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FABRICATION PROCESS OF SINGLE SPOKE RESONATOR TYPE-2 (SSR2) FOR RISP*

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Abstract

Rare Isotope Science Project (RISP) in the Institute of Basic Science (IBS), South Korea, is now constructing superconducting linear accelerator 3 (SCL3) for low-energy beam experiment and also making prototypes of superconducting cavity, RF power coupler, tuner, and cryomodule of superconducting (SC) linear accelerator 2 (SCL2) for high-energy beam experiment. Single spoke resonator type-1 (SSR1) and type-2 (SSR2) superconducting cavities are now on the prototyping stage, which is applied a "balloon-variant" concept invented by TRIUMF. This paper explains about SSR2 fabrication process from press-forming to electron beam welding (EBW) with RRR300 niobium sheets.

INTRODUCTION

RISP linac is composed with two sections, one is the low-energy acceleration region which includes the low-beta SC cavity – QWR and HWR - and the other is high-energy acceleration region which includes high-beta SC cavity – SSR1 and SSR2 [1]. SSR1/2 have each 0.3/0.51 beta and both single-spoke type, made by high-purity niobium material and covered by STS316L material liquid helium (LHe) jacket. This paper explains about the fabrication process of SSR2 SC cavity.

SSR2 DESIGN MODEL AND MANUFACTURING DRAWING

The design concept of SSR2 is based on the "balloon-variant" concept which is proceeded by the prototyping contract between RISP and TRIUMF [2]. TRIUMF invented the balloon-variant concept which has higher multipacting suppression performance with the expected acceleration gradient over 9MV/m and target Q value over 5E9 [3]. The SC cavity development engineers of RISP have developed the engineering design of SSR2 since 2017 [4], and RISP contracted with domestic vendor for making six SSR2 SC cavity prototypes. Figure 1 shows the exploded view of SSR2 SC cavity, and Table 1 shows the design specifications of SSR2 SC cavity.

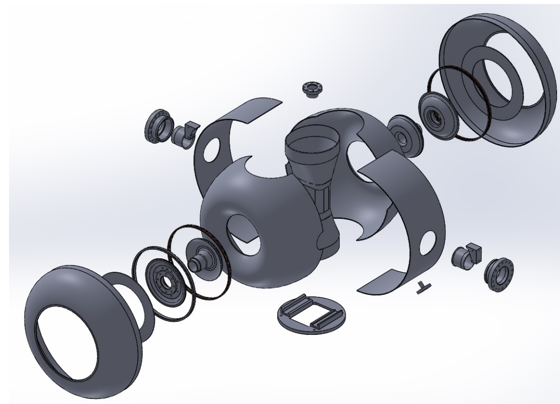

Figure 1: SSR2 dressed cavity exploded view.

Table 1: SSR2 Design Parameters

Parameters	Values	Units
Operating Frequency	325	MHz
Beta	0.51	-
Operating Temperature	2	K
Quality Factor	5E9	-
Epeak	35	MV/m
Vacc	4.1	MV
df/dP	10	Hz/mbar
Tuning Range	180	IkHz
External Q	6E6	-
RF Bandwidth	40	Hz
Beam Aperture	50	Imm
Pressure Envelop 300K	2	bar
Pressure Envelop 5K	5	bar

SSR2 HALF SHELL AND SPOKE PRESS

Engineering design of SSR2 SC cavity was evaluated through the technical advisory committee (TAC) by 2018, and TAC suggested to proceed the prototyping of SSR2 SC cavity [5]. Fabrication process of SSR2 SC cavity applied some modifications of SSR1 SC cavity fabrication process [6], changing half shell production from spinning to press-forming. SSR2 bare cavity is divided into four subcomponents, half shell, beam port, RF port, and spoke. Both the half shell and spoke has been made by press-forming. Comparing with SSR1, SSR2 half shell has almost 70mm deeper shape so the forming process is more difficult than SSR1. After many trial and error, SSR2 half shell press-forming is finished. Figure 2 shows the shape of press die, and Figures 3–5 show the forming shape of SSR2 half shell with different evaluation materials, AL6061T0, oxygen free high conductivity copper (OFHC), and RRR300 niobium. RISP usually uses AL6061T0 for the first forming test, and uses OFHC for the second forming test. After checking first/second forming test results and modifying forming con-

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ditions, finally RRR300 niobium sheet is entered to the forming process so that there is no failure for niobium forming which has the highest risk.

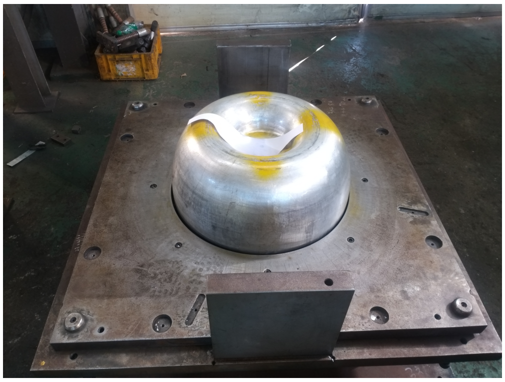

Figure 2: SSR2 press die shape.

Figure 3: AL6061T0 press-forming shape.

Figure 4: OFHC press-forming shape.

