Fig. L.3. 2 20 kW CW CO_2 Laser

(Reported by: A.K. Nath ; aknath@cat.ernet.in)

L.4 Laser based machine for Brachytherapy capsule welding

A laser based welding machine has been developed for welding of irradiation capsules (source), in a hot cell. At present these capsules are being welded by pulsed TIG welding machine that is not preferred any more for ensuring enhanced safety and reliability of source integrity over prolonged duration of use. TIG welding is not suitable for welding of small capsules (thin walled), in particular that of Cs-137 Brachytherapy sources. When these capsules are welded with TIG, due to over heating Cs-137 comes out of the capsules in the form of vapor during welding. The laser welding is the solution for such critical welding because with laser one can control and impart precise amount of thermal energy over a small area, which is just suitable for melting desired volume in a very small duration of time (few ms). Therefore total heat input to the job is minimum and bulk heating of job, to a high temperature, is avoided.

The machine consists of an Nd-YAG laser with fiber beam delivery system and a semi-automated laser welding workstation (see fig. L.4.1). The workstation consists of a job holding rotary fixture, driven by stepper motor, and a welding head. The jobholders (fixtures) are provided with precision sliding fit, with gearbox shaft and with the capsules. This is designed for ease of mounting and dismounting with the help of master slave manipulator (MSM) of hot cell. Two holders are designed for two different size capsules in such a way that welding plane is maintained with respect to cutting head (focus plane of the lens). Specially designed spring catches are provided, at both the locations, to avoid slip or movement between job and holder and also between holder and the shaft

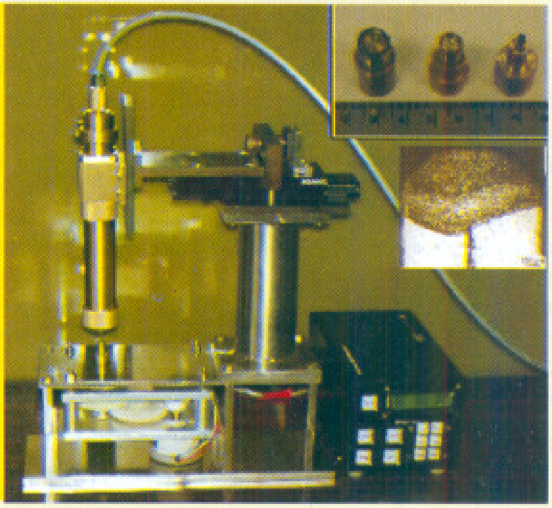

Fig. L.4.1 Capsule welding work station (Inset- welded capsules & cross section of weld-ment).

The welding head is mounted on a precision slide. When the slide is at one extreme the welding head is just above the seam and is kept in the precise position by mechanical stopper cum magnetic catch. The welding head can be moved to other extreme of the slide to replace the new capsule assembly using MSM. One such machine is installed at BRIT, Mumbai, where regular production of capsules is being done.

(Reported by: T P S Nathan; nathan@cat.ernet.in)

L.5 Development of multirod CW Nd: YAG laser

The output power of a solid-state laser can be scaled to higher levels by using multirod systems. We have developed a CW dual cavity Nd:YAG laser capable of producing output power more than 570Watts. The gain module consists of 8mm dia. x 150mm long Nd:YAG crystal pumped by a single krypton arc lamp in a close coupled gold-plated elliptical reflectors geometry. The laser cavity and lamp is cooled by chilled de-ionized water using closed loop water chiller unit. The arc lamps are powered by constant current switch mode power supply with maximum arc voltage of 180V and a regulated current up to 55A. The unique feature of the power supply is, that all the four lamps are parallel triggered with common trigger and booster circuit. Since each lamp is powered by individual DC power source, current flowing through the lamps can be individually controlled. This feature is essential to adjust the imbalance in the performance of gain modules.

