L.2: Diode pumped Nd:YAG laser for selective laser melting and its application

A Diode side pumped Nd:YAG laser of 70 W with M^2 value 3 was designed and developed at SSLD for selective laser melting application. Pump housing was described elsewhere in RRCAT newsletter article "L7, vol 20, issue2 2007". As the objective was to generate high power high beam quality (preferably TEM_{00} mode), laser resonator design was an important aspect of the development. Nd:YAG rod exhibits thermal lensing and stress induced birefringence, these two phenomena limits the extraction of high power in fundamental mode. Resonator mirror curvature and their separation from the active medium have to be optimised based on thermal lens data as a function of pump power to achieve the fundamental mode. Pumping uniformity is important to have large mode volume extraction hence we have used low doped (0.6%) Nd:YAG rod in our geometry. Resonator was convex-concave type resonator with 1m radius of curvature (ROC) convex mirror as rear mirror and 1m ROC concave mirror with 88% reflectivity as output coupler. Both were separated by 188 mm and 340 mm, respectively from the principal planes of the active medium. A 1.3mm water cooled mode selecting aperture was employed to select the fundamental mode. We could achieve an output power of 70W with M^2 value 3 in this configuration. However, with some latitude on beam quality we were able to reach 100W output power by adjusting the mirror separation and aperture diameter ($M^2 = 10$). The beam with higher M^2 value also can be used for SLM applications with some trade off on feature of the grown object. Spatial profile of the beam at 70 W is shown in Fig.L.2.1. The Input current to the laser diode vs laser output power is shown in Fig. L.2.2. The humps seen in the figure are the points where the resonator moves towards unstable zone in the g1g2 diagram of the resonator.

Selective laser melting (SLM) is an additive process to grow complicated objects using laser. Metal powder bed of predetermined thickness is created by spreading the metal powder. Focused laser beam is moved over the bed to fuse the powder along the trajectory of the laser beam. After one layer of fusion another layer of powder of pre-determined thickness is laid and again the laser beam is moved on it to fuse the powder. The process is repeated till the desired object is grown. Objects to be grown are first made in Auto CAD and then it is fed to laser scanner and focussing lens assembly through computer. In order to improve focusability of the laser beam from the resonator, it was first expanded using 6x telescope and then coupled to the laser scanner and focussing lens assembly. Focused spot diameter was measured using CCD camera based laser beam analyzer and was 80 m. Laser system, powder bed and powder spreading mechanism are schematically represented in Fig. L.2.3. Powder bed and spreading mechanism, designed and fabricated in our division are shown in Fig.L.2.4. Scanner and lens assembly along with software were purchased commercially.

Powder spreading chamber (PSC) houses powder reservoir, stepper motor driven translation stage to spread the powder and powder bed loaded on a translation stage. The powder bed is displaced to pre calibrated distance by a translation stage after the fusing process of the previous layer is over. There is a provision to evacuate the PSC and to fill it with inert gas like argon to avoid oxidation related issues. Figs.L.2.5 -9, show some of the objects grown using stainless steel powder. Rectangular solid block shown in Fig. L.2.6 was partially cut and its porosity was estimated to be 15%. Laser beams with slightly higher M^2 value can be used in applications like growing solid blocks as they don't need tight focussing of the beams. In fact, with such beams speed of growth can be improved due to comparatively larger spot size at focal plane.

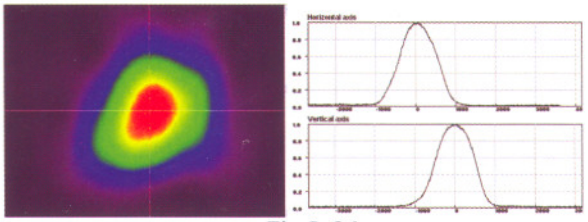

Fig. L.2.1

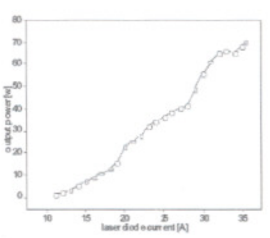

Fig. L.2.2

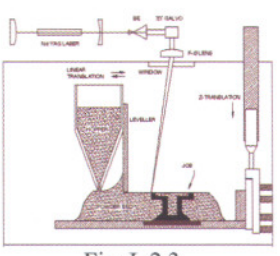

Fig. L.2.3

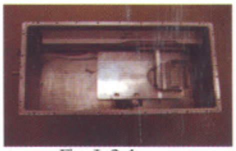

Fig. L.2.4

Fig L.2.5

Fig. L.2.6

Fig. L.2.7

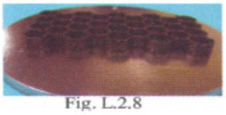

Fig. L.2.8

Fig. L.2.9

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