SSR2 half shell forming was done by pneumatic press and salted water test was also proceeded for checking the contamination of shell surfaces. Half shell was fully-soaked to the five-percent salted water by 30 minutes, dried 48 hours at the 10000 class clean room. After drying, visual inspection was proceeded and contamination was removed carefully. Figure 6 shows the salted water test process and Figure 7 shows the contamination(rust) from forming. After removing contamination, half shell was cleansed, dried, inspected

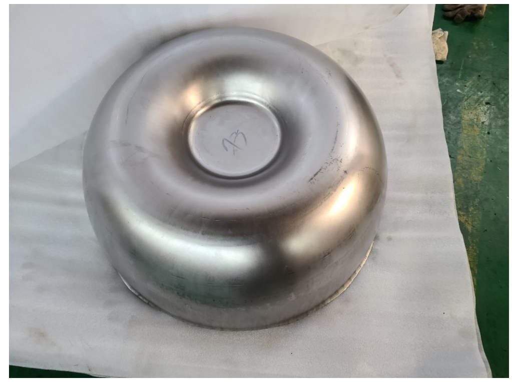

Figure 5: RRR300 niobium press-forming shape.

and moved to part welding when no defect was appeared. Spoke weldment was also made by press-forming and electron beam welding (EBW), and moved to assembly process when dimension check and visual inspection had no issue. Figures 8–9 show the shape of spoke weldment and collar.

Figure 6: Salted water test process.

Figure 7: Appeared rust after drying.

SSR2 SUB-PART WELDMENT

Sub-part and final EBW are proceeded with high vacuum degree lower than 5E-6 mbar [7]. And, for installation LHe jacket to the SC cavity, every stainless steel flanges are attached to the pure niobium pipes with vacuum braze. Figure 10 shows the half shell assembly after sub-part EBW.

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Figure 8: SSR2 Spoke weldment.

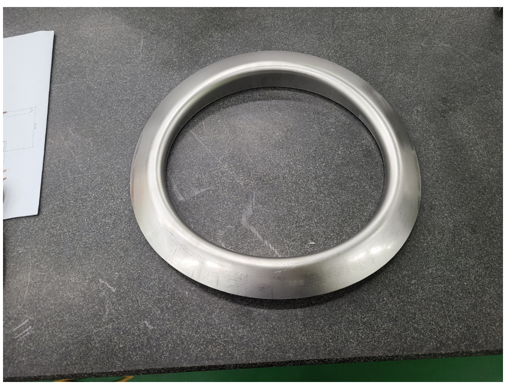

Figure 9: SSR2 Collar.

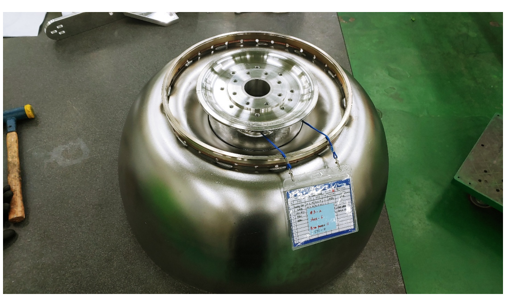

Figure 10: Half shell assembly.

SSR2 CLAMP-UP TEST AND FINAL EBW

For adjusting target frequency before shell-to-shell EBW, RF stack-up test should be proceeded with two half shell weldments and 1 spoke weldment. Figure 11 shows the RF stack-up process. Half shell weldments were trimmed symmetrically and carefully with frequency measurement, and when measured frequency meet to the target value, shell-to-shell EBW was proceeded. After shell-to-shell EBW, RF port holes were machined and shell-to-RF port EBW was proceeded. Figures 12–13 show the RF port assembly before and after EBW. Spoke-collar was also trimmed and welded by EBW, and final EBW was finished after trimming and assembling.

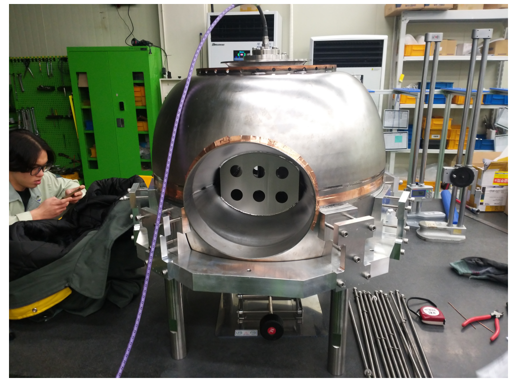

Figure 11: RF Stack-up.

Figure 12: RF port assembly before EBW.

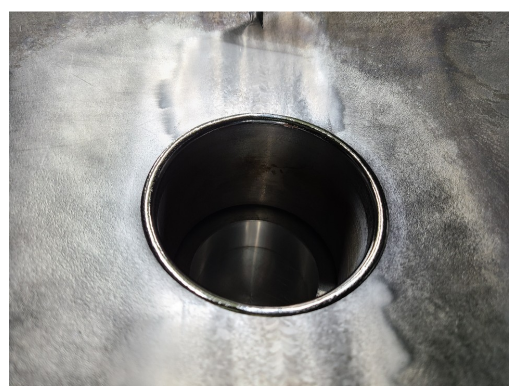

Figure 13: RF port assembly after EBW.

SSR2 BUFFERED CHEMICAL POLISHING (BCP) AND HIGH PRESSURE RINSING (HPR)

Same as QWR and HWR, BCP was applied to SSR2 bare cavity [8]. Nitric acid, fluoric acid, and phosphoric acid was mixed and used by 1:1:2 volume ratio, and cavity inner surface was polished up to about 120um with 1um per minute etch rate. After BCP, SSR2 bare cavity was moved to HPR device and washed with 100 bar DI water [9]. Figures 14–15 shows the BCP and HPR process.

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Figure 14: BCP process.

Figure 15: HPR process.

CONCLUSIONS AND FUTURE WORKS

Currently two SSR2 bare cavities are made and prepared for VT, and other four cavities will be made within this year. We expect that six SSR2 SC cavity prototypes will be tested and evaluated. After bare cavity cold test, we expect that experimental results of SSR2 SC cavity and further mechanical evaluation are presented.

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