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Uni-directional porous metal fabricated by rolling of copper sheet and explosive compaction

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ABSTRACT

A new type of porous metal with uni-directional pores (UniPore) has been developed using the explosive compaction fabrication process of rolled copper foil with plastic spacers. The interface bonding in the novel UniPore metal structure has been investigated by metallographic analysis. The mechanical properties of the new rolled UniPore specimens with different porosities have been determined by experimental compressive testing in transversal and longitudinal directions.

1. Introduction

Porous metals have become an important building material in various modern engineering designs [1], due to their particular mechanical and thermal properties. Porous metals with uni-directional pores (UniPore structures) have been developed recently [2]. These materials are very similar to well-known gasar or lotus porous metals [3–5]) but additionally assure a constant cross-section (not irregular as usual for other porous materials [6,7]) through the whole specimen length with perfectly isolated pores between each other (Fig. 1a). This is achieved with unique fabrication method based on the explosive compaction of thin metal pipes [8,9]. The UniPore structure has an attractive combination of mechanical [8,9] and thermal [10] properties. However, the preparation procedure, which includes filling all inner pipes with paraffin to avoid complete compaction, has to be done very carefully to avoid any left over air bubbles in the pipes which would result in closed pipes during the compaction process. The moderate welding condition to form the wavy interface is not satisfied in some regions between the inner pipes due to varying collision inclination angle of pipes because of their round outer interface surface [8]. Additionally, the inner metal pipes with diameter < 3 mm and wall thickness > 0.2 mm are very difficult to obtain and their cost is very high. For these reasons a new fabrication method of UniPore structures is proposed in this paper. It is based on rolling of cheap thin metal foil with acrylic spacer bars positioned on one surface and the subsequent explosive compaction. Once the thin foil is accelerated uniformly between the spacers, the welding condition related with the collision angle is considered stable, similar to the conventional explosive welding process [11]. It should be noted that the outer dimensions, size of the pores, thickness of the internal walls and consequently the porosity can be easily adjusted for individual application needs. The microstructure of the new rolled UniPore specimens with different porosities has been investigated by the metallographic analysis, while their compressive behaviour in longitudinal and transversal direction has been determined with experimental testing.

2. Fabrication of rolled UniPore specimens

The new fabrication procedure of uni-directional metal copper UniPore comprises of i) preparation of the green specimen and ii) explosive compaction inducing the mechanism of explosive welding. Two different thin copper foils (JIS-C1100) with thicknesses of 0.3 and 0.4 mm were used to study their suitability for

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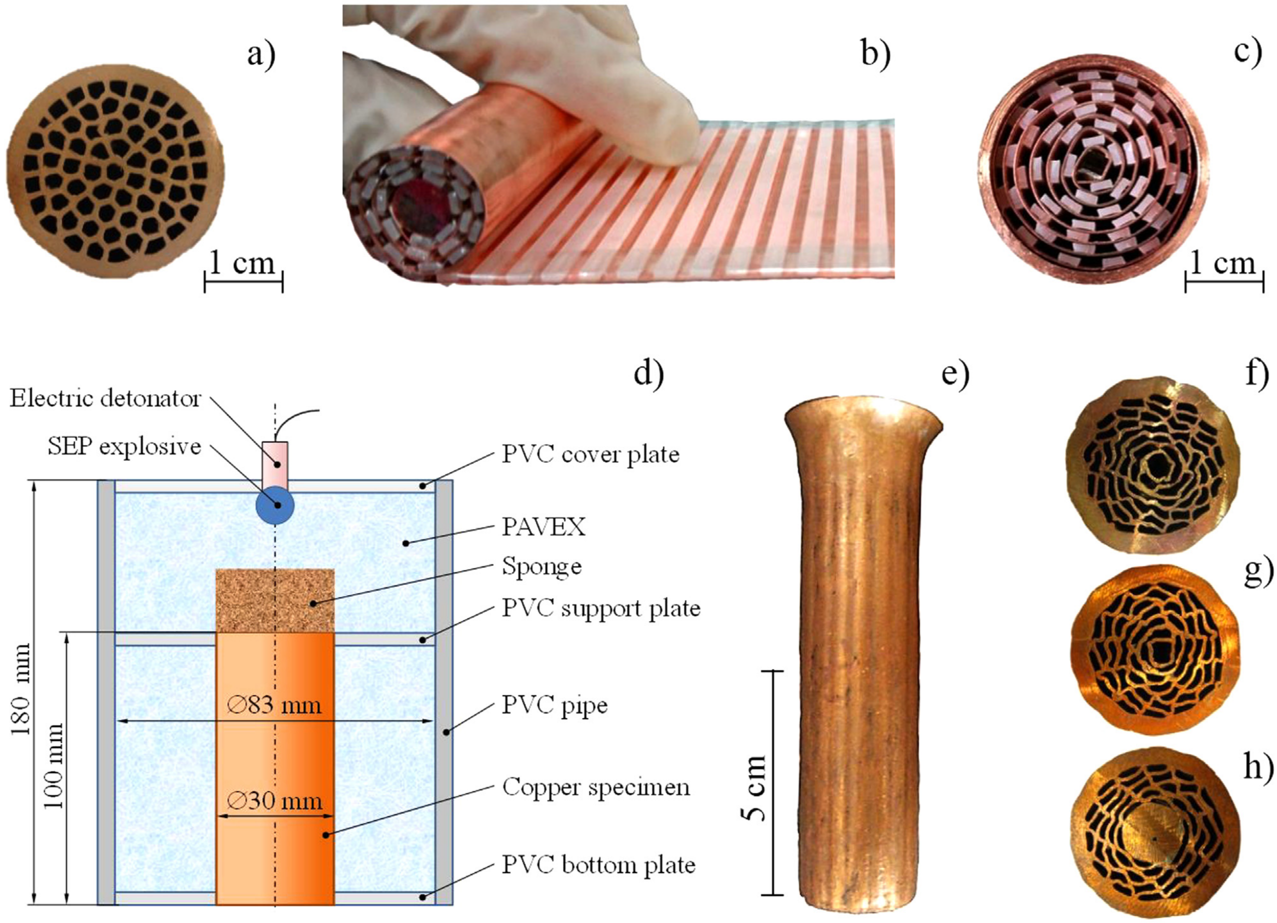

