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PRESSURE TEST FOR LARGE GRAIN AND FINE GRAIN NIOBIUM CAVITIES

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Abstract

The pressure test was performed using a fine grain (FG) and a large grain (LG) niobium cavities. The cavity is 1.3 GHz 3-cell TESLA-like shape. The cavity was housed in a steel vessel. Water is supplied into the vessel and the cavity outside is pressurized. The applying pressure and the natural frequency of cavity were measured during the pressure test. The FG and LG cavities were deformed greatly and the pressure dropped suddenly at 3.4 MPa and 1.6 MPa, respectively. The frequency shifted up to 3.4 MHz and 1.3 MHz, respectively. There was no leak after the pressure test, so the cavity did not rupture under above pressure. The result of the pressure at LG cavity is less half than that of the FG cavity. We calculated the stress distribution in the structure by applying outer water pressure using a FEM. The maximum stress at cell when above test pressure is applied, are 146 MPa in FG and 73 MPa in LG, respectively. These stresses are similar to tensile strength of niobium specimen measure by ourselves. The result of pressure tests agrees well with the calculation.

INTORODUCTION

The authors are investigating the fabrication technique of superconducting radio frequency (SRF) using LG niobium [1]. The SRF cavity is housed in a helium tank and cooled with liquid helium. These are subjected to the High Pressure Gas Safety Act. The working pressure of tank is 0.2 MPa. It is necessary to obtain the stress generated in each part of cavity when pressure is applied from the outside cavity and that the maximum stress is less than the allowable stress of the niobium material. The pressure test using actual cavity (more than 1.5 times of the working pressure) is also required.

The strength of LG niobium is smaller than that of usual FG niobium. Therefore, it was reported that the LG cavity was damaged at a lower pressure [2]. This paper reports the results of pressure test using 1.3 GHz 3-cell cavities made by LG and FG niobium.

EXPERIMENTALPROCEDURE

1.3 GHz TESLA-like 3-cell cavities fabricated in KEK CFF [3] were used for the test. The experimental apparatus is shown in Fig. 1. The cavity is housed in a steel vessel. Water is supplied into the vessel and the cavity outside is pressurized. The cavity inside is the atmosphere opening. Both ends flanges were fixed to the end plate of the vessel, so that the longitudinal displacement of cavity during pressurizing is constrained. The applying pressure and the natural frequency of cavity are measured during the pressure test. The pressure is increased in 0.2 MPa steps and held for 30 seconds. If there is no change, the applying pressure is future increased.

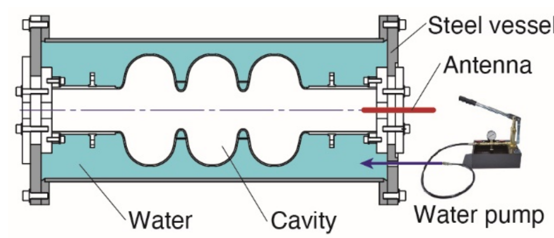

Figure 1: Experimental apparatus.

RESULTS AND DISCUSSION

When the applying pressure was increased, the FG and LG cavities were greatly deformed, and the pressure suddenly dropped at 3.4 MPa and 1.6 MPa, respectively. The test was suspended at that point. Figure 2 shows the cavity after deformation. There was no leak in both cavities after the pressure test, so that the cavities did not rupture under the above pressure. The pressure resistance of the LG cavity is less half than that of the FG cavity. It is similar to the result performed at DESY for 9-cell cavities [2]. The natural frequencies are 3.4 MHz and 1.3 MHz higher than the initial state, respectively as shown in Fig. 3.

The stress distribution of cavity when the above water pressure was applied from outside, was calculated using a FEM. The maximum stress (Tresca stress) at the cell part are shown in Table 1. The tensile strength obtained by the tensile testing using the same niobium material as the cavities is also shown. Both are in good agreement. It was confirmed that the difference in pressure resistance depends on the strength of the niobium material. The experimental results of the LG cavity, 1.6 MPa, is 8 times of the working pressure, and it is considered that the current cell thickness can comply with the High Pressure Gas Safety Act.

