MECHANICAL DESIGN OF THE PROTOTYPE H$^-$ ION SOURCE FOR THE SPALLATION NEUTRON SOURCE *

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Abstract

The mechanical design of the prototype H$^-$ ion source for the Spallation Neutron Source (SNS) is presented. Experience obtained in the ongoing SNS R&D program is being utilized in the current design. The physics design parameters require a 2 MHz RF-driven multicusp ion source operated at 50kW, pulsed (6% duty factor) RF-power. The four major components (plasma-generator, cesium collar, outlet electrode, the source tilt mechanism) of the mechanical packaging of the ion source will be presented in details. The mechanical design has the unique capability of tilting the ion source in one plane in order to compensate the H$^-$ ion beam deflection caused by a strong magnetic field across the outlet aperture. This B- field deflects electrons in the extracted beam back to the outlet electrode. An articulating strut system will provide accurate control over the adjustable tilt angle. This new ion source design will provide easy serviceability of maintenance parts like the RF-antenna and the cesium dispensing system.

1 INTRODUCTION

Experiments [ref.1] performed with an existing volume H$^-$ source helped establish the design requirements for the prototype ion source for the SNS project. A plasma chamber size of 11.5 cm in diameter and 11.5cm in length has been found to be an optimum size for the prototype ion source. Installation of a cesium collar near the outlet electrode proved the advantage of reduced extracted electron current together with a significant increase in the H$^-$ output. The optimum operating temperature of the collar was found to be 300^o C. The location of the filter-magnet from the center of the outlet electrode was optimized to 15 mm. The above-mentioned results, helped establishing the base line design parameters.

2 MAJOR COMPONENTS

The modular design approach of the prototype source is meant to provide easy access to serviceable components with minimum changeover time.

There are four major sub-assemblies in this design: (1) The plasma chamber and cusp magnet assembly, (2) The outlet electrode assembly, (3) The back flange assembly and (4) The tilt mechanism. Each sub-assembly has its cooling system for removing the heat generated by the plasma particles hitting the chamber wall. Figure 1 shows the general arrangement of the prototype source.

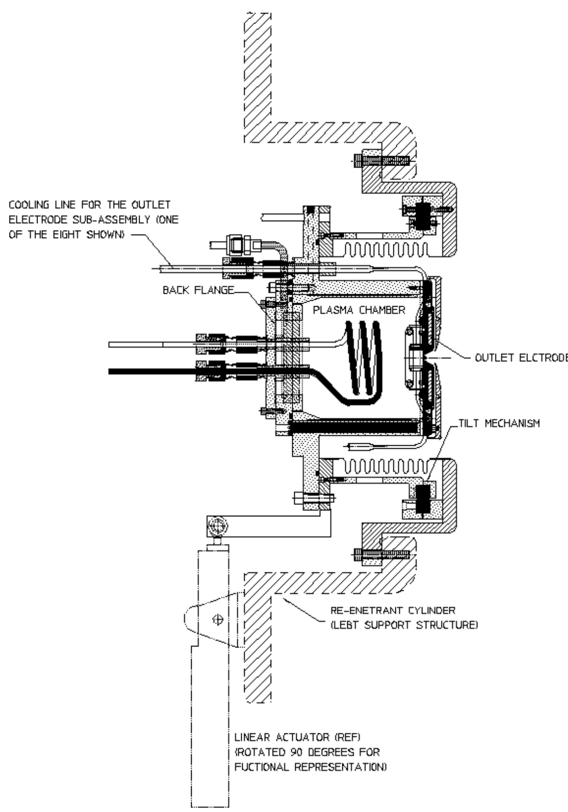

Figure-1 Ion source general layout

2.1 Plasma Chamber

The plasma chamber is machined out of 316L stainless steel and welded with another concentric chamber that holds the twenty NbFeB cusp magnets. The thin annular space between these two bodies is utilised as a cooling jacket. There are four cooling circuits for uniform heat removal from the twenty rows of magnets. The back flange and the outlet electrode at the two ends terminate the plasma

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2.2 Outlet Electrode

The outlet electrode sub-assembly (see figure-2) consists of the outlet electrode itself, the electron deflection magnets, the electron dump electrode and the cooling channels for each area. The filter magnet and the cesium collar assemblies are also mounted from the outlet electrode. Eight cooling lines are oriented azimuthally and they come out through the corresponding vacuum feed-through on the main flange of the plasma chamber assembly. This design allows us to remove the outlet electrode sub-assembly from the source in one package and it provides easy service of the cesium collar. The alignment of the electrode with respect to the plasma chamber is critical. Use of an accurate fixture during mounting the pre aligned electrode assembly will enable us to reach the alignment target described in section 4.

