resonator have been measured with a rotating wire based laser beam analyzer (LBA). The experimental near field closely resembled the desired distribution. Fig.L.4.2 shows the PMMA burn pattern at 1.5 kW laser power. Measurements of laser power have been done both with the conventional spherical stable resonator and with the super-Gaussian GPM resonator. In conventional stable resonator a maximum of 3.2 kW power was obtained in a multimode laser beam while with the GPM resonator 2.8 kW power (η=10%) could be extracted in the super-Gaussian mode with an internal aperture diameter, 2a =22 mm, placed in front of the output coupler (Fig.L.4.3). With 18 mm aperture the GPM resonator yielded a maximum laser power of 1.8 kW in the lowest order mode. This indicates a remarkable enhancement in laser power extraction in single lowest order mode with large waist of the super-Gaussian beam compared to the power extracted by conventional (concave-plane) stable resonator with an internal limiting aperture diameter, 2a=19 mm, placed in front of the rear mirror which generates only 1.2 kW laser power in a mixture of TEM_{00} and TEM_{01}^* modes. The experimentally obtained far field distribution (Fig.L.4.4) of the generated super-Gaussian beam shows a single sharp maximum with negligible side lobes as predicted by the theory. Beam propagation studied with LBA also revealed the characteristic propagation behaviour of super Gaussian beam**.**

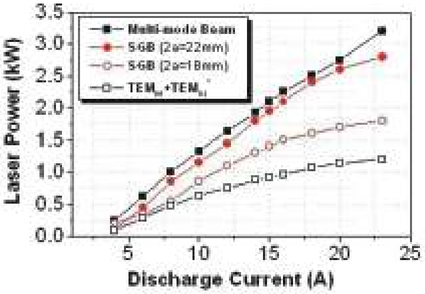

Fig.L.4.3 : Laser power with input current

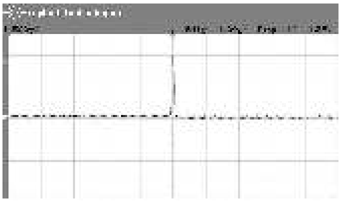

Fig.L.4. 4: Measured Far field intensity of SGB

Thus with this novel approach it has been possible to enhance remarkably the power extraction in single lowest order mode in transverse flow CO_2 laser and this will widen the range of laser material processing applications at ICLS, RRCAT.

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L.5 : A novel Nd:glass laser sub-nano second oscillator

Laser pulses of duration in the range of few hundred picoseconds to few nanoseconds find wide ranging applications in many areas such as laser plasma interaction studies, optical parametric chirped pulse amplification (OPCPA), non linear optics, fiber optic sensors etc. The OPCPA technique has now-a-days become popular for setting up prepulse-free, ultrashort, ultrahigh power laser systems. In this scheme, parametric amplification of a temporally stretched (chirped) seed laser pulse (typically of duration in the range of 200-400 ps) is achieved in phase-matched nonlinear crystals. This requires a good temporal/spatial overlap between the pump laser and the seed laser pulses/beams. Moreover, any fluctuation in the pump pulse energy or in the temporal overlap causes fluctuation in the optical parametric amplification gain and bandwidth, affecting the energy and duration of the compressed laser pulse. Hence, highly stable pump lasers, delivering synchronizable pulses of duration about twice that of the seed pulse, are desirable. Laser Plasma Division of RRCAT has developed a novel, flash lamp pumped Nd:phosphate glass based Q-switched and cavity dumped laser oscillator, which combines the techniques of full-wavelength switching and passive stabilization, to generate stable, synchronizable laser pulses of duration in the range of ~ 800 ps [A.K. Sharma, R.A. Joshi, R.K. Patidar, P.A. Naik, and P.D. Gupta, *Optics Communications 272, 455, 2007*].

A schematic layout of the laser oscillator is shown in Fig.L.5.1. It consists of three main parts: a) Q switch unit, b) flash lamp pumped Nd:phosphate glass laser rod (5 mm dia., 100 mm long) with reflector cavity, and c) cavity dumper unit. While the Q switch unit uses a deuterated KDP (DKDP) crystal based Pockels cell, the cavity dumper consists of a DKDP based double Pockels cell (DPC) in combination with a thin film polarizer kept near the DPC. The resonator cavity is formed by two ~100% reflectivity dielectric mirrors (one plane, other one with 6 m radius of curvature) kept 90 cm apart (round trip time of 6 ns). The active medium is kept closer to plane mirror side to improve the stability of oscillator. A typical spatial profile of laser beam is also shown in Fig.L.5.1. The beam diameter ($1/e^2$ points) was estimated to be ~2 mm.

