porous materials. The current applications of the metal porous materials in the fields of energy and environmental protection, chemical industry, and the biomedical material are introduced in details. In the field of energy and environment, we'll be focusing on automobile exhaust purification technology, clean coal technology, surface combustion technology. In the field of chemical industry, we introduce the metal porous materials as catalyst and catalyst carrier, as the electrode substrate materials, etc. And in the biomedical field, the porous titanium, magnesium, porous skeleton tantalum used in human skeleton construction development are emphatically summarized.

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1. Introduction

Commonly known as foam metal, the metal porous material was the new material which was rapidly risen all over the world in the late 1980s. The metal porous material consisted of the rigid frame and internal holes, which makes those materials own physical properties and good mechanical properties [1], the characteristics of extraordinary metal material. The special characteristics of good permeability, controlled pore and pore size, shape stability, high temperature resistance, thermal shock resistance, regenerate and machinability were gathered on this kind of materials. Metal porous materials can not only be used as functional materials, but also as structure materials. In general, it is a kind of excellent multi-purpose engineering materials that doubles as a function and structure of the dual role. The metal porous materials can be divided into two categories according to its structure, disorderly and orderly. The former is foam material, while the latter is mainly dot matrix material. It can also be divided into two categories according to the hole is connected or not, through-hole and closed-hole. The former contains a lot of independent existence of holes, and the latter is the continuous flow of three-dimensional porous structure.

In recent years, Metal porous materials solved the problem of ceramic material inherent brittle and difficulties in machining, due to its unique characteristics and the combination of the characteristics of structural materials and functional materials. As a result, metal porous materials were widely used in energy conservation and environmental protection, biological, medical, chemical industry and other fields, and the high demand of green material in various fields promoted the development of foam metal. Therefore, researchers at home and abroad have proposed the foaming method, PM method and solidification process, sintering process, metal deposition, casting process and various preparation methods for different performance of metal porous material [2].

2. The characteristics of metal porous materials

2.1. Biological properties

The metal porous materials have the structure characteristics of relatively low density, higher specific surface area, larger specific strength and the others, which makes its bioactivity and biocompatibility increase significantly. The most stable performance of the bionic porous material is the ideal carrier of biological agents and bone substitute material in the feature [3].

2.2. Mechanical properties

The parts or products manufactured by porous materials can reduce the density and improve the mechanical properties such as strength and stiffness. According to the calculation, the quality of the planes using porous materials would reduce half under the same mechanical properties conditions. In addition, the porous material has higher impact toughness [4]. When used in the automotive industry, it effectively reduces the injury of the passengers in the traffic accidents. For example, using the proper original foam aluminum in the impact area of the car can reduce the damage to the greatest extent.

2.3. Permeability property

The metal porous materials have the similar characteristics with the porous media. The permeability performance of foam metal generally increases with the increase of porosity and pore size. The permeability property is also related to the pore surface roughness,

the nature of the fluid (such as viscosity, flow velocity, etc.), seepage pressure and other factors [5,6]. Therefore, the metal porous materials with different permeability [7] can be obtained by adjusting the pore structure.

2.4. Other properties

The strength of the metal porous materials was described by the internal pressure damage strength and shear strength. The shear strength or ring tensile strength before corroding and after that can be measured to describe corrosion. Besides, in meet of the metal porous material strength and corrosion resistance, the performance of the heat transfer ability, electrochemical activity, catalysis and so on are greater than dense metal materials because of the increase of the specific surface. And the porous material also has a series of characteristics which the dense metal has not such as energy absorption and cushion, etc. [8].

3. The current applications of metal porous material

3.1. The application in the field of energy and environmental protection

With the development of economy and technology, the world is facing enormous energy crisis therefore many scholars devoted to the research of this field. In general, there are three main ways to solve the energy crisis. The first is raising the fuel combustion rate to improve energy utilization. The second is exploring new technology and new process to save energy to maximum extent. The last is to develop renewable energy sources such as wind, water, and solar energy. The metal porous materials play an important role in these pathways.

3.1.1. The technology of purifying the automobile exhaust gas

Air pollution in big cities, according to the survey, had more than 40% of NO_x in the gas, more than 70% of HC and more than 80% of CO was from vehicle emissions. With the rapid development of automobile industry, automobile exhaust pollution will be more and more serious. Reducing emissions from now on is the most economic and effective measures for tail gas purification technology. The most key components of exhaust gas purification plant are the catalyst support materials whose performance directly affects the purification effect. Catalyst carrier material should satisfy the properties of the high heat transfer coefficient, high porosity and porosity, high geometric surface area, high temperature resistant properties and antioxidant [9].

The ceramic particles carrier materials of porous ceramic materials were usually used along with the ceramic honeycomb carrier materials of porous ceramic materials. But the ceramic particles type carrier material has low strength, big resistance and is easy to be broken [10], which affects the power of the automobile engine. Ceramic honeycomb carrier material has big heat capacity, slow heating temperature, and the mechanical strength is relatively low. These characters limit the purification efficiency of purifier [11]. However, metal carrier materials have replaced the ceramic carrier materials due to its good thermal stability, large surface area, small thermal capacity and high mechanical strength. The metal carrier materials especially have good prospects for development because of solving the key technology such as fiber preparation and fiber porous body shape.

3.1.2. The technology of cleaning coal

So far, the coal industry is a giant of China's energy industry, but coal burning can cause a series of environmental problems. Combined with the characteristics of high sulfur, high ash of coal in our

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