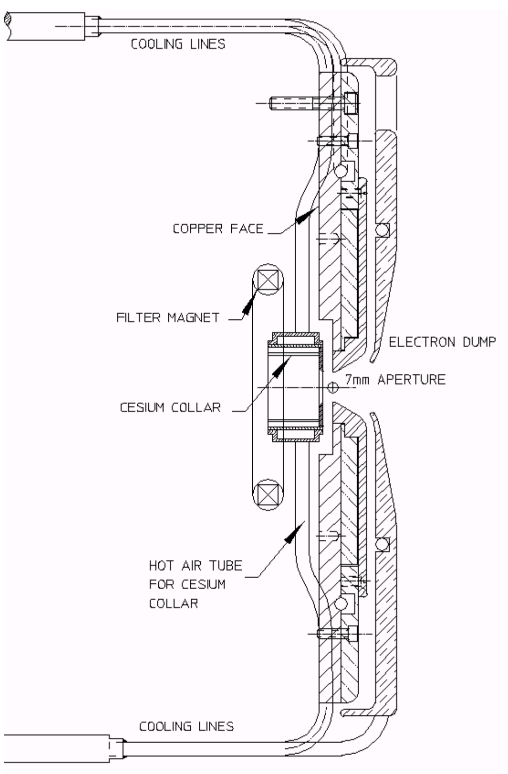

Figure-2 Outlet Electrode Layout

2.3 Back Flange Assembly

The back flange (see figure-3) has four magnet slots and a cooling passage machined in the 304 stainless body. A hidden O-ring serves as vacuum seal between the plasma chamber and the back flange. The RF antenna is mounted through another smaller flange, which facilitates easy repair of feed through components. The two flanges are vacuum-sealed by o-ring. There are two -quartz-window flanges, welded on the back flange. They are needed for laser beam for plasma starting. The back flange sub-assembly is attached with the main flange of the plasma chamber. By removing the back flange section, the RF antenna can be replaced without disturbing the alignment of the ion source.

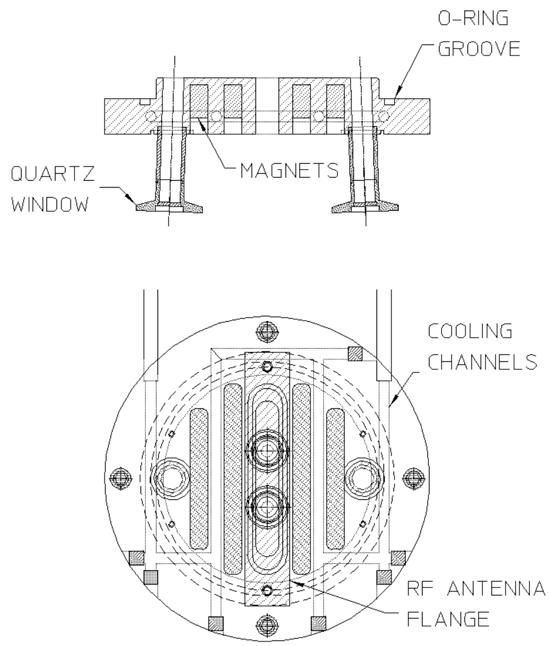

Figure-3 Back Flange Layout

2.4 Tilt Mechanism

To compensate for the deflection of the H^- ion beam due to the strong magnetic field across the outlet electrode, the source has to be tilted. The maximum tilt range is 0 to 6 degrees. This is achieved by mounting the whole assembly on two flexural pins and a bellow connection that will allow the outer support cylindrical structure of the source assembly to articulate in the horizontal plane. The movement of the stainless steel bellow is limited to three degree. The bellow is adjusted to three degree at the neutral position. A stepper motor controlled actuator can rotate the rear end of the source assembly through the required travel. Figure-4 shows the three positions of tilt of the ion source. The resolution of the actuator movement is accurate enough to articulate the source in very small increments to suit the operating criteria of the source. The source is prevented from tilt past the zero position by a physical stop in addition to the limit switches.

