L.3: Laser Additive Manufacturing of specially designed nuclear components

Laser Additive Manufacturing (LAM) is leveraging high power and highly accurate laser technology to print a wide range of metals with new levels of precision, complexity and structural flexibility. LAM uses a high-power laser for pre-defined layer by layer fusion of powdered metals into fully dense three-dimensional structures based on the geometric information contained in a Computer-Aided Design (CAD) solid model. LAM is becoming important to address the diverse and extreme operating conditions of today's industrial arena, which cannot be satisfied by simple geometry components made of single-material. Recently, we employed in-house integrated 2 kW fiber laser based LAM system for the fabrication of two important components: *Honeycomb geometry orifice plate* and *SS-Ti graded transition joint*.

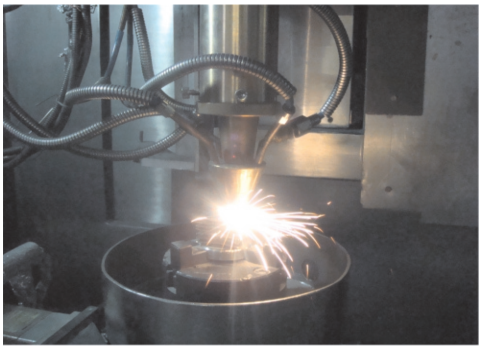

Fig. L.3.1: In-process LAM

Honeycomb geometry orifice plates made of SS304LN/SS304L are installed at inlet of Prototype Fast Breeder Reactor (PFBR) sub-assemblies as pressure drop devices facilitating stringent requirement of uniform temperature and flow distribution of liquid sodium. This honeycomb geometry orifice plate has a complex structure with several hubs and ribs joining each other. It is 120° symmetric and 60° rotation gives a full offset with respect to preceding plate stacked together. A number of techniques (including GTAW, conventional casting, investment casting) have been tried, but all yielded a limited success and further improvement for better dimensional control and surface finish is required. Hence, LAM of these orifice plates were taken up at our laboratory as per the input received from Central Workshop Division of IGCAR, Kalpakkam. The major challenge in fabrication of this orifice plate is its complex shape and hanging structure. Special methodology was developed to tame these issues for the LAM of these orifice plates. The LAM of these orifice plates were carried out in two steps. In the first step, the first half was manufactured with suitable cutting allowance. The deposited structure was cut along the diameter using electric discharge wire-cut machine and subsequently, other half was fabricated by keeping the deposited structure in inverted position on the specially designed fixture. Fig. L.3.1 shows in-process LAM while LAM fabricated honeycomb geometry orifice plate is shown in Fig. L.3.2.

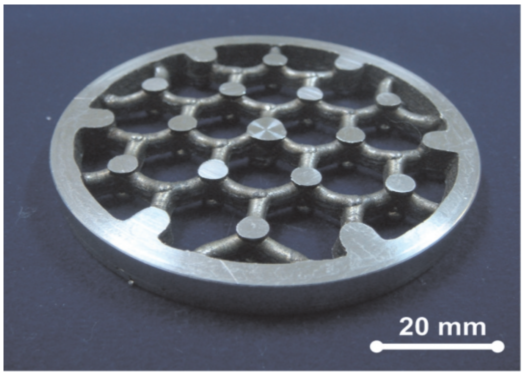

Fig.L.3.2: LAM fabricated honeycomb geometry orifice plate

The fabricated orifice plates were evaluated at Metrology Lab, Accelerator Component Design and Fabrication Section of RRCAT for its shape, size and surface finish and found confirming to the requirements. 10 nos. of such orifice plates are being fabricated and will be provided to IGCAR for further evaluation.

SS-Ti transition joint finds wide industrial applications including in reprocessing plant of nuclear reactors. Joining of SS-Ti using conventional welding processes does not yield defect-free and long-lasting joint due to metallurgical incompatibility. Therefore, traditionally non-conventional processes (like- roll bonding, pressure welding, explosive welding, vacuum brazing and diffusion bonding) are used to join these metals. When these joints are exposed to cyclic loading conditions, they are more prone to premature interfacial failure due to mismatch in thermal physical properties. As layer-by-layer deposition of LAM facilitates the variation of the material composition during the fabrication of the components in a controlled way, it was exploited to develop SS-Ti graded transition joint in our lab (Fig. L.3.3).

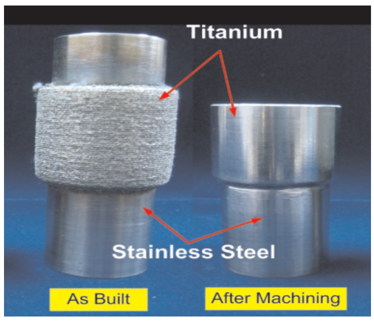

Fig. L.3.3: LAM SS-Ti Transition Joint

Reported by:
C. P. Paul (paulcp@rrcat.gov.in) and B. Singh