PRODUCTION OF POROUS COPPER DISCS FOR HYDRODYNAMIC SHOCK EXPERIMENTS

Nicholas J. Bazin, Tim Whiteside, Sav Chima Doug Faith & Tina Jewell
AWE plc., Aldermaston, Reading RG7 4PR.

Abstract

This paper discusses the manufacture of porous copper discs in support of hydrodynamic gas gun experiments being performed at Imperial College London. At room temperature the density and integrity of the porous disks is shown to be a direct function of the applied pressure for a given material. Pressing was carried out using commercially available apparatus and characterisation included physical metrology, SEM and X-ray tomography analysis of both particle and pore size.

Introduction

The process used to induce a dynamic shock in to material involves a gas gun where by a flyer plate is accelerated down a closed tube driven by high pressure gas into a disk of the target material. Figures 1a and b show a typical gas gun and target chamber assembly respectively. The aim being to melt the target material through the transfer of the energy.

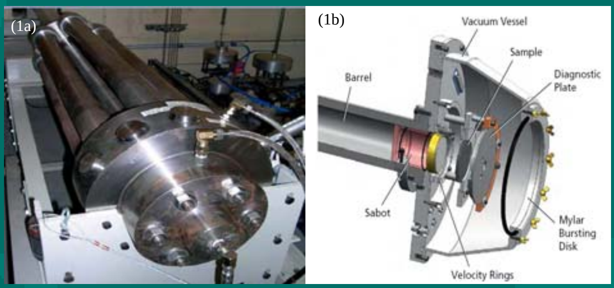


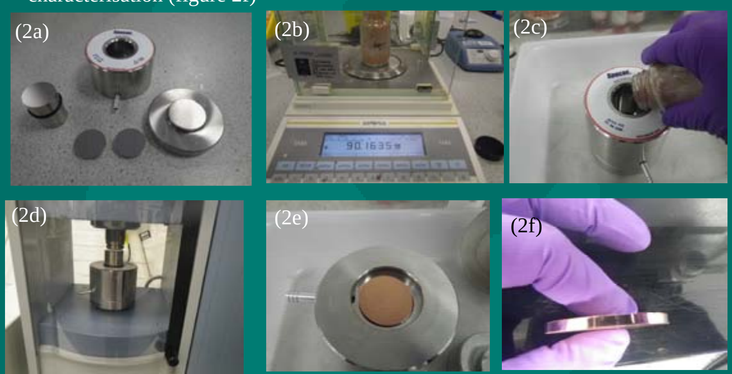
Figure 1: a) AWE Helium Gas gun and b) Target chamber.

However, due to the extreme pressures required to induce melting there is insufficient energy to achieve this in fully dense material. One solution is to build a larger gas gun, alternatively modelling suggests the use of porous materials would allow melting at lower pressures and as such this is the preferred option. The TFG group, has investigated the feasibility of pressing copper powder into disks of varying densities using a hydraulic press.

Experimental

The pressing process is carried out at room temperature. Details for pressing a powder into a disk are as follows:

1. Moulds and dies are prepared (cleaned and assembled, figure 2a)
2. The appropriate mass of copper powder (commercially sourced) is weighed out (figure 2b)
3. The powder is transferred to the die and the die is sealed ready for pressing (figure 2c)
4. The die is placed in the press (figure 2d) and pressed according to the set program i.e. applied load and time.
5. After pressing, the die is released (figure 2e) and the disk removed ready for characterisation (figure 2f)



Figures: 2 a) Die assembly for pressing copper disc 2b) Weighing out powder required 2c) pouring of powder in die 2d) die in press ready fro pressing 2e) Copper powder after pressing in the die 2fi) disc removed from die.

Results

The pressed copper disks were qualitatively found to be of varying texture and integrity with the higher density disks appearing reflective and solid whilst the lower density disks appeared matt and fragile. This is supported by SEM analysis shown in figure 3. The particles in figures 3a & b look similar with those packed close together enough to support itself as a solid billet. In figure 3c however the actual particles have been flattened, hence the bulk reflectivity. In both 3b and c it can be seen the pore size is comparable to that of the particles (<10μm).

