COMBINED SYSTEM OF OPTICAL INSPECTION AND LOCAL GRINDER

Y. Iwashita, ICR, Kyoto University, Uji, Kyoto, JAPAN
H. Hayano, T. Kubo, K. Wtanabe, Y. Yamamoto, KEK, Ibaraki, JAPAN

Abstract

Optical inspections on superconducting accelerating tubes have been playing an important role on improving their accelerating gradients. Instead of treatments on whole cavity inner surfaces to eliminate the found defects on the surfaces, the local grinding method succeeds to remove them efficiently. A combined system of the optical inspection and the local Grinding machines are fabricated.

INTRODUCTION

Superconducting (Sc) technology is getting popular for accelerating cavities. The fabrication cost is one of the big aspects for the Sc cavities to be applied for wide applications. Since the ILC project needs more than 16000 9-cell cavities, their production yield had been a big issue before the high resolution optical inspection technique was developed. The high resolution optical inspection system revealed the physical sources of the reduced performances, which enabled us to pursuit further investigations such as replica technique and curing the defects on the surface (see Fig.1) [1,2,3,4,5,6].

Figure 1: The High Resolution Cavity Camera (Ver.5)

EFFECTIVENESS OF REPAIR

Figure 2 shows typical defects that degrade the cavity performances. Many of them usually appear on the EBW seam area. While these defects are localized, the weakest cell performance limits the whole 9-cell cavity. The local grinding technique cures the local defects instead of the deep Electro-Polish (EP) process to entire cavities, which usually takes a few weeks for the process. Example of the local repair for MHI-08 is shown in Fig.3, where two defects limited the gradient and one of them appeared after EP [8,9]. The defects were removed by the local grinding and light EP was performed. Figure 4 shows the improvements of the Q-slope. Accelerating gradient 16

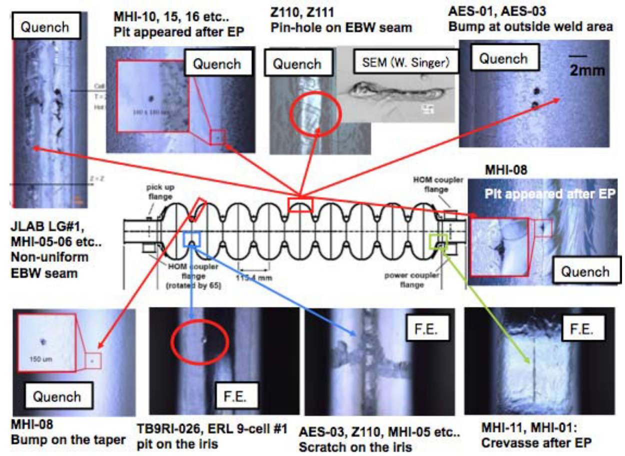

Figure 2: Defects against performance.

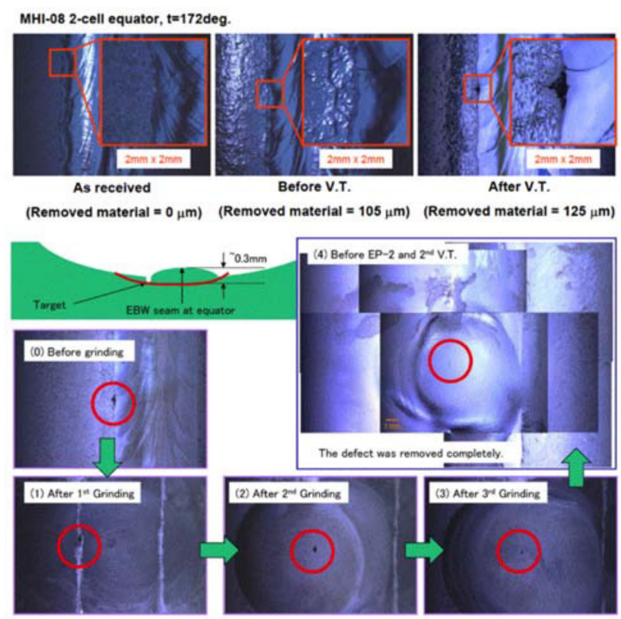

Figure 3: Example of local repair: MHI-08.

