A.3: Design, development and testing of linear actuator for superconducting radio frequency cavity tuner

The superconducting RF (SCRF) cavities are equipped with two types of mechanical tuners for *in situ* tuning. Various types of tuning mechanisms are developed and used at various laboratories. Many of them incorporate both slow and fast tuning actuators in the same mechanism. An integrated (fast and slow) tuner is under design and development at AAMD Division of RRCAT. Fast (fine) tuners are required to reduce the effect of microphonic detuning, active vibration detuning, and Lorentz dynamic detuning. Slow (coarse) tuners are required to overcome the detuning due to thermal and beam loading effects on the structures.

Design of linear actuator: Design and development work on a few numbers of schemes is underway for SCRF cavity tuner. One of the main parts of any tuner mechanism assembly is linear actuator. The function of linear actuator is to provide linear movement (hence force) to a mechanism which in turn presses the single or multi-cell cavity, along the axis (within elastic limit) and hence leads to frequency change / tuning. One such linear actuator designed is shown in the inset of Fig.A.3.1. In this actuator, the linear motion is achieved by a ball screw, which is driven by a stepper motor through a specially designed worm and wheel reduction gearing assembly. Here, the wheel is directly mounted on the ball screw, hence moves along with it. To accommodate this movement, the wheel is modified, teeth are made straight and there is no crown radius. The main feature of the concept here is an indigenously designed and developed worm and wheel based reduction gear. Blade tuner and other tuners use harmonic reduction gear drive, which is very costly (~ Rs.3 lakhs)

Testing at liquid nitrogen (LN_2) temperature : The actuator design was modified for cryo-temperature, UHV compatible material of construction, and standard machine elements. The worm-wheel is made of Be-Cu alloy, and ball bearing is replaced by SS ball bearing. At present, thrust bearing and ball screw is not available in SS, so we will continue with conventional alloy. The design was also modified and made with integrated sealed chamber with bellow for low temperature testing only (Fig.A.3.1). All the machine elements were ultrasonically cleaned and MoS_2 fine powder solid lubricant was applied by burnishing technique. The excess powder was removed by pure methanol (laboratory grade) spray. MoS_2 is one among the few solid lubricants which are used in for machines at "liquid helium temperature and UHV". The design was checked for the differential contraction and hence probable jamming (secondary forces and stresses) for the combination of materials used in design for the parallel metal path of the mechanism.

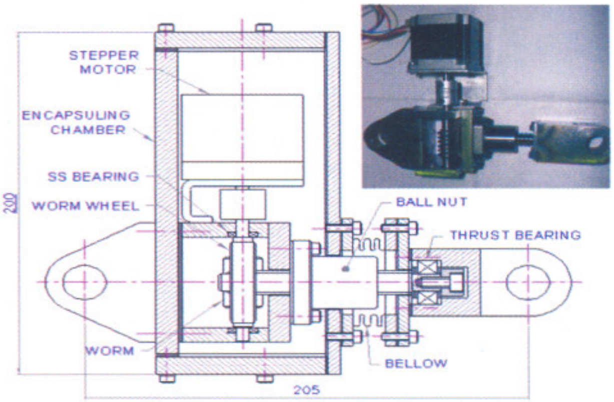

Fig.A.3.1: Actuator assembly (inset) and integrated chamber assembly for LN_2 temperature testing.

The modified actuator was assembled with the lever type tuner. A load cell is put in the middle, instead of cavity. The actuator was immersed in a container filled with LN_2 and tested (Fig.A.3.2). The results are quite encouraging. The force generated is marginally less than that at room temperature. The experiment was repeated many times, at room temperature and at LN_2 temperature alternatively for the full load (~ 2000 N). The motor phase current is maintained same at room and also at LN_2 temperature (the coils resistance reduces to ~1/6 at LN_2 temperature). Another important feature of this actuator is that a stepper motor under indigenous development has been used.

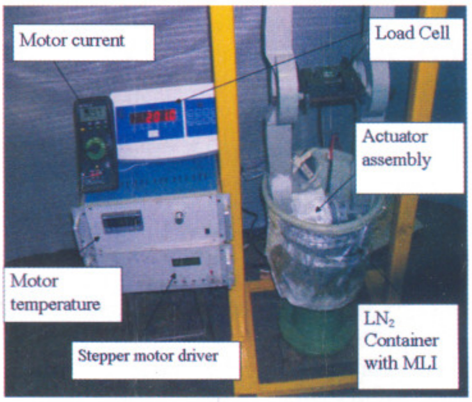

Fig.A.3.2 Liquid nitrogen temperature testing of linear actuator for tuner.

The testing will be continued for a large number of cycles (accelerated testing) to assess wear and tear effectiveness of lubricant etc. It is also planned to modify the test set-up to incorporate testing under vacuum and liquid helium temperature.

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