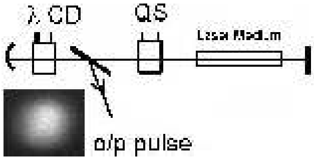

Fig.L.5.1 Optical layout of the cavity dumped oscillator and typical spatial profile of the output laser pulse.

In the present oscillator design, by applying a 3.4 kV single step pulse to the DPC of cavity dumper, one obtains laser pulses of duration of 800ps (governed by rise time of the HV step pulse). The laser cavity was dumped at a stable point (~4 round trips after the peak pulse buildup) of pulse buildup to minimize the fluctuation in energy of output pulse. Shot-to-shot rms fluctuation was ~2.5% in pulse height over 30 shots has been observed, which may be further reduced by minimizing the fluctuations in the flash lamp output and increasing the pump energy or optimizing the loss level of the cavity. The output laser pulses were synchronized with chirped laser pulse train (100 MHz pulse repetition rate) of 250 ps duration pulses derived from an independent cw mode locked glass laser oscillator (Fig.L.5.2). The temporal jitter between two pulses was measured to be ~200 ps, which is limited by the speed of the electronics circuitry. The oscillator design will be modified to get single longitudinal mode operation and super-Gaussian spatial and temporal profile of output laser beam for efficient optical parametric amplification.

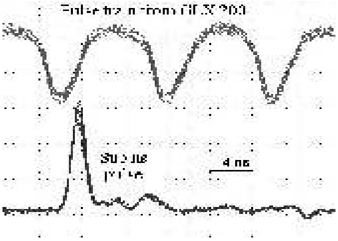

Fig.L.5.2: The laser pulses of sub-ns duration from the cavity dumped oscillator and 250 ps duration laser pulse train derived from an independent femtosecond laser oscillator.

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L.6 : Development of an efficient cw Nd:YAG laser

Solid State Laser Division of RRCAT is engaged in development of high power lamp-pumped cw and pulsed Nd:YAG laser systems for various material processing applications related to DAE. Over the past few years, our home-built pulsed Nd:YAG laser with 250 W average power and 5 kW peak power having multi-port fiber optic beam delivery has been established as a work horse for cutting of up to 14 mm thick stainless steel (SS) and up to 2 mm welding depths in SS and has been efficiently utilized for Indian nuclear power programme, as well as for various industries. However, for a few applications such as deep penetration welding (~5-10 mm) and laser rapid manufacturing, kilowatt power level cw Nd:YAG lasers with fiber optic beam delivery have been recognized as an efficient tool. In an initial effort to fulfill such applications, a cw Nd:YAG laser with maximum output power of 880 W, having an M^2 value of ~110, and 4.4% electrical to laser conversion efficiency, has been developed. The output beam has been efficiently delivered through a 600 µm core diameter optical fiber with a transmission efficiency of 90%. It may be noted that in most of the commercial lamp pumped cw Nd:YAG laser systems, the reported efficiencies are about 3-3.5%. This laser system is based on multi-rod resonator configuration in which two pump cavities have been placed in beam imaging configuration in an optical resonator. Each pump cavity has been individually optimized for maximum efficiency and good beam quality for input pump power from 0-10 kW by means of spectral conversion using a samarium flow tube over the rod and water flow optimization to reduce thermal lensing. Both the pump cavities have been made approximately identical to double the output power and to achieve the same beam quality as from a single pump cavity. During initial welding trials with this system, weld depths of ~1.5 mm with 2 mm weld bead size have been achieved. This laser system is being engineered with safety features and interfacing with CNC work station for commissioning at Material Science Division, BARC, for laser rapid manufacturing.

Fig.L.6.1: A view of the cw Nd:YAG laser giving a maximum power of 880 W.

Figure L.6.1 shows a view of developed Nd:YAG laser system. Fig.L.6.2 shows the variations of laser output power as a function of input pump power and Fig.L.6.3 shows M^2 value as a function of input pump power. It may be noted that the output power varies approximately linearly over the whole range of operation and may be used at any power level below the maximum value of 880 W.

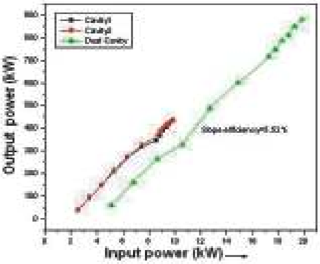

Fig.L.6.2: Output power as a function of input pump