THE FABRICATION OF BEPCII 500MHZ SUPERCONDUCTING CAVITIES

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Abstract

Since Nov. 2006, the 500MHz SRF system of Beijing electron positron collider upgrade (BEPCII) has been running stably. But there's a hidden danger for no spare cavity is existed. If there's any serious trouble happened on either one of the two operating cavities and cannot be recovered in time, it will affect the operation of BEPCII facility. Spare cavities began to be investigated since 2009. Now three cavities are developed and two of them have been vertical tested at Jan and July 2011, respectively. This paper will briefly present the manufacturing, post-processing and vertical test performance of the cavity.

INTRODUCTION

All parts of a BEPCⅡ 500MHz spare cavity, including two half cells, large beam pipe, small beam pipe, the support of the coupler are formed by spinning technique and welded together by electron beam welding (EBW). A schematic layout of the cavity is shown in Fig. 1.

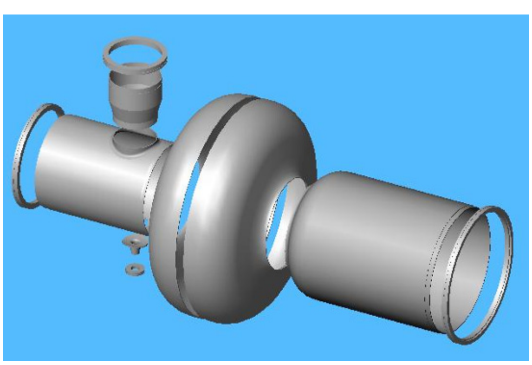


Fig. 1: Layout of the BEPCⅡ cavity.

Surface processing is very important for a superconducting cavity. After a certain post-procession procedure, the cavities reveal good properties during vertical test.

FABRICATION TECHNIQUES

Spinning is a simple force-forming technique which is widely used on metal bodies with rotational symmetry structure [1].

Many parameters will affect the final shape of the workpiece, mainly including the fillet radius of the roller, the headstock rotation speed, the roller feed speed, the gap between the die and the roller, even the lubricate method. Choosing a set of right parameters is essential to achieve best spinning quality.

High purity niobium (Nb) has good properties for spinning [2], but there's no experience on Nb spinning for domestic industry before. The cold hardening of this material puzzled us a lot before finding a set of optimized annealing parameters.

Table 1: The mechanical parameter

Annealing status	Tensile strength R_m（MPa)	Yield strength $R_{0.2}$(MPa)	Elongtation (%)
Original	167.2	88.7	57.3
no spinning no annealing	206.2	159.6	40.2
750°C	198.2	151.4	43.7
800°C	196.4	138.7	41.4
850°C	199.6	117.3	45.5
900°C	180.1	93.6	48.7

From Table.1, we found that spinning makes the material harden and higher temperature annealing recovered it. But on the other hand, if the annealing temperature is too high, the strength should be worried when the cavity is evacuated. So a set of appropriate annealing parameters, especially the temperature is very important.

Figure 2 shows all the spinning parts of a cavity.

(a) one half cell (b) support of coupler

(c) small beam pipe (d) large beam pipe

Fig. 2: All the spinning parts.

All the parts formed by spinning technique are electron beam welded together in a vacuum chamber whose vacuum is better than 5×10^{-3}Pa. The welding parameters are chosen to achieve full penetration welds.

The flange material of the cavities is Nb-Ti alloy [3]. The welding between Nb and Ti should pay more attention because the electron beam should shift to Nb side to get good welding quality for the large melt-point difference between Nb and Ti.

The most difficult part for EBW is the equator seam for its large diameter, 525.66mm. The roundness and thickness uniformity is hard to ensure. At the same time, the equator seam is the last welding seam and cannot be cosmetic welded from the back side. All the problems mentioned above made the equator seam difficult to be welded. Figure 3 shows the whole cavity after EBW.

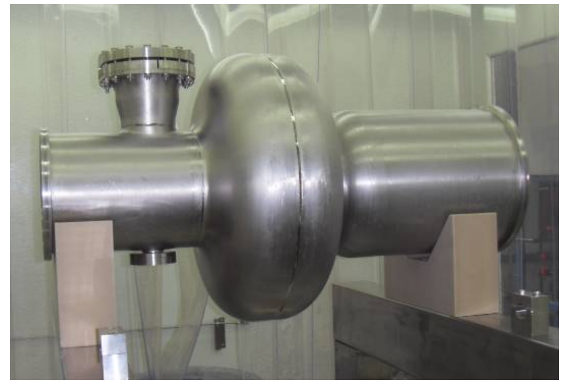


Fig. 3: The fabricated 500MHz superconducting cavity.

POST PROCESSION

After mechanical fabrication, we did the surface check, leakage check and size check before the post procession. The post procession procedure mainly includes mechanical polishing, buffered chemical polishing(BCP), ultrasonic water clean(UWC), high pressure water rinsing(HPR), high temperature annealing, frequency pre-tuning, etc., shown in Fig. 4.

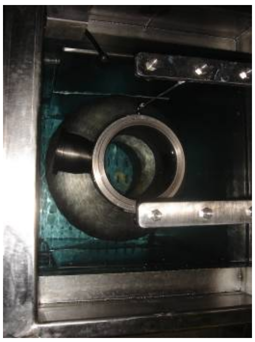
VERTICAL TEST AND PERFORMANCE

Vertical tests had been done to evaluate the cavities' performance. Before vertical test, the cavities were baking at 120℃ for 48h. Then the cavity is put in the dewar which is shielded by permalloy to decrease the influence of geomagnetic field to the cavity and cooled by bath liquid helium (LHe). By measuring the reflected power and the transmitted power at each input power level, we can calculate the Q value and the accelerate gratitude (E_{acc}). Table.2 and Fig. 5 show the final test results of two cavities.

The 1# spare cavity didn't reach the highest V_c for the reason of LHe. The 2# cavity reached 2.3MV after pulse procession, but still met Q-slope at high field. It may be caused by hydrogen disease. So we should pay more attention to the hydrogen pollution during BCP and cooling down for the third spare cavity.

Table 2: The test results of two spare cavities

	Target value	1# spare	2#spare
Vc	1.5MV	1.80MV	2.3MV
Q0@ Vc above	5.0E8	1.12E9	1.20E9



(a) Ultrasonic water rinsing (d) HPR

(b) BCP （e）Pretuning

(c) Annealing Ti box (f) Assembled cavity

Fig. 4: Post process pictures.

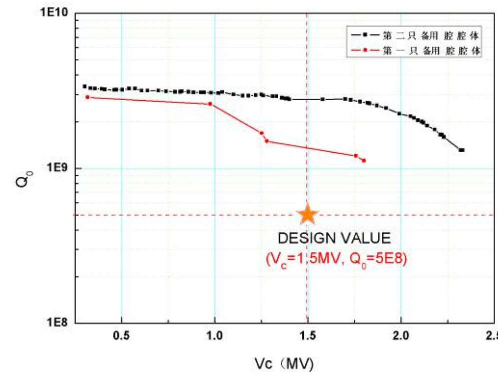


Fig. 5: The curve of Q_0-E_{acc} of two spare cavities.

CONCLUSION

IHEP SRF group fabricated, post processed and tested the 500MHz superconducting cavities independently. The test results indicate that the performance of these cavities meets the designed value. All the fabrication and post-process techniques are reasonable.

The high power input coupler, high order mode damper and cryostat have been development successfully in IHEP before.

One cavity will be assembled with the coupler, HOM damper and cryostat and plan to carry high power horizontal test at OCT 2011.

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