L.2: Diode pumped 1.4 kW fibre coupled continuous wave Nd:YAG laser

High power Nd:YAG lasers are suitable for industrial applications such as cutting, welding etc. Diode pumped Nd:YAG lasers have huge advantage, as it has better optical to optical and electrical to optical efficiencies when compared with lamp pumped system. Further, long life of pump diodes compared to flash lamp offers a laser system with low maintenance. Commercially available pump diode lasers are rated for life time of 10,000 hours which is more than order of magnitude higher compared to that of flash lamp. Nd:YAG lasers can be coupled to optical fibre to transport the laser beam to the work piece, thus enabling remote in-situ material processing operations. However, design and development of high power Nd:YAG lasers are not free from challenges as laser rod at high pump powers exhibits problems such as thermal lensing and stress birefringence, which plays major role in resonator design to extract high power or good beam quality or both. Good beam quality in terms M^2 value is an important parameter which plays a major role in coupling the laser beam to a fibre. Therefore, it is important to consider all issues in developing a fibre coupled high power Nd:YAG laser.

A high power diode pumped continuous wave (CW) Nd:YAG laser with output beam coupled to 600µm core diameter fibre was developed. Pump heads for the high power laser are made up of diffused reflector and three stacks of diodes, with each stack containing eight diodes. These stacks were arranged at 120^0 with respect to each other around the active medium. Three such pump heads were used in this system with each head employing 0.4 % doped Nd:YAG rod of length 150 mm and diameter 8 mm.

The pump heads were characterized individually by recording fluorescence, birefringence profiles, and measurement of thermal lensing. A plane-plane resonator accommodated the three pump heads placed equi-distant with 70% mirror as output coupler. Figure L.2.1 shows the schematic of resonator and fibre coupling setup. If the laser cavities are evenly placed between mirrors, their thermal lenses form a periodic lens-guide enabling power scaling while keeping the beam quality same as of single module.

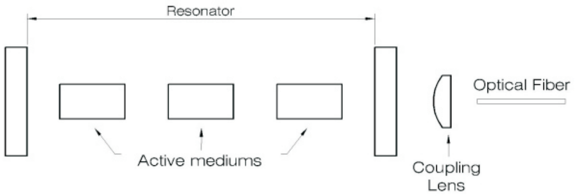

Fig. L.2.1: Triple pump head based high power fibre coupled Nd:YAG laser.

An output power 1.56 kW was achieved at input pump power of 4620 W in a 1.2 m long resonator.

This corresponds to an optical to optical efficiency of 33.8% and the measured slope efficiency was 41.9%. Figure L.2.2 shows the photograph of the laser in operation. Output coupler was optimized for maximum optical to optical conversion efficiency at high pump powers. Beam quality (M^2) value for this multiple head resonator was measured for the entire pump power range and it varied from 64 to 92. The output beam at maximum power was coupled to 600 micron core diameter fibre to deliver 1.4 kW output power. Laser power up to 1060 W can be coupled to fibre of 400µm core diameter. Figure L.3.3 shows the output power from the laser and fibre coupling efficiency vs input pump power.

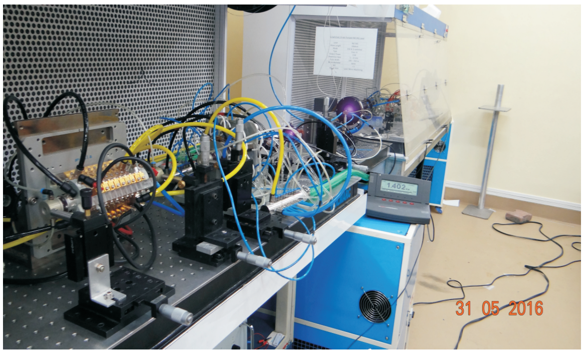

Fig. L.2.2 Photograph of the fibre coupled diode pumped Nd:YAG laser in operation.

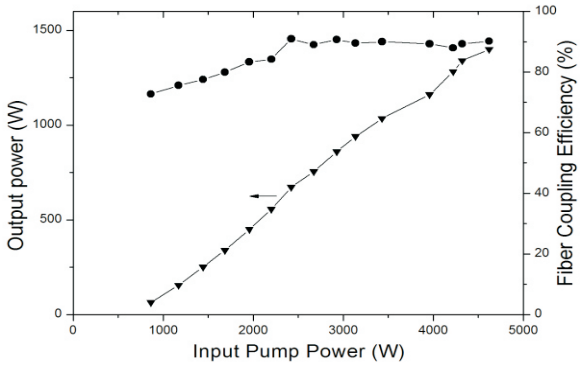

Fig. L.3.3: Output power from the laser and fibre coupling efficiency as a function of input power.

A high power diode pumped fibre coupled Nd:YAG laser operating at 1.4 kW was designed and demonstrated at Laser Development & Industrial Applications Division (LDIAD).

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