Development of SRF cavity cell forming at RRCAT

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Abstract: Development of cavity cell forming is taken up at RRCAT as part of its SRF cavity development program. The forming tooling for 1.3 GHz and 650 MHz, beta 0.9 SRF cavity half cells are designed, manufactured and used for forming using in-house hydraulic press. Blank sizing, forming loads, dies alignment scheme and half cell ejection from dies were developed. Two stage forming process viz. deep drawing followed by coining to correct the curvature at iris region is used. We have arrived at the final shapes of the forming tooling after several iterations of design, analysis, manufacturing, 3-D inspection and forming. The special material required for the tooling has been procured in the form of forged and rolled plates of aluminium alloy of grade AA 7075. There has been a gradual improvement in the forming results both for 1.3 GHz and the 650MHz cavity half cells and the process improvements are being continued. Several prototype half cells have been formed from OFE copper blanks and inspected on CMM for form errors. In this paper we present the work done at RRCAT on the design, analysis, manufacturing, inspection of forming tooling and formed cavity half-cells.

Keywords: SRF cavity, Cell forming, deep drawing, CMM inspection, Profile error

INTRODUCTION

650 MHz and 1.3 GHz SRF cavities are required for high intensity proton Linac. These cavities are elliptical in shape. End half cells of these cavities have different geometry from regular half cells for reasons of trapped HOMs. The cavities are required to operate at about 2K, at high accelerating gradient and quality factor.

1.3 GHZ CAVITY HALF CELL FORMING

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. The geometry of center half cell is shown in Fig. 1. Figure 2 shows set of forming dies for center half cell. The deep drawing was done on 200 Ton hydraulic press available in house as shown in Fig. 3. The coining is done to correct the iris curvature using a smaller die as shown in Fig. 4. The half cells are machined using a special machining fixture as shown in Fig. 5. This fixture permits machining of all features in a single setting on Lathe. Several geometrical errors are introduced during metal forming -symmetric errors due to process like spring back and thickness variation during forming and asymmetric errors due to the anisotropy of niobium [1]. The half cells are inspected using a matching template and also scanned on a coordinate measure machine along four planes as shown in Fig. 6 to determine the profile error. We have received profile tolerance of ±0.2 mm on niobium half cells.