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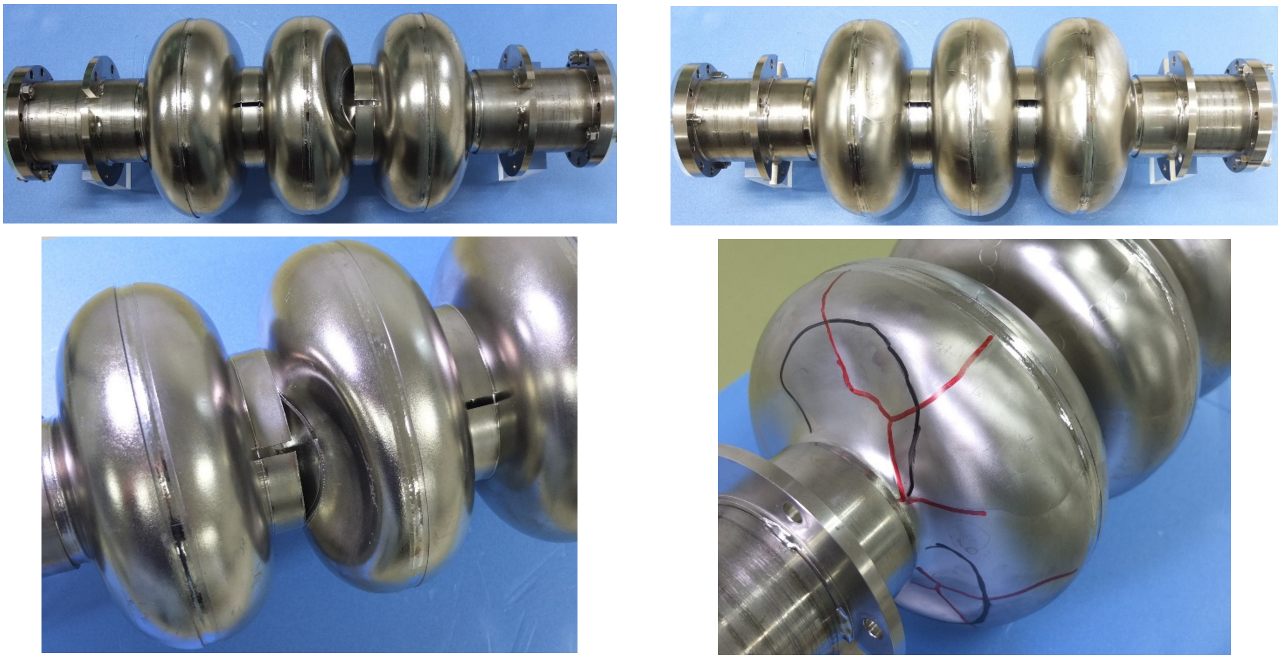

a) b)

Figure 2: Cavities after deformation. a) Fine grain. b) Large grain (Grain boundary and area of deformation are traced by red and black felt pen, respectively).

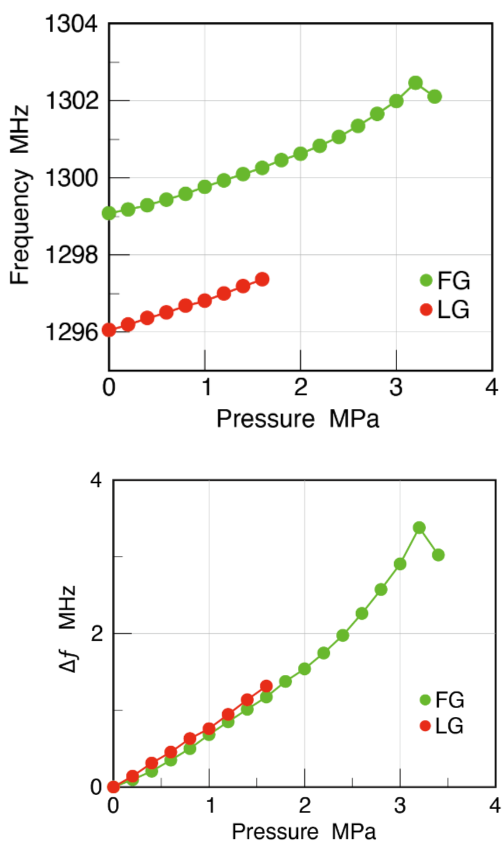

Figure 3: Change of natural frequency.

Table 1: Result of Pressure Test

	FG	LG
Pressure resistance [MPa]	3.4	1.6
Max. stress at cell [MPa] (calculation)	146	73
Tensile strength [MPa] (measured)	120	84
Change of natural frequency [MHz]	3.4	1.3

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