L.9: Design, fabrication, testing and installation of a vacuum chamber for pulse compressor of a 50 TW laser system

A vacuum chamber, to house the optical pulse compressor of a 50 TW laser system, has been designed, fabricated, tested at Accelerator Components Design and Fabrication Section, and installed at Laser Plasma Division. The 650 ps laser pulses from the stretcher are amplified in Nd:Phosphate glass amplifiers and then compressed in time in the pulse compressor. After the pulse compression, the intensity of the laser pulse becomes very high, which can cause distortion and self focussing of the laser beam if transmitted in air. Hence, the beam (from pulse compression onwards) has to be transported in vacuum, hence the need of the vacuum chamber.

The overall inside dimensions of the chamber are 2100 mm x 850 mm x 600 mm. It has been made in two cuboidal segments considering the constraints of handling / transportation to the laboratory. A vacuum compatible breadboard (of size: 1800 mm x 750 mm x 100 mm thick), for mounting optical gratings and reflective optics for compression of the optical pulse, has been kept inside the chamber. The chamber is made of stainless steel with rectangular and circular demountable ports for entry and exit of the laser beam, evacuation, feed-throughs for stepper motors and detectors. The front and back sides of the chamber are kept demountable (openable) of size 850 mm x 600 mm in order to insert the breadboard with optical components mounted on it. The top of the chamber is provided with four demountable openings (of sizes: 550 mm x 300 mm) for the purpose of access to optics mounted on breadboard from top without opening the chamber from side. One side of the chamber has entry and exit beam port and evacuation port with compatible flange for gate valve and TMP. An additional port for evacuation has also been provided. The back side is provided with two ports for optical diagnostics. Both the sides have two ports each for measurement and feed-throughs.

The design of the chamber is based on the theory of plates. The chamber is designed rigid enough to withstand the external pressure equal to atmospheric pressure, as well as keeping deflection with in limit for sealing the demountable joints with the help of 'O' rings reliably. In this, we have designed separate plates using theory of plates with end conditions as fixed ends in order to keep conservative approach. All the groves are designed very carefully with proper groove dimensions to fulfil the sealing requirements i.e. appropriate surface contact and surface finish of the order of 1.6 micron. All permanent joints are designed in such a way that no crevices are left, thus avoiding trapped volumes.

Manual GTAW welding process was used for welding using AWS 5.9 ER 316L filler wire and ultra pure argon gas under controlled RH (< 40%) in clean room. As higher coefficient of thermal expansion of austenitic stainless steel leads to unacceptable distortion during welding, the proper fixturing was used to avoid the same. The chamber was machined on CNC horizontal boring machine for its desired tolerances. Surface finish of the order of 1.6 micron was achieved on sealing surfaces of the components using positive rake polished insert face milling on 4- axes CNC milling machine. Surface finish of all the 'O' ring grooves is better than 1.6 micron, with no scratches and dents.

Fig.L.9.1: Photograph during leak testing

All crevices in trapped volume were removed to facilitate evacuation of the chamber. The stainless steel central chamber and other stainless steel parts were chemically cleaned and electro-polished in order to reduce the outgassing from them, while all aluminum covers plates were cleaned thoroughly for the same reason.

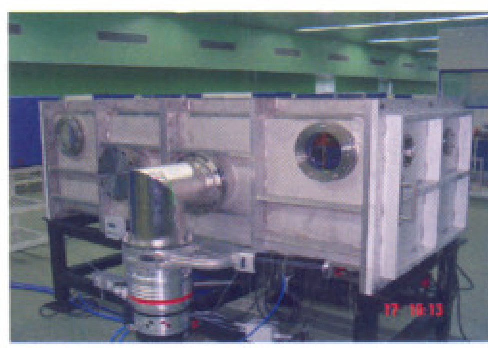

Fig.L.9.2: Photograph of the installed chamber

Leak tightness of 9×10^{-10} mbar-lit/sec in all the joints and ultimate vacuum of the order of 10^{-5} mbar was achieved in the chamber (keeping all the relevant optical gratings and reflective optics duly mounted inside) using a turbo molecular pumping system of 1250 lit. / sec, connected through a high vacuum gate valve. This chamber is now a part of the 50 TW laser system. Figures L.9.1 and L.9.2 show the photographs of the chamber during leak testing and after installation respectively

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