HIGH POWER TEST OF MA CAVITY FOR J-PARC RCS

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Abstract

We have been testing the RF cavities for the J-PARC RCS, so that we can operate the cavities without severe problems. Before some MA cores were damaged, then we found such cores have low ribbon resistance. After that we have tested the cavities loaded with cores which have improved ribbon resistance.

INTRODUCTION

We reported the high power test results of the Magnetic Alloy (MA) loaded cavity for the J-PARC Rapid Cycling Synchrotron (RCS) [1]. At that time, we have tested two cavities, and we observed some damages on the MA cores. Almost all of the damages happen at the cores which are placed nearest to the accelerating gap and experience highest electric field.

By investigating the measurement results, it seems that the MA core which has poor electric isolation between the ribbons suffers the damages. Then, we carefully set the cores in the cavity, the cores which have good electric isolation should be placed nearest to the accelerating gap, and the others should be far from the accelerating gap.

After that, we have performed high power long run test for 10 cavities and we do not observe any severe damages on the MA cores. We describe the high power test results and some knowledge we gained that prevents the damage to the cores.

RCS MA CAVITY

We use 18 MA cores for each cavity. The MA cores are cooled by pure water directly in the water vessel as shown in Fig. 1. The quality factor of the cavity is around 2. Before we tried to use the cut core technique [2] to get such quality factor for the RCS MA cavity because the intrinsic quality factor of the MA core is around 0.6, but the parallel inductor scheme [3] realizes such quality factor without cut core. Then, we install only the uncut cores in the water vessels, and perform the high power test.

Table 1: The parameters for the RCS cavity.

Frequency range	0.939∼1.672 MHz
Maximum voltage	45 kV / cavity
Cavity length	1950 mm
Number of gaps	3
Number of cores	18 / cavity
Core outer diameter	850 mm
Core inner diameter	375 mm
Core thickness	35 mm
Shunt impedance	800 Ω / gap
Q-value	2 (with Parallel inductor)
Resonant frequency	1.7 MHz (with Parallel inductor)
Average power dissipation	120 kW / cavity

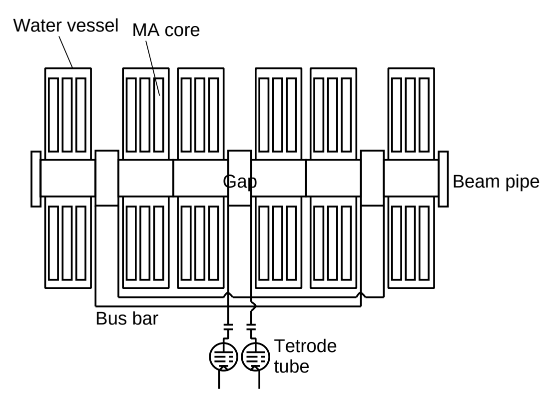

Figure 1: The MA cavity for the RCS.

MA CORE IMPROVEMENT

The most important reason why the MA cores have no severe damage at the high power test is some improvement of the MA core production. There are three types of MA cores:

- Type D: Original type of MA core production. The core winding process is so called 'vertical winding'. The electrical isolation between layers tends to become poor as shown in Fig. 2 and 3. The solid line shows the ideal ribbon resistance and the square marks show the measurement results. Figure 2 is the case of the damaged core which is placed nearest to the accelerating gap in the cavity water vessel. Figure 3 is an example of a type D core which is installed in the cavity water vessel far from the accelerating gap after we learned that poor electric isolation is related to the damage.

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- Type C: The core winding process is changed. It is so called ’horizontal winding’. The electrical isolation is improved as shown in Fig. 4.
- Type A: The core winding is ’horizontal’ same as type C, but the tension during the winding process is weaker than that of type C. Furthermore, another criterion is set to the MA ribbon reel. The core consists of several ribbon reels, and its resistance should be kept over 70 % of the ideal value. Then, the ribbon resistance becomes almost ideal as shown in Fig. 5.

