THE EARLY STAGE OF THE CAVITY FABRICATION PROCESS (ECT AND FURNACE) FOR RAON*

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Abstract

RAON will have an acceleration line which have three parts. These are SCL1, SCL2 and SCL3. SCL1 and SCL3 are, respectively, made from QWR (Quarter Wave Resonator) and HWR (Half Wave Resonator) while the SCL2 is made from an SSR1 (Single Spoke Resonator) and an SSR2 (Single Spoke Resonator). Accordingly, The RAON needs 48 QWR, 276 HWR, 88 SSR1 and 136 SSR2 to get the performance that we want. To accelerate the particle using lots of cavity, we have to make a process of cavity fabrication for RAON. We will compare each process made from the other laboratories to obtain the optimal process for RAON. And that process will consider the type of cavity and the purpose of the accelerator. This paper will introduce the early stages of the cavity fabrication process for RAON.

INTRODUCTION

RISP (Rare Isotope Science Project) has a plan in making an accelerator which will be referred to as RAON. The main usage of RAON will be to generate a rear high beam that the other accelerator can't generate. For that reason, RAON facility will require 550 superconducting cavities that made from high pure niobium to accelerate the beam.

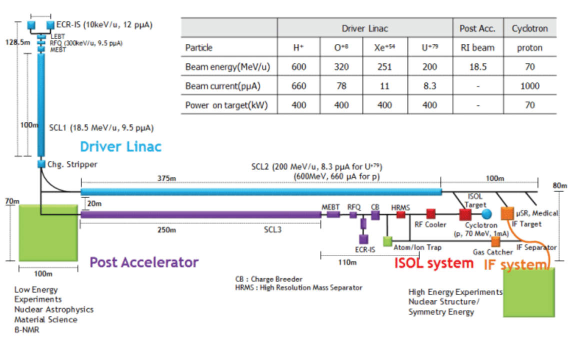

Figure 1 The conceptual design illustration for RAON

Figure1 is conceptual design illustration of RAON. The superconducting cavities will be used for the Driver Linac part and post accelerator part. It will have four kinds of cavities which are the QWR(Quarter Wave Resonator), HWR(Half Wave Resonator), SSR1(Single Spoke Resonator) and SSR2(Single Spoke Resonator) .

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Driver Linac will then be consisting of the SCL1 that will consist of QWR and HWR and the SCL2 that will consist of the SSR1 and SSR2.

Table 1: Cavities number for RAON

Location	Type	Number
Driver Liac	QWR	24
	HWR	138
	SSR1	88
	SSR2	136
Post accelerator	QWR	24
	HWR	138

The cavity of RAON's structure is complicated compared with 9-cell elliptical cavity. Because of this, fabrication facility for RAON's cavity has to be very particular. This paper is going to explain about the plan of Niobium sheet inspection equipment and furnace for heat treatment.

EDDY CURRENT TEST EQUIPMENT

In many cases, superconducting cavity made using the niobium as raw material and performance of cavity depends on smoothness of cavity's inner surface. An Nb sheet has to take an inspection before making the cavity for getting high performance. Typically, the inspection of Nb sheet consists of an examination with the naked eye and soaking it in the water to find rust and using the Eddy current test equipment to find defect.

Using that method, we can get confirmations regarding the property of the Nb sheet's surface and can thereby being able to choose the smoother side. The smoother side will be used as the inner surface of the cavity to achieve high performance.

Already, many accelerator laboratories used this system to find defects like DESY(GER), Fermialb(USA, Fermi National Accelerator Laboratory) and KEK(JAP, High Energy Accelerator Research Organization). [1-6]

The ECT equipment consists of three parts. The first part is the measurement equipment which includes a probe.

The specifications of the measurement equipment which are the probe and the oscilloscope will be changed depending on the shape and size of a defect. The parameters of the probe which Fermilab's ECS(Eddy Current Scanner) currently has are frequency, probe current, phase, gain, X/Y spread, High and low pass filter and air pressure. [5-6] The probe which KEK's ECS uses has a feature of 500Hz frequency, 0.5mm lift-off and the ability to measure defects for up to a diameter of 50μm and a depth of 50μm [7].

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The specification of probe for RAON is under study base on the other laboratories ECS.

The second part is the machine equipment that will do automatic measurement. RAON will require a total 550 cavities to get 2oo MeV/u as a first beam energy. For that reason, we will use lots of Nb sheet. To inspect all of these Nb sheets, we will need machine equipment that will do automatic measurement. There are two designs that automatic measurement equipment. One of them is using the turn table and one direction which start from the front to the rear to move probe automatically and the other is using two-direction that X and Y axis. The ECT system of the other accelerator laboratory uses a turntable and one direction [1-3] but RAON's ECT system will use two-direction ECT systems because a two-direction system is more accurate and easier to modify of structure. The last part is about analysis of the result. The ECT system of RISP is going to use a 3D program to get information regarding a defect's information.

HEAT TREATMENT (FURNACE)

Superconducting cavity has to have a heat treatment to remove H_2 gas and water on the inner surface of the cavity. This is one of the most important processes to make a cavity which will result in a good performance. For that reason, the cavity for RAON will also take the heat treatment to remove H_2 and water from cavity inner surface and to use heat treatment as well to make an NbN (Niobiumnitride) with N_2 gas under high temperatures. NbN is one of the good candidates to replace Nb for superconducting materials [8] Jefferson lab (USA) has a result regarding NbN doping on inner surface cavity at high temperature[9] and Fermilab(USA) is currently studying about NbN doping process. For the purpose of which are mentioned above, the furnace for RAON will need the following requirements listed in table 2.

Table 2: Specification of high vacuum furnace for RAON

Vacuum range	1×10^{-5} mbar (@1000℃)
Operating temperature	1000-12000℃
Cooling gas	N2
Temperature uniformity	±5℃
Heating material	Molybdenum
Size	1000×1000×1500 (mm)
N_2 pressure	2×10^{-2} mbar

Heat treatment is one of the important processes of the cavity fabrication process, but a high vacuum furnace for superconducting cavity is not a commercially available. So for that, we decided on the major factors of vacuum furnace for RAON's cavities.

The RISP's heat treatment process will operate to remove H_2 gas and water at about 1000-1200 degree Celsius for 10-12 hours. Additionally, the RAON cavity will take a heat treatment under N_2 gas to make a film of NbN (Niobiumnitride) on the inner cavity surface and has to have a high vacuum feature of at least $1x10^{-5}$ mbar and temperature uniformity of ±5 degree Celsius. Also, the RAON's furnace has to make Molybdenum to reduce contamination during the heat treatment process. The cavities of QWR, HWR and SSR will take heat treatments with a helium jacket so that the usable space will be 1000x1000x1500mm at the least

CONCLUSION

The early stage of planning regarding the inspection of niobium surface and heat treatment for RAON were explained with information of the cavity type in this paper. The specification of ECT equipment for inspection of niobium is currently being studied based on the other laboratorie's ECS. The most important parameter of high vacuum furnace for heat treatment referred.

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