PERFORMANCE OF CRYOMODULE AND CRYOGENIC NETWORK SYSTEM FOR THE SUPERCONDUCTING LINAC AT IUAC. DELHI.

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Abstract

The Superconducting Linear Accelerator as a booster of existing 15 UD Pelletron Accelerator is under construction at IUAC. The heart of superconducting linac is three cryomodules, each one housing eight quarter wave niobium cavities. In recent past two online tests with one linac module have been carried out and the beam (28 Si $^{+10}$) energy has been enhanced approximately from 130 MeV to 150 MeV with five effective cavities. The present paper highlights the operational experience of the cryogenic network system and its accessories during present run. Analysis of measured heat load at 4. 5 K from first Linac cryomodule is also presented

INTRODUCTION

To augment energy of heavy ion from 15 UD pelletron and to widen the mass range up to 80 to have energy above coulomb barrier, the Superconducting Linear Accelerator [1] is under development at IUAC, Delhi. Acceleration is achieved by using Superconducting quarter wave bulk niobium cavities operating at 97 MHz. The heart of linac is three cryomodules, each one is housed with eight cavities and one solenoid magnet. At present the first linac module along with superbuncher and rebuncher cryostats are installed in beam line and are integrated with helium and nitrogen refrigerator through indigenously developed cryogen distribution line. Except the portion of field joints connecting the cryomodules, the entire helium transfer line [2] is liquid nitrogen shielded, multilayer insulated and enclosed in a vacuum jacketed pipe of 8inches diameter. The Central VME based Cryogenics Data Acquisition System is developed to monitor and control operating parameters of cryostat, refrigerator and distribution system. Static and dynamic loads at 4. 2 K from all the cryomodules along with distribution line is met by a CCI make helium refrigerator of capacity 600 W at 4.2 K. The total load at 4.2 K on complete system as well as break up load in each cryomodule has been measured. Measured data with respect to vacuum, helium pressure, temperature of linac cryomodule related to the performance of cavities are analyzed and presented in this paper.

LINAC CRYOMODULE & COOLING METHODOLOGY

This is a rectangular cryostat [3] of dimension 3.0m x 1.2m x 1.9 m to house eight cavities and one solenoid magnet. A rectangular copper shield at 80- 100K is used to reduce the radiation load. Eight cavities and solenoid magnet are supported on two solid rectangular aluminum bar, which is supported from top plate with two SS sheet. Each cavity can be individually aligned in X – Y - Z

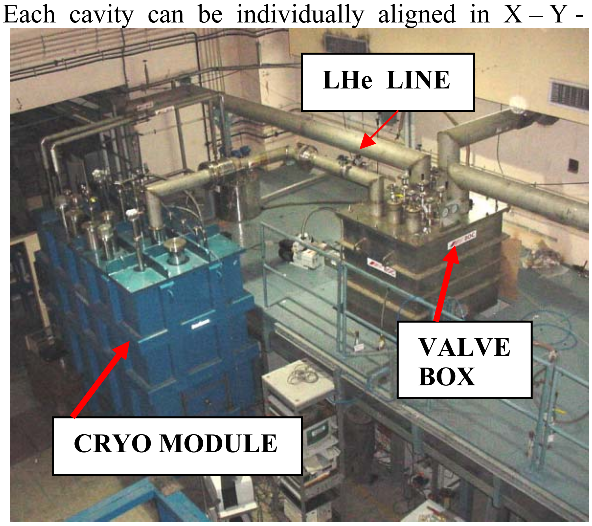

Figure 1 : Linac cryomodule with valve box

direction. Total cold mass in one linac module is estimated to be ~ 600 kg. All RF accessories like drive coupler, slow tuner, liquid nitrogen cooled RF cable are assembled from top plate of cryostat.