The resonator is formed by plane-plane mirrors and stabilized by thermal lensing of the Nd: YAG rod. With the optimized single gain module, for an input pumping power of 10kW, we achieved more than 300Watts output power. The beam parameter product (BPP) was found to be 32mm mrad. Using a lensline-like setup the beam quality of multirod symmetrical resonator with 'n' modules and a total length of 'nL' is identical to that of a single resonator of length 'L'. In order to preserve the beam quality in dual gain set-up the same design was employed. And the resultant beam quality was found to be same as in the case of single gain module. Our future plan is to add two more gain modules i.e. total four modules to increase the output power beyond kW level and subsequent fiber coupling of the laser output will enable us to carryout material processing applications.

(Reported by: T P S Nathan; nathan@cat.ernet.in)

L.6 Development of fiber-optic distributed temperature sensor

A fiber-optic distributed sensors work on the principle of Optical Time-Domain Reflectometry (OTDR). A short laser pulse is launched into the fiber and the Raman backscattered signal is monitored at the launching end by time-gating the signal. Every point in the fiber produces the Anti-stokes and Stokes components of Raman scattered signal. The ratio of the anti-stokes to stokes signal is a direct function of the absolute temperature of the scattering point. Therefore, by obtaining the two signals individually one can obtain the continuous spatial variation of temperature along the fiber length. The performance of the sensor is adjudged by two parameters namely, spatial resolution and temperature resolution.

The spatial resolution determines how closely separated two hot zones are resolved. This parameter is governed entirely by the laser pulse width and the detector bandwidth. For higher spatial resolution one must select shorter pulses. A 100ns pulse will give at best a spatial resolution of 10m. The temperature resolution determines how closely separated two temperatures are resolved. The temperature resolution is determined by a number of factors such as backscattered signal level, signal averaging capability and detector noise.

In the present setup, a frequency doubled Nd:YAG laser having pulse width of 85ns and pulse energy of 2μJ is being used as the source of short laser pulses. A 200μm silica fiber (core 800micron, NA 0.21) is used as the sensor. A monochromater and photomultiplier tube is being used for detection, and a Boxcar unit is used to time-gate and average the signal. Digitized data is transferred to a PC for post-processing, which involves further digital filtering and calculation of stoke to antistoke intensity ratio.

In the present settings the spatial resolution has been determined to be 8.5m and a temperature resolution of 5°C has been obtained. Efforts are on to upgrade the laser being used in order to improve the temperature resolution. It is expected that a laser of higher pulse energy and better stability will enable us to achieve better temperature resolution although a resolution of 5°C may be adequate for early fault detection in many practical systems.

Fig. L.6.1 shows a representative case. Two 25m sections of the fiber were heated to a temperature of 65°C. The ratio of the Anti-stokes and Stokes signals is shown here. This data is digitally filtered and the temperature is calculated from it using a standard formula in which the only unknown variable is the absolute temperature.

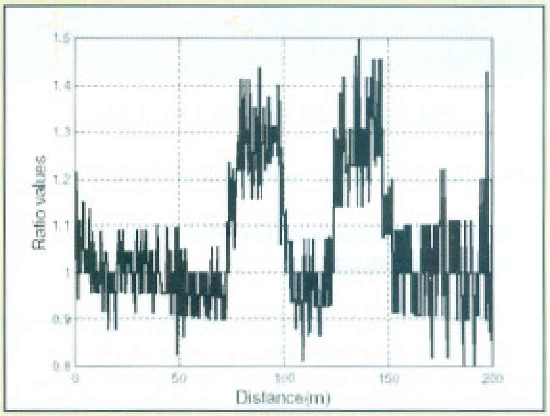

Fig. L.6.1 Ratio of Anti-stokes to Stokes signal from a 200m long fiber with two 25m sections heated to 65°C

(Reported by: T P S Nathan; nathan@cat.ernet.in)

L.7 Simultaneous measurement of pulse-front tilt and pulse duration of femtosecond laser beam

Since the last decade, chirped pulse amplification based ultra-short pulse laser systems are being increasingly used for a variety of research investigations in ultrahigh intensity laser matter interaction. Slight misalignment of the gratings used in these laser systems may produce a pulse-front tilt. The pulse-front may also get tilted on propagation through dispersive elements like prism due to the relative