DESIGN OF HIGH POWER FEEDTHROUGH FOR HIGH POWER INDUSTRIAL ACCELERATOR (HPIA)

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Abstract

This paper reports the design, assembly & dismantling and maintenance of a feedthrough for High Power Industrial Accelerator (HPIA). It has been designed to serve three purposes. It provides electrical insulation between primary windings (at ~2.5kV) and cover flange (at ground potential) with the help of Nylon bushes. It also ensures leak tightness for SF_6 gas filled inside the vessel at 10 bar. It also provides sealing for water connectors between the primary winding and secondary winding. The key function of this feedthrough is to supply ~800 A of current to the primary circuit. Technical requirement/constraint is leak tightness and electrical isolation of feedthrough. This feedthrough will be connected to the primary windings inside the vessel. Current will flow through a copper tube conductor which is at a potential of ~800 V. Inside the tube water is flowing. Inlet water temperature is ~30°C. Flow rate of water is 35 litres/minute at 6 kg/cm^2 pressure to remove the heat losses.

INTRODUCTION

Different types of feedthroughs are required to transmit electrical current, fluids, optical signals or mechanical motion through the walls of a vacuum system [1].

HPIA is a 2.5 MeV 100 kW DC Accelerator. An electrical & fluid feedthrough is designed & developed to feed current to the primary coil of the HV generator of the accelerator module and facilitate the supply of water for forced convective removal of the conductor losses [2]. The feedthrough also needs to withstand the 10 bar internal pressure of SF_6 gas. Since, both the primary coil and the vessel wall are stationary, the feedthrough has designe flexibility to accommodate two rigid systems. It is this condition which forces a custom made design of the feedthrough as the 'off-the-shelf' high current feedthroughs do not offer this flexibility. Locations of feedthrough is shown on the Fig.1 by arrow.

DESIGN

Primarily, this feedthrough has to supply current to the primary circuit and which is at a high potential. Followings are the components of the feedthrough (Fig.2): (1) Input copper tube (2) Inner Nylon ring (3) Nylon bush (4) Outer Nylon ring (5) Outer Nylon nut (6) Outer Metal nut (7) O-rings (8) O-rings (9) O-rings (10) Socket head cap screw. Nylon bush is used to electrically isolate these two parts.

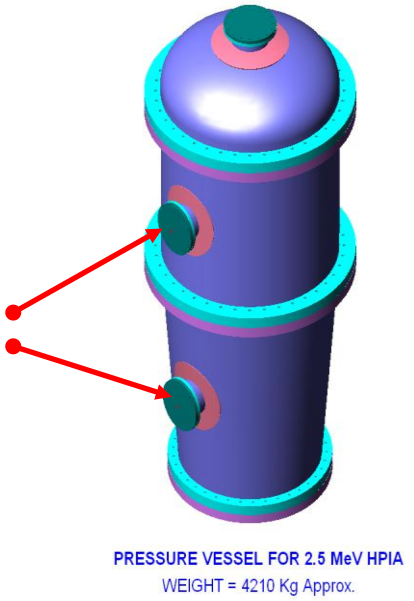

Figure 1: CAD Model of HPIA.

Input copper tube has two functions. Firstly to supply current to the primary windings, secondly to supply the cooling water inside the tube for removing the heat generated in the windings due to the conductor losses.

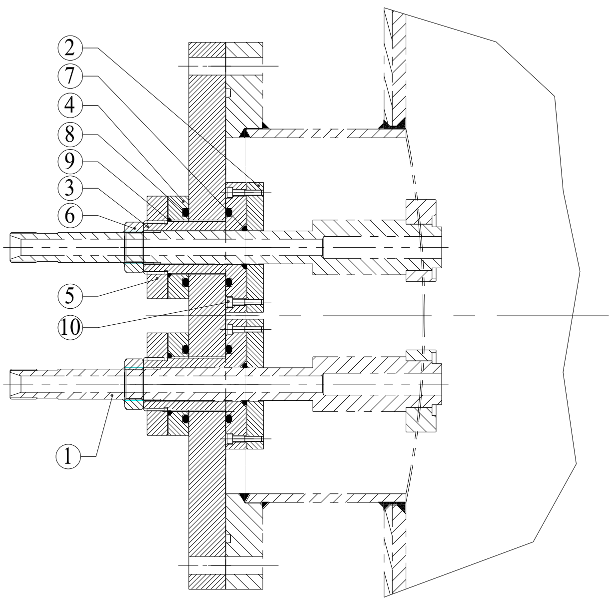

Figure 2: Sketch of Components of Feedthrough.

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It is made of OFE copper and chosen for its high electrical and thermal conductivity

Bush, inner ring and outer rings are made of Nylon to electrically isolate the input copper tube and flange cover to avoid short circuiting. Nylon has exceptional resistance to high temperatures, chemical reaction and corrosion. Nylon products are resistant to ionizing radiation, maintaining significant physical properties. It is thermally stable up to about 360°C in air and has the lowest known dielectric constant of any plastic material [3].

Figure 3: Feedthrough and Nylon Components.

O-rings are used for sealing at various susceptible locations for providing demountable sealings[4].

Leak tightness at the junction of feedthrough and vessel is an mandatory requirement for environmental safety and accelerator operation as the vessel is filled with SF_6 at 10 bar. Redundant and multiple point O-ring sealing are used to make the sealing highly safe.

Water is flowing inside the copper tube at 35 litres/minute and 6 kg/cm^2 pressure to remove the heat losses from windings. Leak proof arrangement at this connection was mandatory for safe and efficient operation of machine and it was assured by O-ring sealing again.

All the O-ring joints are tested by Mass Spectrometer Leak Detector (MSLD) using Helium as tracer gas and it has been qualified for a leak of 1×10-10 mbar-lit/sec. Helium

In this design, we have tried to minimize time and cost of fabrication. The availability and machining of these components are easy. Material and machining cost is also less. The design also ensures of easy assembly and disassembly of feedthrough components.

Since the feedthroughs connect to a very large winding, it should be flexible enough to assemble them with some misalignment also. Moreover access requirements for assembly were limited which has been met by assembly design.

PREVENTIVE MAINTENANCE SCHEDULE

Input copper tube is a critical part and sees a very high pressure. It may fall short by mechanical failure. The O-rings mainly degrade due to chemical reactions triggered by oxygen. Nylon components may fail due to the environmental conditions and contact with corrosive electrolytes produced during reaction between SF_6 and moisture [5].

Preventive Maintenance

An annual preventive maintenance schedule (PMS) has been worked out to guard against the failure modes mentioned above. The key activities of the PMS are listed as:

- Visual inspection and dimensional check of all metallic parts and replacement of deteriorated components.
- Replacement of all O rings
- Replacement of all Nylon parts
- Visual inspection and pressure testing of assembly.

CONCLUSIONS

The design can be used in cases where flexibility in assembly is required.

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