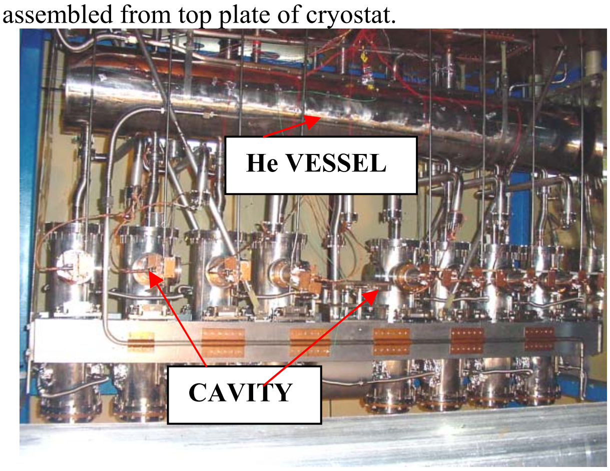

Figure 2 : Inside view of Linac cryomodule

Cool down of linac cavities [4] from 330 K to 4.2K is achieved in three steps, viz. inverse radiation cooling (330-220K) from shield, LN2 precooling (220- 140 K) and liquid Helium cooling (140 – 4.2 K). In-spite of slow cool down rate (15 K/ hr) in the critical zone, Q disease has not been reported. Minimum human interference is achieved by reducing final JT pressure with moderate liquid helium flow rate of 40 litres/hr. A complete cool down profile of linac module over three days is shown in figure 3.

PROBLEMS ENCOUNTERED AND SOLUTION

Vacuum

Earlier are reported [4] that the cryostat vacuum as measured by a Pfeiffer make cold cathod ionisation gauge did not show any improvement on Helium cooling. At the same time helium or nitrogen was not found by residual gas analyzer. Measurement was repeated with a Varian Nude ion gauge, which indicated better vacuum in the range of 10^{-7} to 10^{-8} Torr

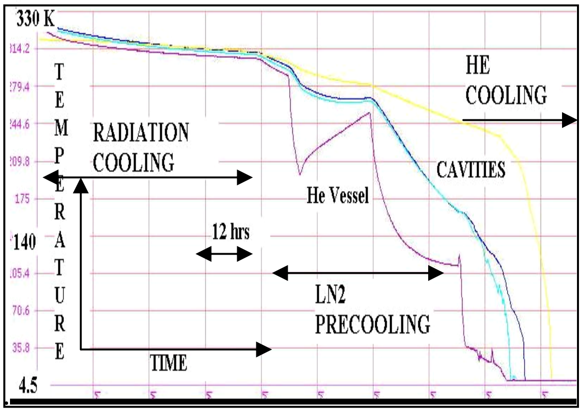

Figure 3: Cool down profile of linac cryomodule

Helium Pressure Stabilization

To evaluate the performance of slow tuner response time, measurement and analysis of helium pressure fluctuation in the cavity has been done in different modes

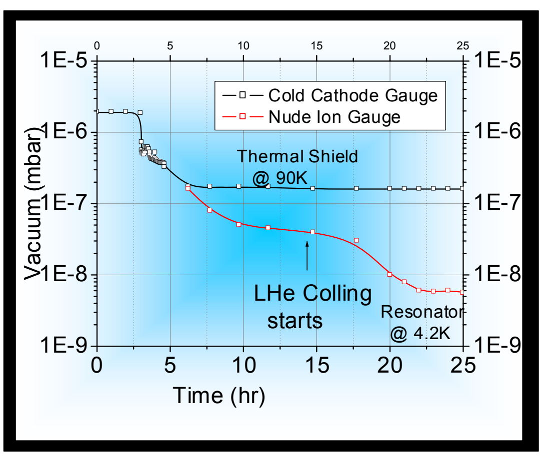

Fig 4 : Vacuum Profile of Linac module

of operation. It was observed that in normal mode, either in refrigeration or liquefaction mode, pressure fluctuation is less than 2 mbar/min and in case of power failure, the pressure fluctuation jumps to 6 mbar./min and lock invariably breaks. From recent observation, it may be concluded that rather than pressure fluctuations, vibration due to closing and opening of vacuum gate valve contributes more on breaking the resonator controller lock. Figure 5 and figure 6 explains the nature of pressure fluctuation in different modes of operation.

