PRELIMINARY RESULTS OF HALF CELL FORMING FOR 650 MHz, BETA 0.9 SRF CAVITY

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Abstract

650 MHz superconducting radio frequency (SRF) cavities may give significant benefits as compared to the 1.3 GHz cavities in the initial stages of Project-X, a proposed multi-MW proton facility. Apart from simplifying the beam dynamics issues for proton linacs, larger aperture of 650 MHz cavities is also beneficial from the activation point of view. This work of half cell forming, done under Indian Institutions and Fermilab Collaboration, focuses on development of beta = 0.9 cavities. The preliminary cavity geometry used is evolved by Fermilab. The cavity is elliptical in shape and consists of three types of half cells. In order to understand the cavity cell forming issues, prototype dies were designed and manufactured for 650 MHz, beta = 0.9 SRF cavity half cells. The dies are quite large in size and are made of aluminum alloy. Experimental half cells were formed in aluminum recently at RRCAT to understand the forming process for these 400 mm diameter half cells. The details of this work are described in this paper.

INTRODUCTION

Project X is a multi-MW proton accelerator facility based on an H^- linear accelerator using superconducting RF technology [1]. The Project X, 3 GeV CW linac employs 650 MHz elliptical 5-cell cavities to accelerate 1mA of average beam current of H- in the energy range 160 – 3000 MeV. The 650 MHz portion of the linac is further split into two sections with two different geometric phase velocity factors: beta = 0.61 for 160-520 MeV and beta = 0.9 for 520-3000 MeV. The end half cells have different geometry for reasons of trapped HOMs. The layout of cavity is shown in Fig. 1 [2]. The cavity half cell geometry and dimensions are illustrated in Fig. 2 and Table 1 [2]. The cavities are required to operate CW in superfluid helium in a temperature range of 1.8-2.1K, with gradients, E_{acc}, 16 or 19 MV/m, respectively, and unloaded quality factors, Q_0>1.7 x 10^{10} at 2K. The cell shape is designed to minimize the peak surface magnetic and electric fields, H_{peak}/E_{acc} and E_{peak}/E_{acc}, to achieve the required gradient and minimize field emission, and to minimize multipacting. Each cavity may dissipate no more than 25W average and peak power at 2K. The cavity will have suitable end groups with ports for RF power input and pick up.

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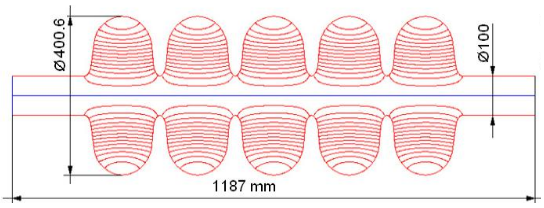

Figure 1: Layout of beta 0.91, 650 MHz cavity

TABLE 1.

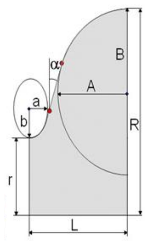

Figure 2: Half cell geometry

Dimension	Beta=0.9	
	Regular cell	End cell
r, mm	50	50
R, mm	200.3	200.3
L, mm	103.8	107.0
A, mm	82.5	82.5
B, mm	84	84.5
a, mm	18	20
b, mm	38	39.5
α, °	5.2	7

PROTOTYPE FORMING DIES DEVELOPMENT

The conventional method of manufacturing SRF cavities is to make half cells by deep drawing and electron beam welding them on iris and equator. We have also used deep drawing process. The designed profile of male die is similar to that of half cell inner profile while female die profile is designed so as to have a uniform clearance equal to sheet thickness of cavity blank. The preferred material of construction of forming dies is high strength aluminium alloy 7075 T6 but we used aluminium alloy 5082 for these prototype dies as this was readily available and was considered suitable for this purpose. The dies were designed to be made by stacking available plates of 125 mm thickness by using strong dowels and fasteners to build the required thickness of 265 mm. The dies as shown in Fig. 3 were machined on a vertical turning lathe available in-house. The machined internal surfaces of the die and punch profile did not show any steps or edges after machining and forming. Dies have features for handling them for loading/ unloading on press. The dies were inspected on a CMM which is available in-house (Make: LK, UK) and the profile was found within 0.1 mm (see Fig. 4). The designed blank thickness is 4 mm.

Figure 3: 650 MHz forming dies

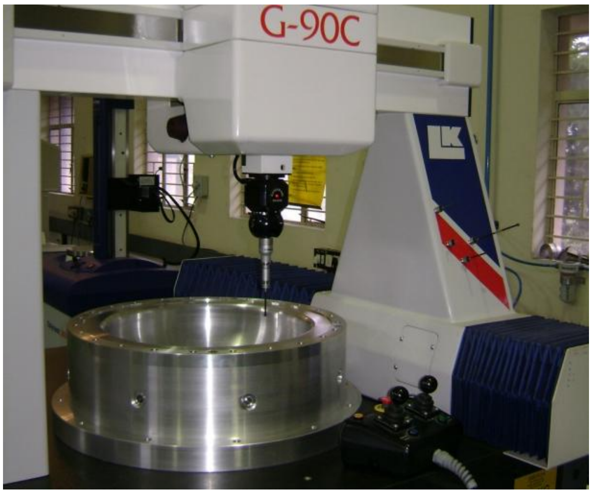

Figure 4: Dies under CMM inspection

HALF CELL FORMING

The forming trials were done on a 120 Ton hydraulic press available in-house. A load of 40 Tons was used for forming. The dies were aligned using a Teflon block. The dies were cleaned and motor oil was applied on blank and dies. The blank was clamped using pressure plate and fasteners were hand tightened without using tightening devices. The initial trial was taken on 3 mm thick unalloyed aluminium blank in annealed condition to study the general forming behaviour and avoiding possible jamming due to thickening of formed areas.

PRELIMINARY RESULTS

The formed half cells have wrinkles in elliptical region as shown in Fig. 5. Some more forming trials were done using 3 mm thick blanks with increased blank holding force by tightening fasteners (12 No.) to a torque of 25 N.m and the wrinkles were still observed. The dimensional inspection of half cell was done. Half cell inspection using template is shown in Fig. 6.

FUTURE PLANS

Forming trials using blanks of designed thickness (4 ± 0.1 mm) will be carried out. The blank diameter may need to be increased to have a restraining force on blank in final stage of deep drawing. We are also planning for multi stage forming.

Figure 5: Formed half cell-inside view

Figure 6: Half cell inspection using template

ACKNOWLEDGEMENTS

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REFERENCES

[1] Functional Requirement Specification of 650 MHz Superconducting Cavity for Project X, 11 Sept. 2010.

[2] V. Yakovlev, “650 MHz option for high-energy part of the Project X Linac” IPAC'10, http://www.JACoW.org