

Mechanical property and energy absorption of aluminium foams under dynamic and quasi-static compression

Jianyu Xiong, Yuncang Li, Mark Forrest, Peter D. Hodgson and Cui'e Wen
Centre for Material and Fibre Innovation, Deakin University, Geelong Victoria 3217, Australia

Introduction

The mechanical properties of aluminium foams can be improved by matrix reinforcement e.g. adding fine ceramic particles (SiC, B4C and CBN) in the base powder in the powder metallurgical route. Another method to improve the mechanical properties of aluminium foams is to impregnate Al foams with epoxy resin. The deformation behaviours and the energy absorption under dynamic and quasi-static compression of these improved Al foams were investigated in this study.

Experimental

Space-holder sintering process

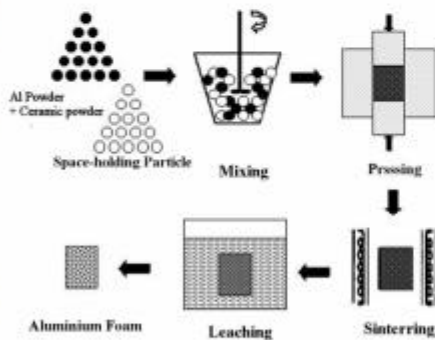


Fig.1 Space-holder sintering process

Impregnation process

For the preparing of the impregnated aluminium foam samples, aluminium foams with various porosities were prepared by the powder metallurgical method first. Subsequently, these foams were infiltrated with an 'infusion grade' epoxy resin (L285 and matching amine hardener H287).

Quasi-static compressive tests were conducted with a strain rate of $1 \times 10^{-3} \text{ s}^{-1}$ at room temperature using a 100 kN MTS testing machine with control software. Compressive samples with sizes of 10mm x 10mm x 20mm were cut from large sample plates. The energy absorption was calculated from the integrated area under the stress-strain curves up to 50% strain.

Stress-strain behaviour at dynamic strain rate was characterized using the Split Hopkinson Pressure Bar method (SHPB) at a strain rate range from $0.2 \times 10^3 \text{ s}^{-1}$ to $1.9 \times 10^3 \text{ s}^{-1}$. The relationship between the compressive stress and strain at a dynamic strain rate was characterized to evaluate the impact energy absorption of the aluminium foam samples.

Results & Discussion

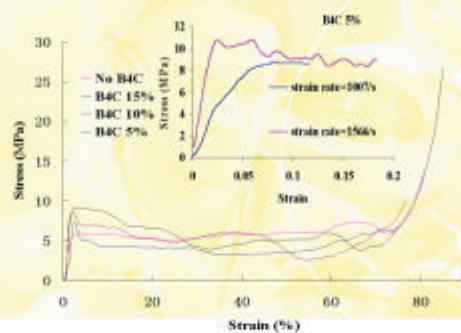


Fig.2 Dynamic and quasi-static compressive property of Al foams with 70% porosity and B4C additions

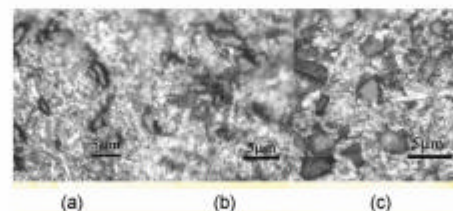


Fig.3 Microstructure of Al Foams with ceramic particle additions: (a) B4C addition, (b) SiC addition, (c) CBN additions

Table 1 Characteristic of Al foams conducted with ceramic additions

Specimens	Al (wt%)	NaCl (wt%)	C (wt%)	Porosity (%)	σ_{max} (MPa)	E (GPa)	W (MJ/m ³)
No ceramic	45	55		59.5	9.2	6.8	31.9
	35	65		69.8	8.9	5.9	10.9
With B4C	35	65	5	68.2	7.4	7.3	7.8
			10	67.9	8.5	8.0	11.3
			15	66.8	9.2	9.7	11.9
With CBN	35	65	5	68.6	6.7	4.5	12.6
			10	67.7	7.8	8.4	14.3
			15	68.9	8.4	7.8	19.4
With SiC	35	65	5	68.3	6.7	8.1	13.0
			10	67.7	8.5	7.5	15.5
			15	68.0	8.4	9.1	15.2

*C: Ceramic additions based on Al powder weight; σ_{max} : Peak stress; E: Elastic modulus; W: Energy absorption

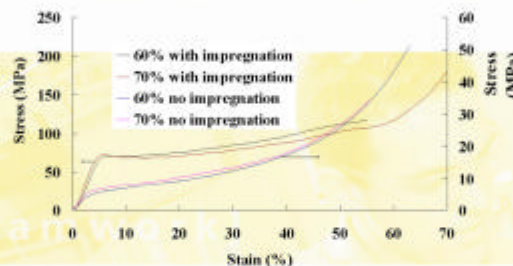


Fig.4 Compressive property of Al foams with resin impregnation

Table 2 Characteristic of Al foams conducted with resin impregnation

Specimens	Porosity (%)	σ_{max} (MPa)	E (GPa)	W (MJ/m ³)
No impregnation	60	6.9	1.7	22.6
	70	6.9	2.0	25.6
With impregnation	60	70.8	17.6	159.3
	70	72.8	18.6	150.2

* σ_{max} : Peak stress; E: Elastic modulus; W: Energy absorption

Conclusions

➤ Both methods are promising techniques to improve the mechanical properties and the energy absorption capacity of aluminium foam

➤ Ceramic particle additions such as B4C, CBN and SiC on Al foams are benefit to increase the peak stress and modulus of Al foams, furthermore change the mechanical properties

➤ The stress-strain curves of these composite foams show more fluctuation or instability in the semi-plateau region compared to Al foam without any additions. Dramatic increments of Energy absorption of Al foams with ceramic particle additions were observed in the present study except with B4C addition. Additions of B4C, CBN and SiC particles

➤ SiC and CBN additions reduce the stress-strain rate sensitivity of the aluminium foams, which CBN addition is better than SiC addition. B4C addition does not improve the stress-strain rate sensitivity of the aluminium foams. Furthermore, the mechanical improvement on Al foams by ceramic particle addition is confirmed by the SHPB testing

➤ The resin-impregnated aluminium foams exhibited much higher stress, therefore, much higher energy absorption during compression. The peak stress at the onset of the stress-strain curves for the resin-impregnated foam samples is nearly 10 times of that of the foam sample without resin impregnation.

➤ The energy absorption for resin-impregnated aluminium foams is nearly 6 times as that of foam sample without resin-impregnation. The modulus increases near 9 times compared with untreated Al foams. On the other hand, the resin-impregnated aluminium foams showed the lower stress-strain rate sensitivity.



Geelong Technology Precinct

www.deakin.edu.au