Figure 6 shows the summary of the MA core measurement. The horizontal axis is the core serial number, and the vertical one is the impedance ratio described in [1]. The core which has a high impedance ratio is a well electrical isolated one. As can be clearly seen, the ratio becomes high and there is no big difference between cores of type A, but there is a bigger variation and almost all cores of type D have lower impedance ratio.

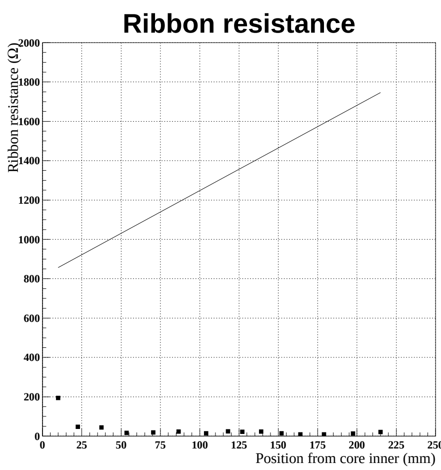

Figure 2: The ribbon resistance of a type D core. This core has damage.

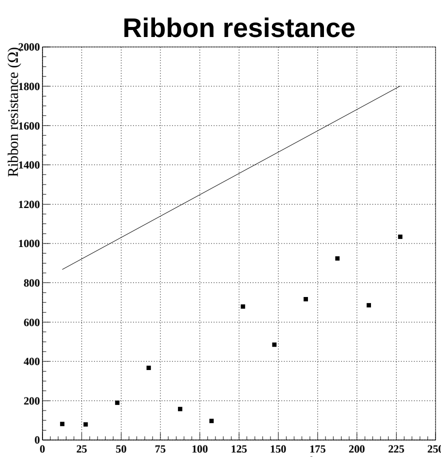

Figure 3: The ribbon resistance of a type D core. This core is used at the short side.

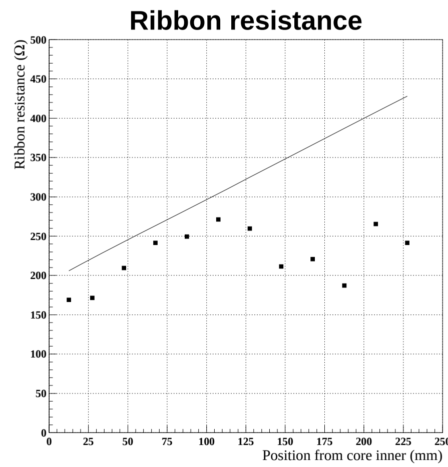

Figure 4: The ribbon resistance of a type C core.

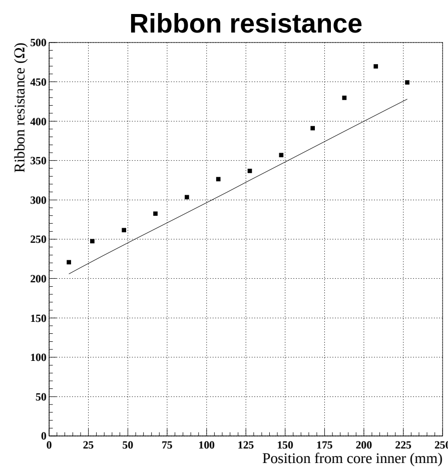

Figure 5: The ribbon resistance of a type A core.

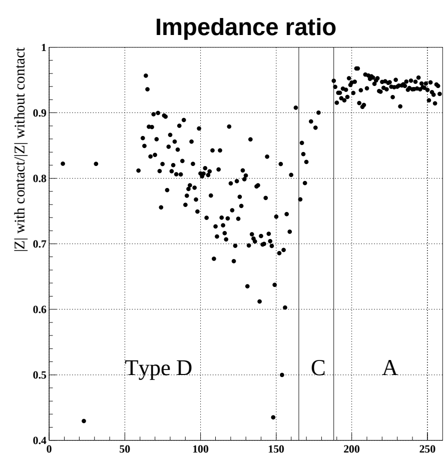

Figure 6: The summary of the MA core production.