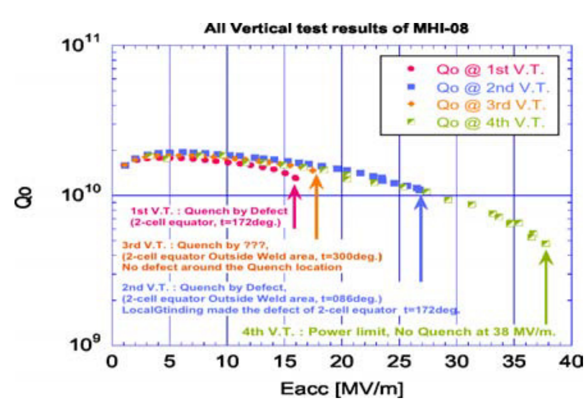

Figure 4: The Q-slope curves of MHI-08 over the repair.

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MV/m at the first VT was raised to 27 MV/m in the 2nd VT by the local grinding process and finally reached to 38 MV/m at the 4th VT.

cERL injection and main cavities were also processed. The results of the injection cavity #4 and the main cavity #1 are shown in Figs. 5 and 6. In both the cases, the Field Emission (FE) was successfully suppressed, hence the observed radiation levels decreased.

Table 1 summarizes the results on the local repair on the processed cavities (up to 2011) [11]. Recent results are reported in Ref.18.

Table 1: Result of the local repair

Cavity	Before	After
AC71 (DESY)	26 MV/m (#1-#2 iris repaired)	30 MV/m [10]
MHI-08	16 MV/m	38 MV/m [7]
AES-01 (FNAL)	Quench at 22 MV/m (Cell #3 repaired)	Waiting VT [11]
AES-03 (FNAL)	Quench at 20 MV/m (Cell #1, #3, #6 and all irises repaired)	34.6 MV/m [11]
JLAB LG#1 (JLAB)	Quench at 30 MV/m (Cell #5 repaired)	improved to 43 MV/m [14]
TB9 RI-026 (FNAL)	After quench at 30 MV/m, FE started from low field. Max 20 MV/m. (#8-#9 iris repaired)	36.6 MV/m no F.E. [11]
cERL 9-cell #1	18 MV/m with F.E.	25 MV/m without F.E.[12]
CERL 2-cell #4	20 MV/m with heavy F.E.	25 MV/m without F.E.[13]

RECENT DEVELOPMENT

The high resolution camera, Fig. 1, is still being developed for better and easier observation of the cavity inner surfaces. One of the recent revisions was the advancement in the illumination unit. The first version used an Electro Luminescence (EL) sheet that was divided into 20 strips longitudinally for the freedom of the light source positions (angle). Although the EL sheet had an advantage of the thin thickness, the brightness and the lifetime were not satisfactory. Therefore it was replaced by acrylic strips with LED's at the both edges for the second version (two LED's per one strip). The brightness and the lifetime were significantly improved [15]. When the request for the application to a larger cavity (SPL cavity at CERN) came, the brightness had to be enhanced further. The number of LED's per strip was increased from two to 28 LED's, while the control of ON/OFF was still for each strip [16](see Fig. 7). The latest version has a control of each dot, which enables us to make a more flexible illumination.

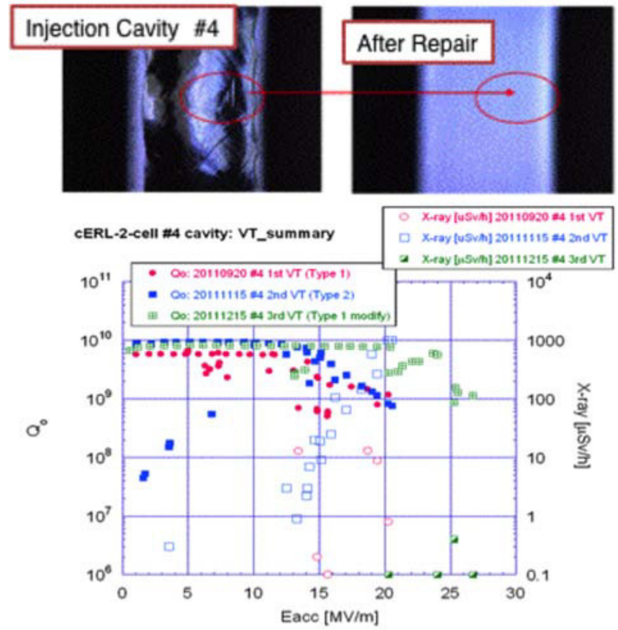

Figure 5: Results on cERL injection cavity.