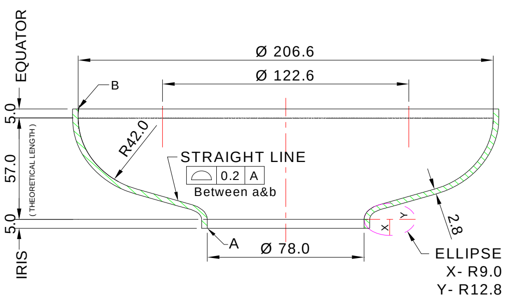

FIGURE 1. 1.3 GHz half cell geometry

FIGURE 2. Forming dies for center half cell

FIGURE 3. Deep drawing at 80 Tons

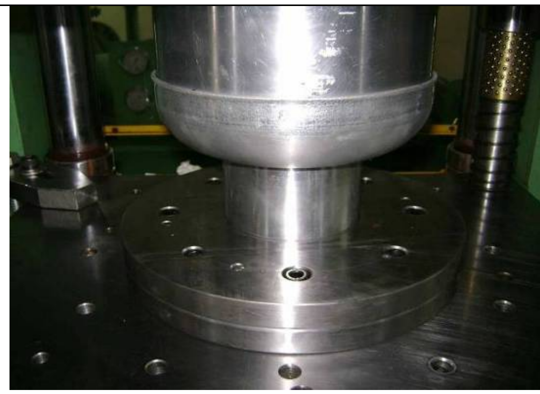

FIGURE 4. Coining at 25 Tons

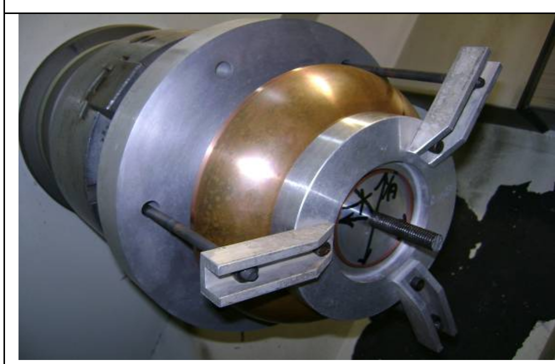

FIGURE 5. Machining of Iris face

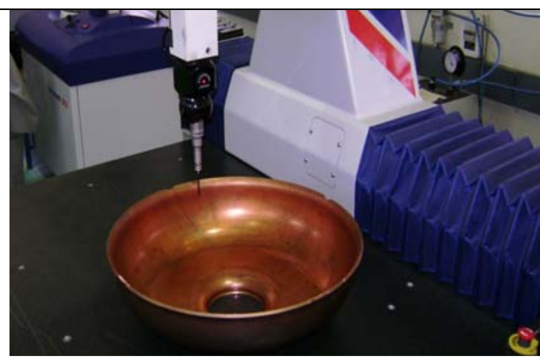

FIGURE 6. CMM inspection of half cell

650 MHZ CAVITY HALF CELL FORMING

650 MHz SRF cavities are may give significant benefits as compared to the 1.3 GHz cavities in the initial stages of proton linac. Apart from simplifying the beam dynamics issues for proton linac, larger aperture of 650 MHz cavities is also beneficial from the activation point of view [2]. The geometry of center half cell is shown in Fig. 7. Forming dies were machined on a vertical turret lathe available in house. Figure 8

shows a set of forming dies. Half cell forming trials were done in OFE copper on 120 Ton hydraulic press in-house as shown in Fig. 9. A 650 MHz copper half cell is shown in Fig.10. Half cells are inspected using template conforming to cavity profile as shown in Fig. 11 and also scanned along four planes on a CMM. We have found profile error of 0.38 mm in the half cell as shown in Fig. 12.

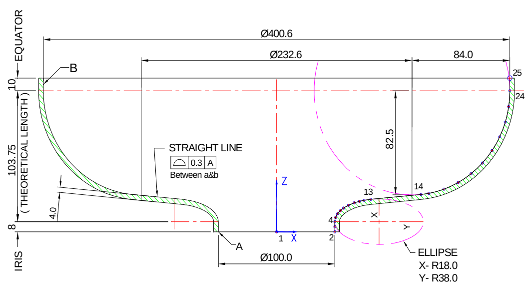

FIGURE 7. 650 MHz half cell geometry

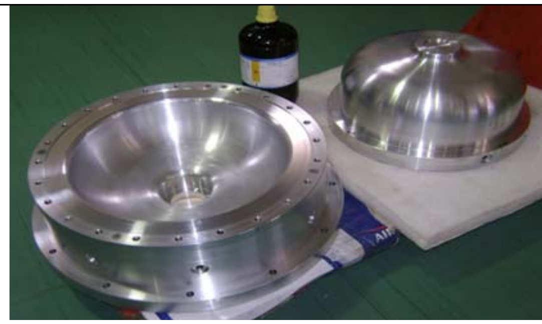

FIGURE 8. Forming dies (profile within 0.1 mm)

FIGURE 9. Half cell forming trials

FIGURE 10. OFE copper half cell

FIGURE 11. Half cell inspection using template

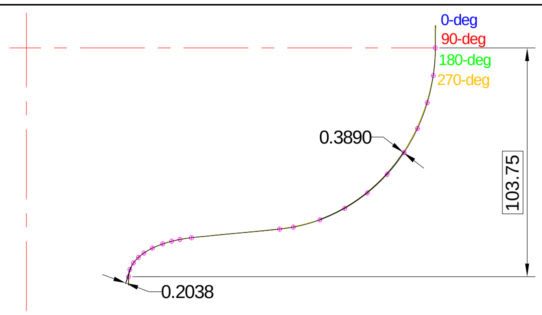

FIGURE 12. CMM inspection of half cell

CONCLUSION

There has been a gradual improvement in the forming of 1.3 GHz and 650MHz cavity half cells and the process improvements are being continued. Half cell forming for 1.3 GHz SRF cavity is now well established at RRCAT. 650 MHz cavity niobium half cells will be formed after some more trials in OFE copper. We also have a plan of developing flexible tooling in future.

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REFERENCES

1. Arup Ratan Jana, J.N.Rao, R.S.Sandha, Jishnu Dwivedi , "Methodology for efficient analysis of the effect of geometrical errors on RF parameters of SC cavity" in InPAC-2009, Indore.
2. R.S. Sandha, S.G. Goswami, R.S. Choudhary, Abhay Kumar, Jishnu Dwivedi, G. Mundra, S.D. Sharma, R.K. Gupta, V.K. Bhatnagar, Kamlesh Yedle, Sanjay Sharma, S.C. Joshi, A.C. Thakurta , "Preliminary results of half cell forming for 650 MHz, beta 0.9 SRF cavity" in InPAC 2011, New Delhi.