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According to the impedance ratio, we decide to use the type A cores nearest to the accelerating gap, the other cores are sorted from the good one sequentially. It should be over 0.9 for the gap side cores, it is around 0.8 for the middle position cores, and it is around 0.7 for the short side cores.

HIGH POWER TEST RESULT

We have checked all of the MA cores to be installed in the RCS cavities. Each core should be tested with high power for at least 300 hours. Furthermore, one cavity performed a 1000 hours long run test to have more confidence. We started the high power test with a constant cavity voltage of 45 kV and 30 % duty with 0.3 Hz, and RCS acceleration pattern with 25 Hz after the pattern signal generator on low level rf system is ready to use. The parallel inductor scheme is also examined.

The high power test result is good, we do not see any severe damage on all MA cores. We can confirm the reason why the severe damage happened when we used the type D cores nearest to the accelerating gap [1].

However, we observed very tiny brown spots on the type A core surfaces as shown in Fig. 7. The size of the spots is a few mm, and the number of spots is a few on each core. Although we do not discover the reason why these tiny brown spots appear, we think this is not so severe, because once a spot appears, it does not become larger any more. We confirm that during 1000 hours long run test as follows; we open the cavity water vessel after 300 hours, observe the tiny brown spot, we put it back in the cavity water vessel, then we continue the high power test up to 1000 hours. After 1000 hours, the tiny brown spot did not change.

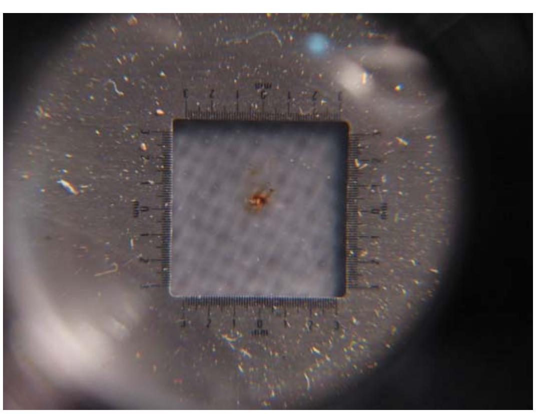

Figure 7: The tiny brown spot on the MA core surface.

The tiny brown spot appears on the early number of the type A cores, we rarely observe it on recent type A cores. Now we are investigating what is done on recent cores during the core production.

CAVITY INSTALLATION INTO RCS BUILDING

The high power test has been finished in April this year, then we have installed all 10 cavities into the RCS building. We already performed the high power test on one of the cavities in the RCS tunnel, then we check the rf system works the same way in the test bench. Now, we set up the tube amplifiers, the power supplies and the low level rf systems, and we will put the power to the all 10 cavities in July.

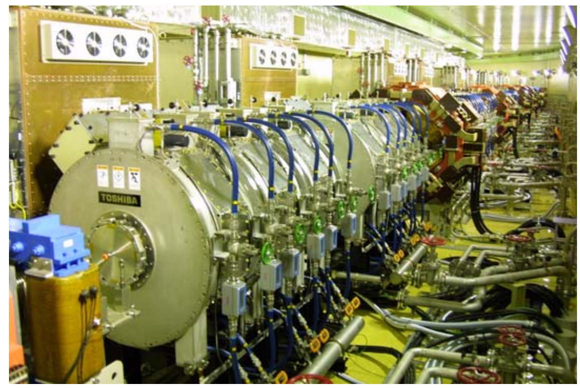

Figure 8: The cavity installed into the RCS building.

SUMMARY

We have been constructing the J-PARC RCS cavities. The high power tests were performed for all 10 cavities for at least 300 hours, and one of them performed up to 1000 hours. In these tests, we carefully put the core which has good electrical ribbon isolation nearest to the accelerating gap side. Then, the test results are good, we do not see any severe damage on the MA cores. This means the major reason why we suffered from the core damage as described in last report [1] is that we used cores which had poor electrical isolation between the ribbons.

REFERENCES

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