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Warm Tuner for the PEFP Superconducting RF Cavities

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Abstract

A warm tuner has been designed for tuning the field flatness of the superconducting radio frequency (SRF) cavities of the Proton Engineering Frontier Project (PEFP) at room temperature, based on a cavity field flatness tuning principle and the features of the PEFP cavities. The mechanical drawings of the warm tuner have been produced, and the warm tuner is under construction.

1. Introduction

Proton Engineering Frontier Project being built at Gyeongju is supported by the Korean government to develop a 100 MeV, 20 mA pulse proton linear accelerator for developing technologies of proton beam utilization and promoting industrial applications of developed technology [1,2]. Superconducting RF cavity is considered to accelerate a proton beam upwards of 80 MeV with a repetition rate of 60 Hz at 700 MHz in the PEFP linac and its extended project (PEP) linac in future [3,4].

The SRF Linac of PEFP and PEP possibly includes three different beta cavities: the low beta cavity (β=0.42, with 5 cells and the cavity length of 0.86 m); medium beta cavity (β=0.61, with 6 cells and the cavity length of 1.23 m); and the high beta cavity (β=0.81, with 6 cells and the cavity length of 1.44 m).

A net accelerating voltage, a peak surface field and a Lorentz detuning coefficient are the ones of the important physical parameters to evaluate a SRF cavity's performance. Those parameters are strongly affected by the field flatness in a multi-cell SRF cavity [5]. In order to get the good field flatness of a multi-cell SRF cavity, the warm tuner is used to tune the cavity's field flatness and frequency by deforming the individual cell of the cavity or the whole cavity.

In order to efficiently and easily tune the field flatness PEFP cavities, a warm tuner has been designed and is being fabricated. In this paper, the PEFP warm tuner's design consideration and the functions of its main parts have been introduced.

2. Principle of the field flatness tuning

The field flatness in a N-cell cavity can be expressed as [5]:

$$\eta_{ff} = \frac{E_{c\max} - E_{c\min}}{\frac{1}{N}\sum_{i=1}^{N} E_{ci}} \times 100\% \qquad (1)$$

Here, E_{ci} is the peak axial electric field in the ith cell. An ideal value of the field flatness is zero. Because of the field sensitivity limit of a cavity, it is difficult to get zero field flatness. For the PEFP cavities, a specification of the field flatness is lower than 8.0%. A field flatness after warm tuner tuning is supposed to be around 3.0%, which is the same as that of the SNS cavities. Fig. 1 shows a sketch of the PEFP low beta cavity.

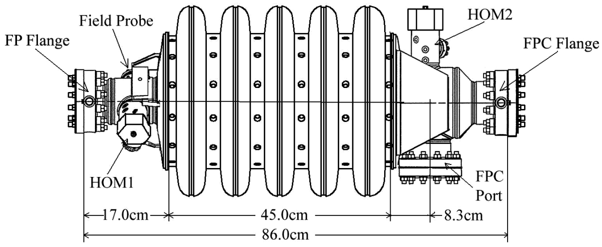

Figure 1: A sketch of the PEFP Low Beta Cavity.

According to the Eq. (1), the tuning method of the field flatness is to change individual cell's axial electric field E_{ci} for obtaining more uniform field distribution. Normally we use a pair of cell jaws to stretch or squeeze the cell shape in the longitudinal direction to change the cell's field, as shown in Fig.2. The field variation induces a cavity frequency shift $\Delta f = f - f_0$, which is used to monitor the cell field change in the tuning process.

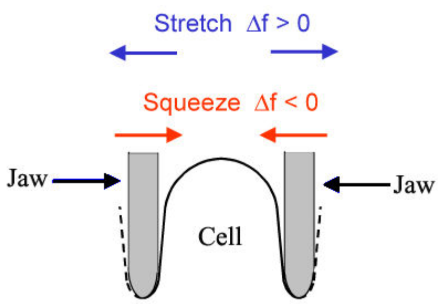

Figure 2: A sketch on how the jaws to tune individual cell of a SRF cavity

3. Design of the warm tuner

According to the principle of the field flatness tuning and the PEFP and the PEP cavities properties, a warm tuner has been designed for tuning PEFP SRF cavities largely based on the SNS warm tuner and its operation experiences (see Fig. 3). This tuner includes seven main parts: Active Carriage, Gearbox Carriage, Active

Tailstock, Tailstock, Drive Wheel, Bed and Support Legs.

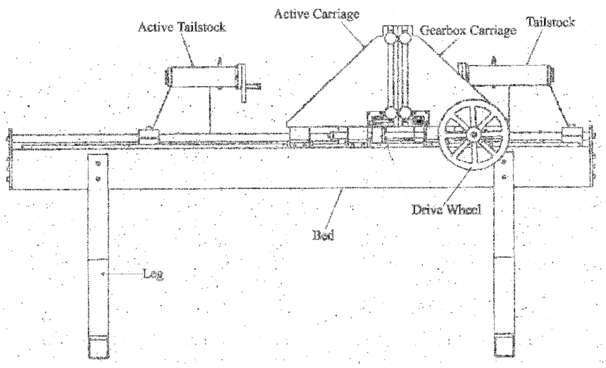

Figure 3: Assembly of the PEFP warm tuner.

The Active Carriage and Gearbox Carriage are used to hold and to drive the jaws. Each Carriage holds one jaw. They are connected together by a gearbox and a drive screw. The Active Carriage and Gearbox Carriage can be freely moved on the Bed in the longitudinal direction. After the individual cell tuning, the cavity frequency is changed. In order to control the cavity frequency, the jaws also are used to tune the whole cavity. Therefore the Active Carriage and Gearbox Carriage need to have a large open-close movement range. Considering the warm tuner will be used for all the PEFP SRF cavities, an active movement range of 1.5 m was designed. Because the low beta cavity with a stiffening structure of double ring is steadier than the medium beta and the high beta cavities with single stiffening ring, according its mechanical properties, a stretching or squeezing force of 50000 N for the gearbox and drive screw has been specified.

The Active Tailstock and Tailstock are used to hold the cavity ends (Field Probe flange and FPC flange) for jaws' tuning. Active Tailstock can be moved on the Bed, when the cavity is been fixing on it. The cavity flange holder of the Active Tailstock can move freely in the longitudinal direction during tuning. The Tailstock and its cavity flange holder can not be moved. The maximum movement distance between Active Tailstock and Tailstock is designed as 2.03 m.

The Drive Wheel is used to drive the Active Carriage and Gearbox Carriage by a cavity tuning operator. The wheel diameter is 0.52 m.

The Bed with a length of 2.90 m and a width of 0.51 m and two legs with a height of 0.83 m and a sit span of 0.73 m are used to support other parts.

Because the low beta cavity has two stiffening rings with different diameters, two sets of the cell jaws were designed.

4. Material choice and fabrication

The different materials were chosen according to the functions of individual part of the warm tuner, for example, the materials of the Active Carriage and Gearbox Carriage are Aluminum 6061-T6 and stainless Steel 304. The flange plates of the Active Tailstock and Tailstock were made of Glass Filled Nylon in order to protect cavity flanges. But the main bodies of the Tailstocks are made of steel A36.

At present the warm tuner is under fabrication by the Korean VIZRO TECH Company.

5. Conclusion

The PEFP warm tuner was designed based on PEFP and PEP cavities' properties. All the mechanical drawings of the warm tuner have been completed. At present it is under fabrication.

6. Acknowledgement

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