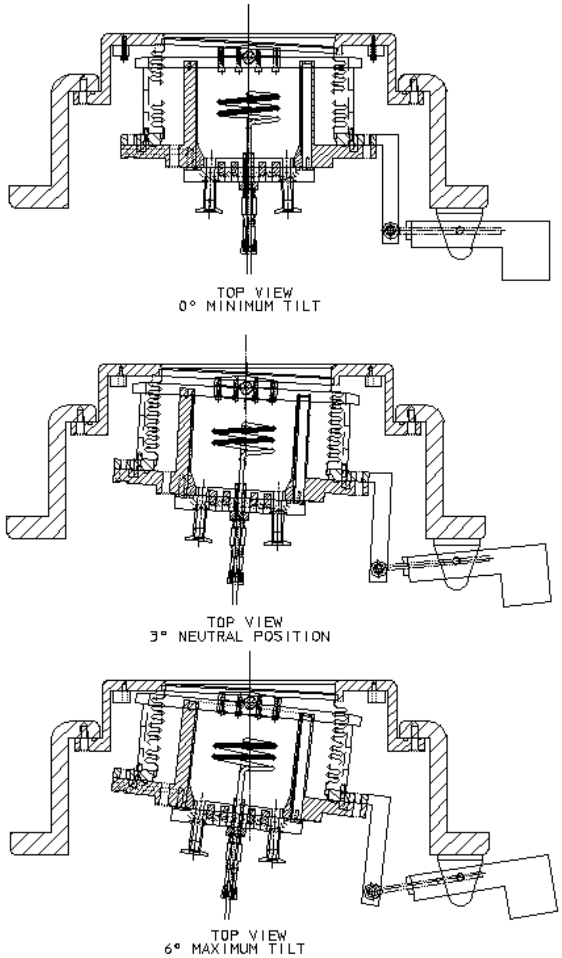

Figure-4 Ion source tilt position 0-6 degrees range

3 COOLING SYSTEM

The heat to be removed from the plasma chamber is approximately equal to the RF power consumption of the source (50 kW at 6% duty factor). The plasma chamber is bombarded by the hot-electrons at the locations of the cusp permanent magnet. This heat load is removed by the water jacket surrounding the whole plasma chamber. Similarly, the magnets in the back flange are cooled by the water channels machined in the body of the flange. Heat is also added in the form of hot air flow to the cesium collar from outside. This collar is maintained at the optimum operating temperature of 300^o C. The hot-collar radiates heat to the outlet electrode inside face. To prevent the radiation heat transfer from the cesium collar, a gap is maintained between the collar and the electrode plate. In addition, the copper surface of the outlet electrode sub-assembly has a cooling line for removal of heat produced by deflected electrons from the filter magnets. The electron dump electrode also has its individual cooling line. These cooling lines are accessed through the insulated vacuum feed through in the main flange of the ion source.

4 ALIGNMENT

The ion source positional accuracy is critical for ion beam optics in the low energy beam transport (LEBT) section.
Figure-5 shows ion beam deflection in the SNS LEBT if one of the electrostatic lenses is shifted transverse to the beam direction (calculated by the 3D optics code KOBRA).

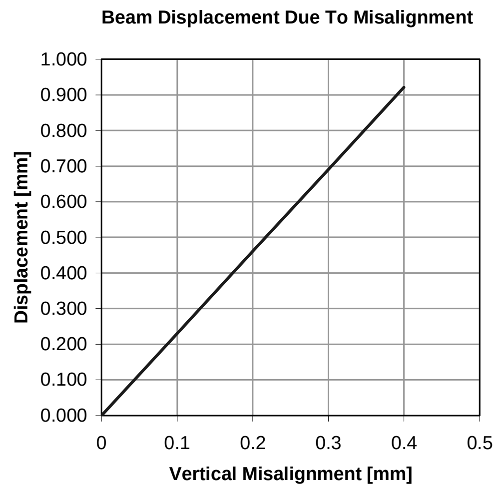

Figure-5 Effect of lens misalignment

As shown in the graph a lens-transverse-misalignment of .05mm would result in a beam deflection of .1mm out of the center position. The alignment target +/- .05 mm in X and Y planes, (perpendicular to the beam direction), is achieved by using a common axis reference between the source and the LEBT. The source tilt mechanism is kept on axis by the precision flexural pins and the position accuracy between the removable flanges is controlled by the use of precision dowel pins.
This new H^- ion source is being fabricated and testing is scheduled to start in June, of this year. Results of the source operation will be reported in the near future.

5 REFERENCES

[1] M. A. Leitner, D.W. Cheng, J. Greer,, K.N. Leung, S. K. Mukherjee, P.K. Scott, M.D. Williams, "High-Current, High-Duty-Factor Experiments with the RF driven H^- Ion Source for the Spallation Neutron Source", these proceedings.

[2] D.W. Cheng, M.D. Hoff, M. A. Leitner, J.W. Staples, M.D. Williams, R. A. Gough, R. Keller, K.N. Leung " Design of the prototype Low Energy Beam Transport Line (LEBT) for the Spallation Neutron Source", these proceedings