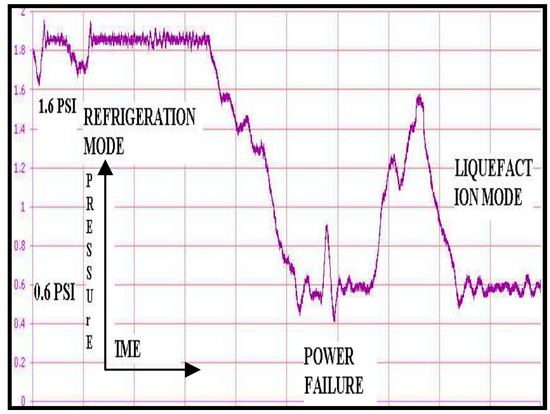

Fig 5 : Suction pressure of helium refrigerator

Temperature reading fluctuation

The temperatures at different locations in the cryostat were monitored by using Lake Shore make Silicon diode DT 470 thermometers. Earlier it was reported that temperature reading fluctuated with RF activity. To eliminate this noise, various steps like twisted double leads, cu shield on sensor as well as filter in the instruments is incorporated. Although fluctuation amplitude has been reduced significantly, it still exists. Fluctuations with high RF power through cables (200 W) without any field is bare minimum. Combination of high power with moderate field on poorly performing cavity contributes major fluctuation in the temperature reading.

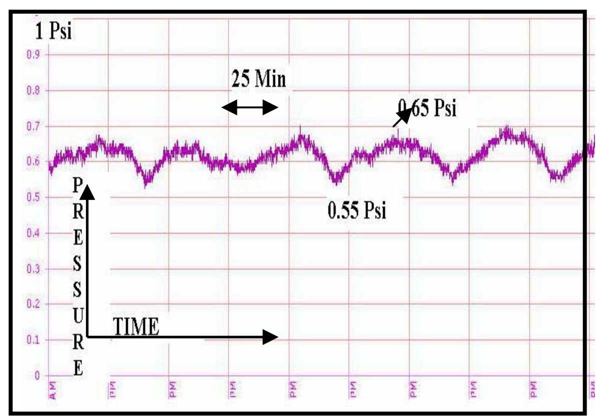

Figure 6 : Pressure fluctuation on Liquefaction mode

Control Shield Temperature

To avoid two phase flow in the suction side of nitrogen refrigerator and to have moderate constant shield temperature, automatic controller with two heaters of 600 W each and a feedback option from the LN2 level sensor has been developed and hooked up with CRYO DACS. The performance was found to be satisfactory.

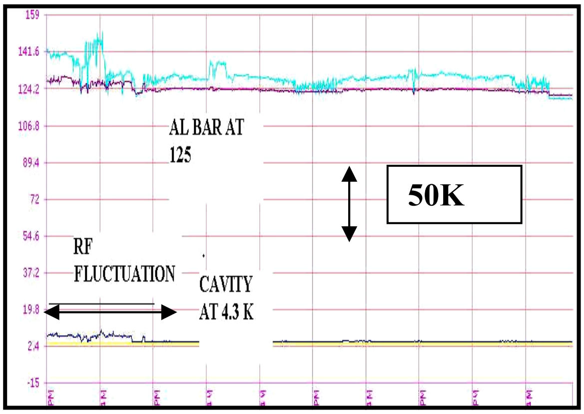

Figure 7: RF effect on temperature reading

Heat load in Linac module

An attempt has been made to measure total refrigeration load from linac, buncher and part of distribution line by isolating the linac system and simulating the same condition by an immersion heater in the master dewar. The static heat load measured at 4.5 K on linac module with cavity and RF accessories is 30- 35 W. The value is higher than the design value of 20 W. On thermal analysis, it is concluded that conduction from Al support bar at 125 K and drive coupler contributes about 10 W and 5 W loads respectively. Both these loads depend on number of cavities.

CONCLUSION

Cooling methodology is well established for one linac module with buncher and rebuncher. It is planned to have minor modification on 2 nd and 3rd linac cryomodule to have better cool down rate by using the cold enthalpy of helium gas efficiently. It is also planned to have intermediate UPS, backed by generator to have uninterrupted run of linac.

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