L.3 Laser Rapid Manufacturing of Porous Structures for Engineering Applications

Laser rapid manufacturing of porous structures of Inconel 625 using cross-thin-wall fabrication strategy was carried out and studied at Laser Materials Processing Division (LMPD). The porosity up to 60% in structure was achieved, which to the best of our knowledge is the highest in Inconel-625 structures using this route. Such structures are suitable for engineering applications in nuclear and chemical industries.

In Laser Rapid Manufacturing (LRM), the material is selectively deposited at the desired points. The locus of these desired points is called "LRM strategy". Various LRM strategies (like - Cross thin wall fabrication, Recursive ball deposition) are employed to fabricate the porous structures with independent control on porosity and mechanical properties. In cross thin wall fabrication strategy, the porous material is fabricated by depositing the material in mutually orthogonal directions in successive layers. Fig. L.3.1 presents a schematic of the cross thin wall fabrication strategy.

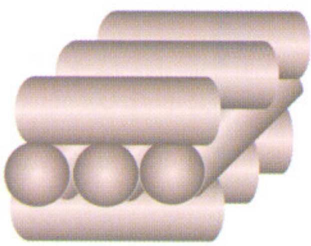


Fig. L.3.1: Schematic of the Cross thin wall fabrication strategy.

Fig. L.3.2 presents a typical laser rapid manufactured structure of ~20% porosity. These fabricated structures were characterized using various mechanical and metallurgical tests.

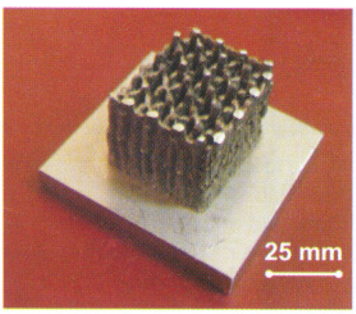


Fig.L.3.2: Laser rapid manufactured structure of ~60% porosity.

The range of the parameters under investigation were 120 kJ/m to 360 kJ/m for laser energy per unit traverse length, 10 g/m to 40 g/m for powder fed per unit traverse length and 0.7 - 2.4 for the transverse traverse index. The investigation showed that the powder fed per unit traverse length was a predominating parameter in determining the porosity of the structures, followed by transverse traverse index and laser energy per unit traverse length.

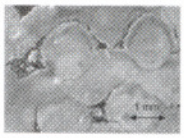
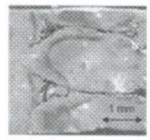
Along Scanning Direction (X-axis)	Along Transverse Traverse Direction (Y-axis)	Along Build-up Direction (Z-axis)
		

Fig. L.3.3: Typical optical micrographs of cross-sections of ~12% porous structure of Inconel-625 along different directions.

The pores in laser rapid manufactured specimen, as seen in Fig. L.3.3, were arranged in a regular array. The location of these pores was at the junctions of adjacent tracks and adjoining layers, specifically at the track overlap region. The shape and size of the pores were different on three different planes, indicating that the resultant porous structures had anisotropy in mechanical properties.

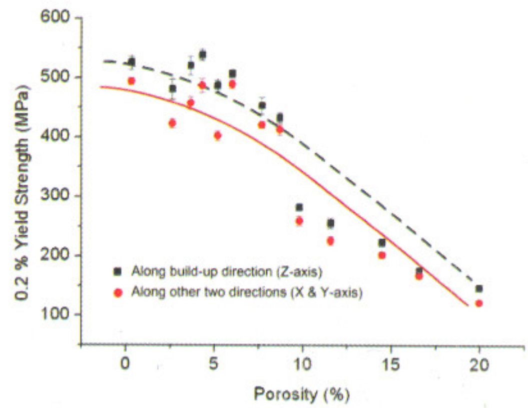


Fig. L.3.4: Standard 0.2% yield strength as a function of the porosity for Laser rapid manufactured cross thin walled porous structure of Inconel-625.

Fig. L.3.4 summarizes the results of compression testing of laser rapid manufactured porous structures and presents the standard 0.2% yield strength as a function of the porosity. The reported tensile yield strength of the conventionally processed Inconel-625 is 414 - 758 MPa, 414 - 655 MPa and 290 - 414 MPa in as rolled, annealed and solution annealed condition respectively.

These studies provide important insight into the fabrication of porous structures with independent control on porosity and yield strength.

Reported by:
C P Paul (paulcp@rrcat.gov.in) and L M Kukreja