

## L.2: Fatigue and Fracture Characteristics of Laser Rapid Manufactured Inconel 625

Laser Rapid Manufacturing (LRM) is an attractive tool for fast and economical fabrication of three-dimensional functional components. As LRM process involves layer by layer deposition in an open atmosphere, the as-fabricated components have oxide inclusions and micro-porosity. Moreover, the process, because of its inherent method of fabrication, involves cast microstructure with associated texturing and segregation effects. All these factors are likely to influence fatigue and fracture behavior of laser rapid manufactured components. The present work, carried out in Laser Materials Processing Division, involved fatigue crack growth rate (FCGR) and fracture toughness characterization of laser rapid manufactured structures of Inconel 625 (IN 625). These studies are essential to ensure the structural integrity of laser fabricated parts for implementation of LRM as an alternate low volume fabrication process. Various stages involved in fabrication of compact tension (CT) specimens for evaluation of fatigue and fracture toughness are shown in fig.L.2.1. Final machined CT sample is shown in fig.L.2.1D.

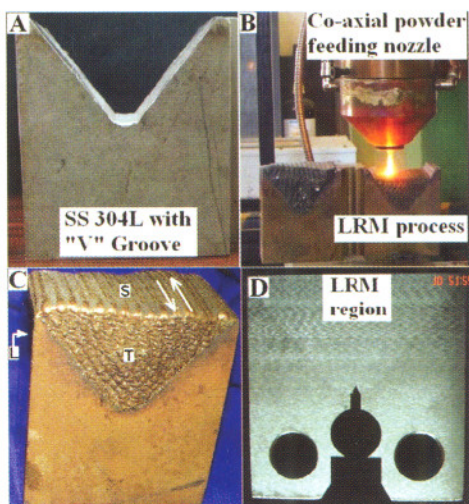


Fig.L.2.1: Sequence of steps involved in the fabrication of compact tension (CT) specimens of Inconel 625.

Fatigue and fracture toughness measurements were performed on 12 and 25 mm thick CT specimens (width,  $W = 50$  mm), as per ASTM E 647 and E 1820, respectively. After FCGR tests, same CT specimens, with desired fatigue crack length as per the ASTM standard E1820, were subjected to J-integral fracture toughness testing by single specimen unloading compliance technique. Fatigue crack growth in LRM specimens of IN-625 was characterized by steady crack growth (Paris' regime) in the investigated stress intensity range ( $\Delta K$ ) of 14-38  $\text{MPa}\sqrt{\text{m}}$ . In the  $\Delta K$  range of 14-25  $\text{MPa}\sqrt{\text{m}}$ , fatigue crack growth rate in laser rapid manufactured specimens was lower than that reported for wrought IN-625 as

can be seen in Fig. L.2.2. Inset of this figure shows fine fatigue striations, which indicates ductile nature of crack growth. J-integral test was associated with stable crack growth without pop-in behavior. The J integral fracture toughness values ( $J_{0.2}$ ) for 12 mm and 25 mm thick specimens were found to be 225-255 and 196  $\text{kJ/m}^2$  respectively. Figure L.2.3 presents dimpled fracture surface of J-tested region of CT specimen. This study demonstrates that LRM can be used to fabricate functional metal structures of IN 625 with adequate fatigue strength and toughness.

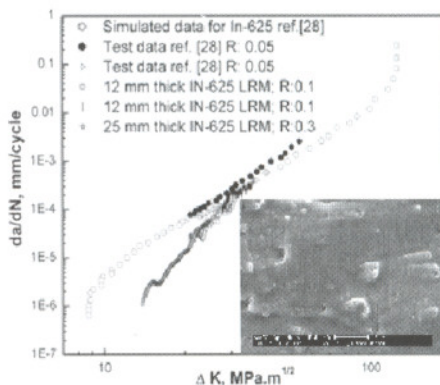


Fig.L.2.2: Comparison of FCGR data of LRMed IN 625 with that of reported data.

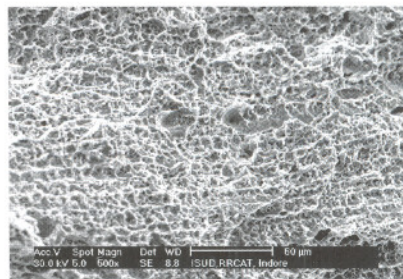


Fig.L.2.3: Dimpled fracture surface of J-tested CT specimen representing ductile crack propagation.

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## L3: Studies on Copper vapour laser pumped narrow line-width Rh110 dye laser

In Laser System Engineering Division (LSED) RRCAT, a CVL pumped narrow line-width Rhodamine 110 dye laser is indigenously developed. The tuning range (553 - 585 nm) of this dye laser is appropriate for selective excitation studies of isotopes of many elements including that of Ytterbium. The dye laser resonator consisted of double prism pre-expander (magnification  $\approx 20$ ), grazing-incidence grating (2400 lines/mm) and tuning mirror (Reflectivity  $\approx 100\%$ ). The dye