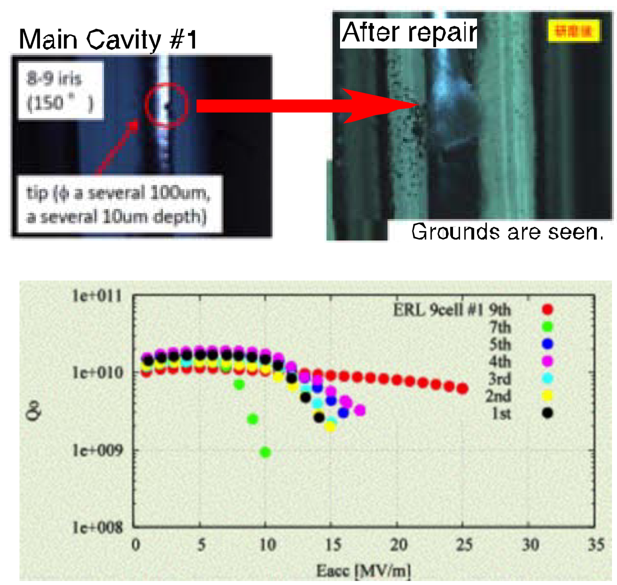

Figure 6: Results on cERL main cavity.

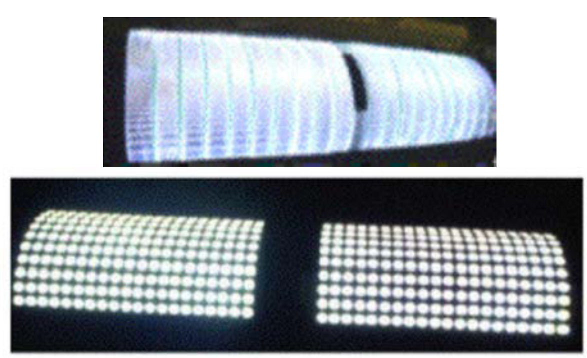

Figure 7: Revised illumination from stripe (top) to dot matrix (bottom). Each dot can be controlled individually.

The local grinder was also improved in the grinding power to reduce the grinding time. Because the grinding motor had been installed on the pantograph head, the power from the small motor was limited. The new design uses an powerful external motor where the torque is transmitted through a drive shaft in the support cylinder (see Fig. 8) [17].

Because the combination of the high resolution cavity camera and the local grinder proved to be useful, a combined system of both the devices was fabricated as shown in Fig. 9, where the camera and grinder cylinders are aligned vertically to reduce the foot print of the system. The fabricated system installed in the STF is shown in Fig. 10.

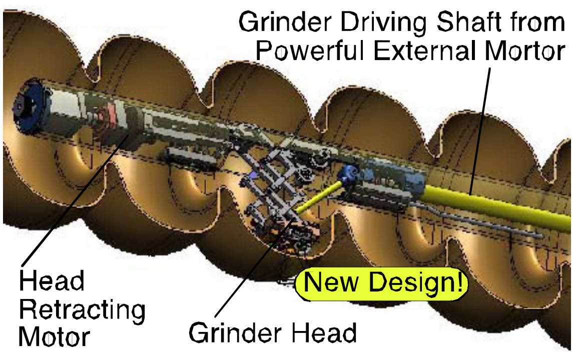

Figure 8: Large external motor delivers more power to the head.

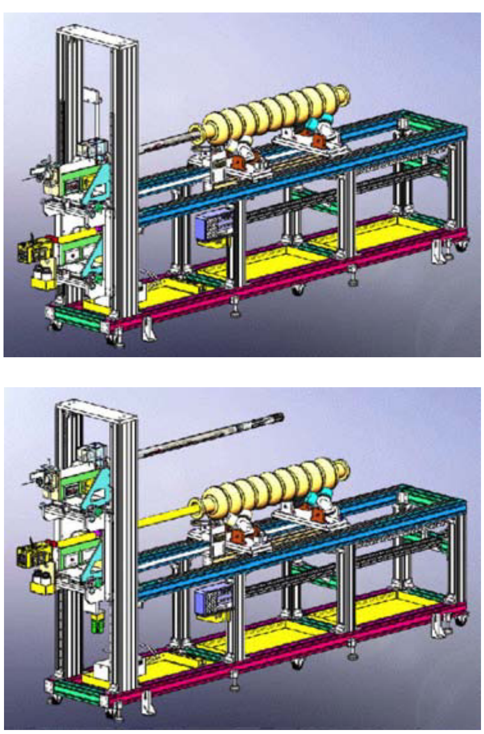

Figure 9: Combined system of camera and grinder. Top figure shows the camera position and the bottom figure show the grinder position.

Figure 10: Combined cavity camera and local grinder.

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