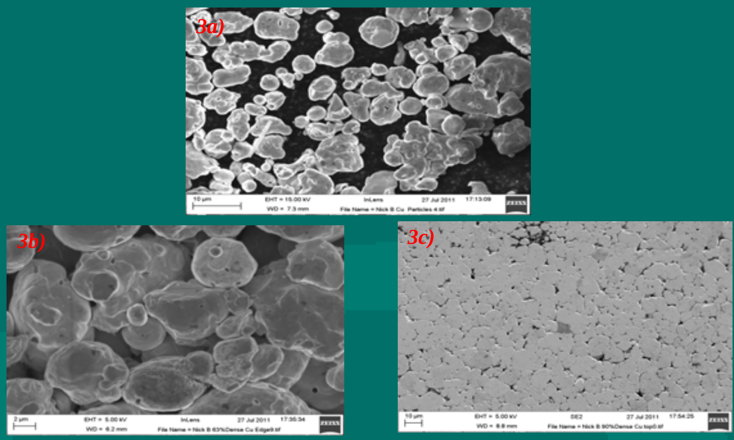


Figure 3: SEM image for the copper powder in a) its free form, b) after pressing into a 63% dense disk and c) a 90% disk.

The load applied using the hydraulic press can be varied from 5-40 tonnes, however, the density of the copper disk is more accurately a function of the pressure rather than the force. Figure 4a, shows plots for force versus applied pressure for the different diameter dies. It can be seen that pressures in excess of 100,000 PSI can be achieved using the appropriate die. Where the plots terminate show the limit of the die or the instrument. Figure 4b shows a density plot versus applied pressure (independent of the die diameter) this trend allows accurate prediction of the required pressures to attain specific densities.

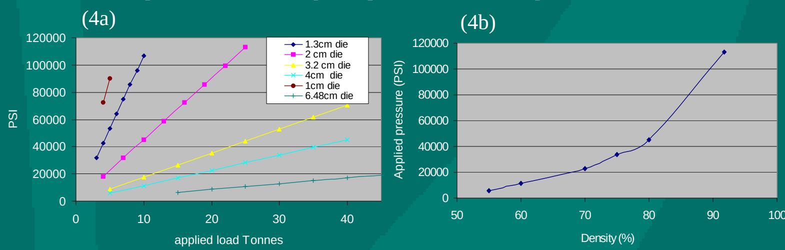
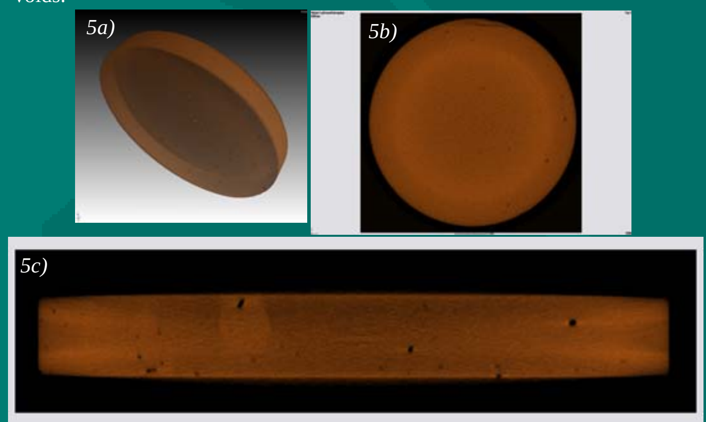


Figure: 4 a) Actual pressure as a function of applied force for different diameter dies and b) Density as a function of pressure for the copper particles.

X-Ray Tomography

All the data was captured on a Nikon XTH225CT Microfocus X-ray Computed Tomography system, the reconstruction was carried out with Nikon's CT-Pro GPU based volumetric CT reconstruction software and analysis conducted using Volume Graphics VG Studio Max V2.1 3D visualisation software. The system features a 225kV Microfocal X-ray source and a Perkin Elmer XRD0820 16 Bit Amorphous Silicon Flat Panel Detector which is 200mm square, has a 0.2mm pixel pitch and 1k x 1k pixels. The 20mm diameter, 2.5mm thick, 71% dense Copper foam sample shown in figures 5 a-c show qualitatively certain regions of denser copper (possible clumping and smaller voids.



Figures: 5 a-c) X-ray tomography of pressed copper disks