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PLASMA LENS DESIGN FOR ACOL

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The two lens design versions shown in Figs. 1 and 2 are slightly modified forms of the prototype lens tested at CERN. The operating principles and performance of the prototype lens have been described by H. Riege, E. Boggasch and H. Gundel[1].

The changes to the lens design include water cooling, the insulating tube and the beam windows. In addition the operating position of the lens has been rotated from the vertical to the horizontal position and the strip line connections have been relocated.

VERSION 1

The lens shown in Fig. 1 has two concentric aluminium oxide (Al_2O_3) insulating tubes cooled by demineralised water. They are sealed at their ends by preformed graphite seals. The seals position the insulating tubes radially and are compressed by insulated tie bars (not shown in the figure). The tie bars traverse the strip line and are attached to six cantilevers at each end of the lens body. The bellows on the right side of the lens body permit movement for compressing the graphite seals.

The double beam windows at each end of the lens permit water cooling of the internal window exposed to the plasma radiation. The external window is also for security in the event of micro cracks occurring in the primary window. A safety interlock will shutdown the pulse generator and proton beam in the event of the window cracking. Water is fed radially to a ring channel in the cover in order to cool it and then the water flows to the outside of the primary window via radial grooves. The electrodes are cooled via tubes brazed on their outside.

The cover and the space for the water, gas and vacuum connections behind the electrodes are shielded from the high thermal plasma radiation by wolfram shields fixed to the end covers.

The lens body is mounted on a combined strip line and support structure on which the water cooling and vacuum connections are also mounted. The vacuum and water pipes are electrically insulated using ceramic spacers. Metal quick release couplings are fitted to allow operation using a remote manipulator (screw connections shown in the figure are symbolic).

The two strip lines which supply the 400 kA at 10 kV to the lens are connected to a bank of capacitors located in a tunnel under the lens. The strip lines are connected to the lens via quick release clamps.

The strip lines, gas-vacuum system and general installation layout are not yet finalised. Great care will be taken to ensure that the installation is compatible with a radioactive environment (i.e. quick release connections and a dust and gas collector).

The emchanical design of the lens is relatively simple, and the major problems are the selection of the materials for the windows and their dimensions. The windows are highly stressed due to (i) the high intensity particle beam causing a high temperature gradient; (ii) the plasma pressure of 100 bar (iii) the thermal plasma load and (iv) the chemical action of the hydrogen gas causing hydrogen embrittlement and loss of material. Also the reliability and reproducibility of the graphite seals have to be verified by assembling them several times with a manipulator.

The greatest advantage of this lens design version is the ease of handling in the laboratory for cleaning, inspecting and modifying the insulating tubes and electrodes.

VERSION 2

Version 2 of the plasma lens incorporates an all-welded electrode, an insulator, a cover and an insert construction. The two concentric insulating tubes have brazed collars between them and the electrode inserts. These collars are electron-beam welded to the insert body. The internal insulating tube is mechanically protected and located in position by a graphite spacer which also protects the insert body from thermal radiation. The electrodes are made from two wolfram discs brazed together and are cooled via internal water channels.

This design provides a welded electrode-insulator-cover unit which can be easily manipulated in a radioactive environment. In addition tie bolts traversing the strip lines are no longer necessary (as in Version 1) because the graphite spacer has no water sealing function.

CONCLUSION

The higher cost of a single Version 2 lens would probably be offset by the reduction in manipulator and specialist time during removal and maintenance of the lens. The disadvantages of Version 2 would be the difficulty of access during tests, cleaning and inspection of the electrodes and insulator. In addition the surface area of the insulator for cooling is reduced due to the collars (this could be improved) which might also cause electrical problems.

The advantages of each version must be assessed once the final specification and parameters of the lens, the mode of operation, the lifetime and the cleaning intervals have been decided. The radiation protection problems, i.e. dust and gas collection, maintenance and storage must also be considered.

REFERENCE

1. Plasma Lens Workshop, Capri, October 1987, CERN/PS/87-99 (AA).