Fig. 1. Original UniPore structure made of explosively compacted copper pipes (a), rolling of copper foil with acrylic spacer bars (b), rolled foil inserted into the copper tube (c), experimental assembly for explosive compaction (d), recovered sample after compaction (e), structure with internal wall thickness of 0.3 (f) and 0.4 mm without (g) and with centre copper core (h).

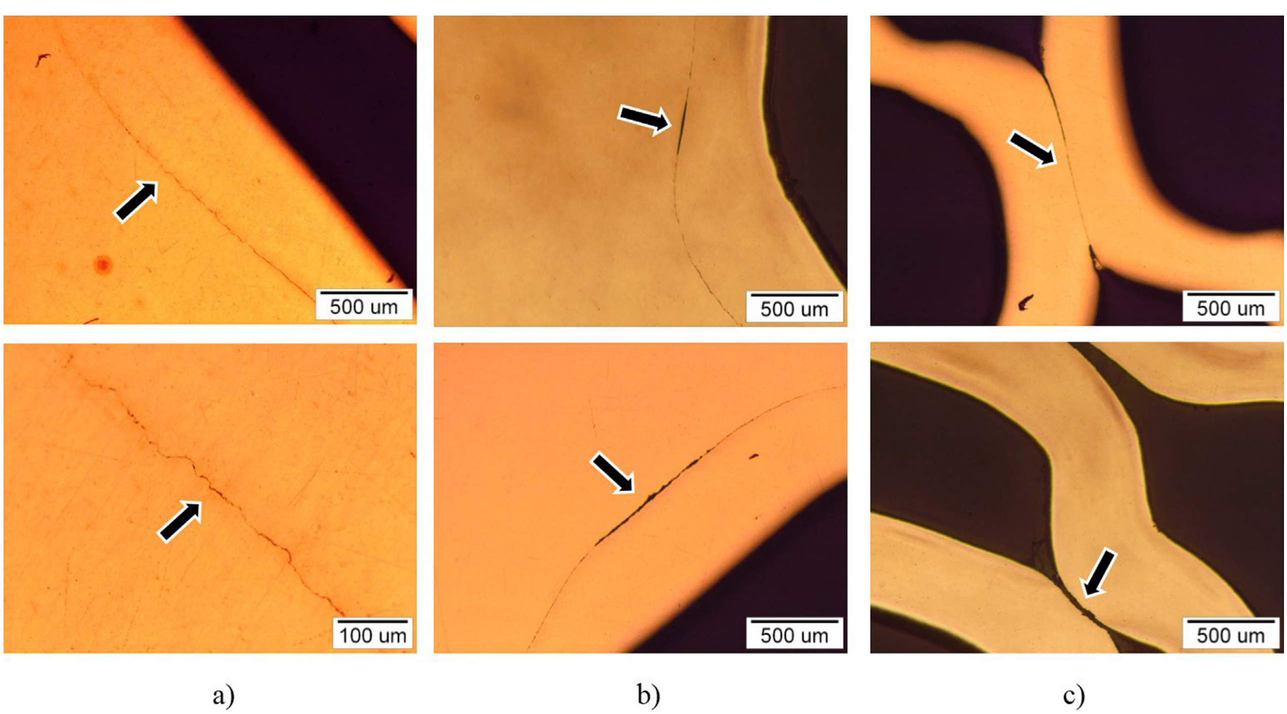

Fig. 2. Microstructure of samples cross-section, welding interface (a), interfaces with separation (b) isolation between pores (c).