Mechanical Properties of Micro-Porous Metals Produced by Space-Holding Sintering

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Introduction Metal foams exhibit unique combinations of excellent mechanical, thermal, electrical and acoustic properties that provide opportunities for a wide range of applications. Among lightweight metallic materials, nickel foams are highly interested since they possess characteristics that can be exploited for multifunctional applications such as electrodes of nickel cadmium and nickel metal hydride batteries for electric vehicles, catalysts, diesel particulate filters, silencers and so on.

To date, the pore size of metal foams investigated varies from hundreds of microns to several millimetres. There is little work on metal foams with a micro-porous structure. Therefore, it is critical to develop new process for fabricating nickel foams with fine and homogenous porous structures, which enables a more precise predicting of the mechanical deformation behaviour of the nickel foams, and also enhanced mechanical performance. In the present study, nickel foams with an average pore size of about 30 microns were prepared by powder metallurgy. The characteristics of the nickel foams were studied by scanning electron microscopy (SEM). The mechanical properties were investigated by compressive tests. For comparison, nickel foams with a pore size of 1,300 microns manufactured by the traditional CVD method were also presented.

Materials and experimental methods

Starting material: Ni powder and space-holding particle material (NH_3HCO_3).
Compressive tests: were carried out on Ni foam samples at a strain rate of $1x10^{-3}s^{-1}$ at room temperature.

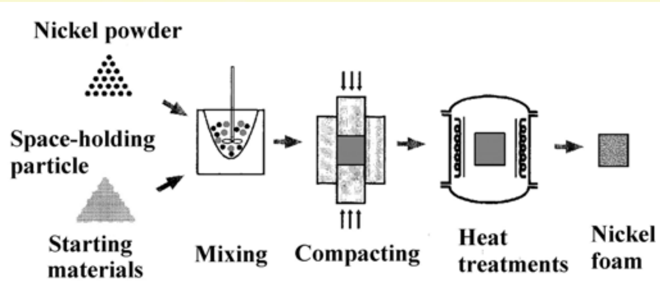

Figure 1 Space-holding particle sintering method used for the fabrication of the micro-porous Ni foams

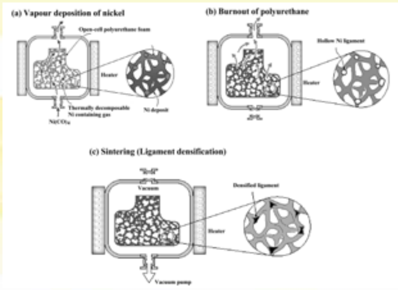

Figure 2 Nickel Deposition on Polyurethane Foams method used for the fabrication of the macro-porous nickel

Results and discussions

1. Porous structure of nickel foams

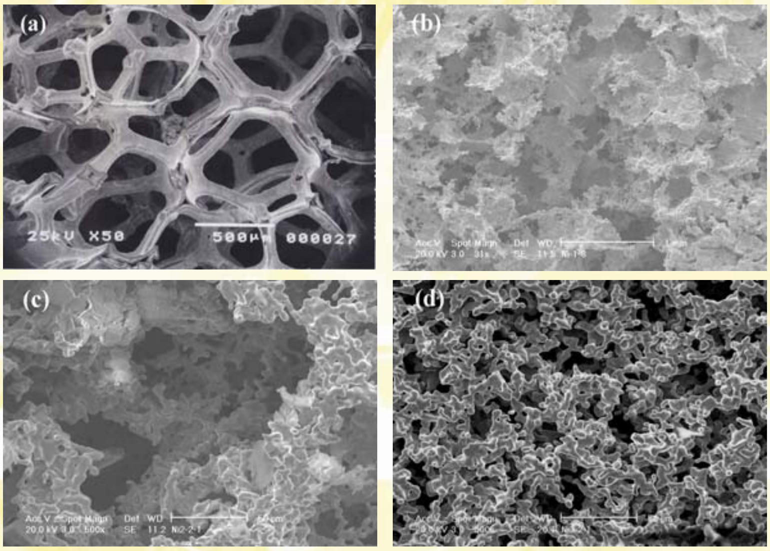

Figure 3 SEM micrographs of the macro and micro-porous Ni samples: (a) pore size 1300 μm, (b) pore size 800 μm, (c) pore size 150 μm, and (d) pore size 30 μm, respectively.

2. Characteristics of porous Ni samples

sample	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Porosity (%)	95	80	80	80	70	70	70	60	60	60
Pore size (μm)	1,300	800	150	30	800	150	30	800	150	30

3. Compressive stress-strain curves

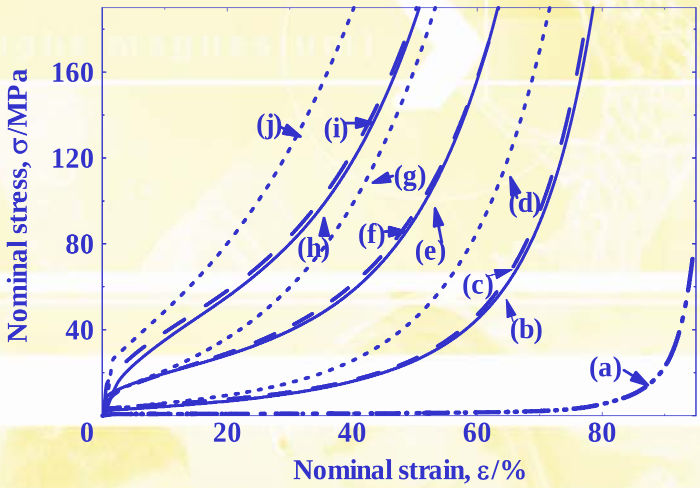

Figure 4 Nominal stress – nominal strain curves of the porous Ni samples (a)-(j).

Summary In the present study, porous Ni samples with the micro-porous structure were successfully fabricated by a powder metallurgical process. The porous Ni sample with a macro-porous structure was also produced by the traditional CVD method. The pore size of the porous Ni samples approximated 30 μm, 150 μm, 800 μm and 1,300 μm and the porosities ranged from 60% to 95%. Results indicated that the porous Ni samples with a micro-porous structure exhibited different deformation behaviour compared to those porous Ni sample with the macro-porous structures. The nominal stress - strain curves for the macro-porous Ni sample showed the typical compressive deformation behaviour. However, the nominal stress - strain curves for the porous Ni sample with a micro-porous structure showed different deformation behaviours, i.e. the flow stress increasing gradually with the strain after the initial elastic deformation stage. Furthermore, the mechanical properties are significantly enhanced by varying the pore size from macro-scale to micro-scale.