HOM Suppression Improvement for Mass Production of EXFEL Cavities at RI

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Abstract

During cold RF tests of the European XFEL (EXFEL) cavities at DESY it was observed that the damping of the second monopole mode (TM011) showed the largest variation, which was sometimes up to 2-3 times lower than the originally allowed limit. It was concluded that this TM011-damping degradation was caused by cavity geometry deviation within the specified mechanical tolerances. The particular influence of different mechanical parameters was analyzed and additional RF measurements were carried out to find the most critical geometry parameters. Stability of the equator welding and regularity of chemical treatment were investigated for different cavity cells. In spite of the high fabrication rate during EXFEL cavity mass production the TM011 suppression was improved to an acceptable level.

STATISTICS

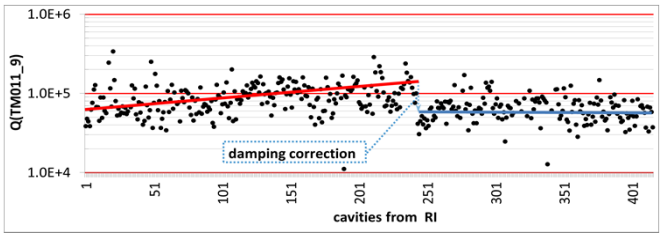


Figure 1: Measurements results of the Qload for the TM011 (zero-mode) at 2K

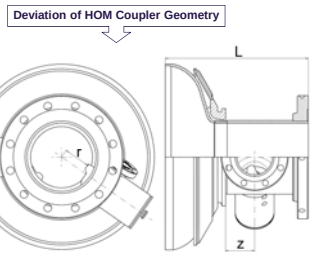
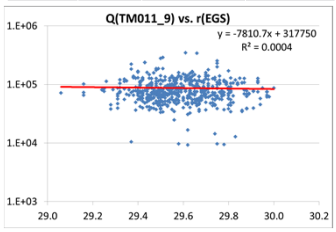
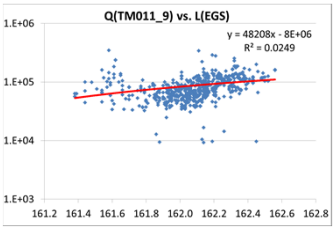


Figure 2: Position of High Order Modes (HOM) coupler #1 in the short end group (EGS):
L – length;
z – distance between HOM coupler and connecting flange,
r – distance between F-part and cavity axis.

Table 1: TM011 damping sensitivity to EGS geometry

Parameter (M)	|dQ/dM|, 10^3 mm^{-1}	Standard deviation (S), mm	Q-deviation dQ/dM * S, 10^3
L	48.2	0.21	10
z	30.8	0.26	8
r	7.8	0.16	1.2





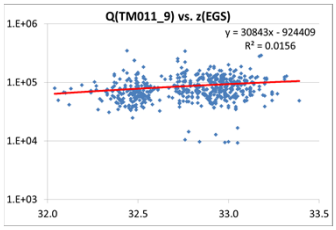
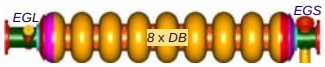


Figure 3: Sensitivities of quality factor for TM011 (y) to EGS geometry deviations (x = L, z and r) in mm.



The EXFEL cavity consists of: long end group (EGL), short end group (EGS) and 8 dumb-bells (DB).

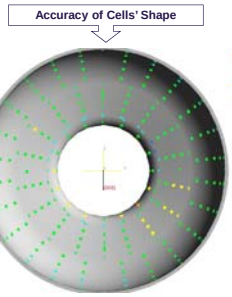


Figure 4: Results of 3D-measurements of cavity half-cell.

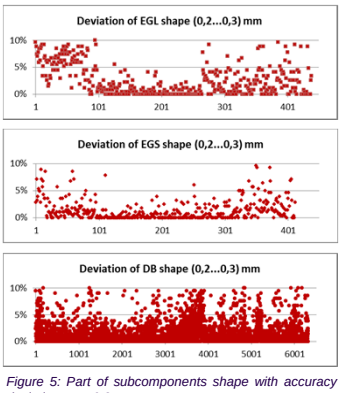


Figure 5: Part of subcomponents shape with accuracy deviation over 0.2 mm.

EQUATOR WELDING (EW) AND ELECTROPOLISHING (EP)

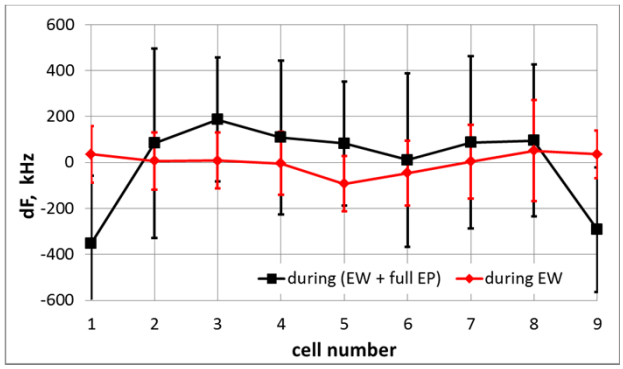


Figure 6: Calculated frequencies deviations in different cells during EW and EP.

TM011 FIELD DISTRIBUTION

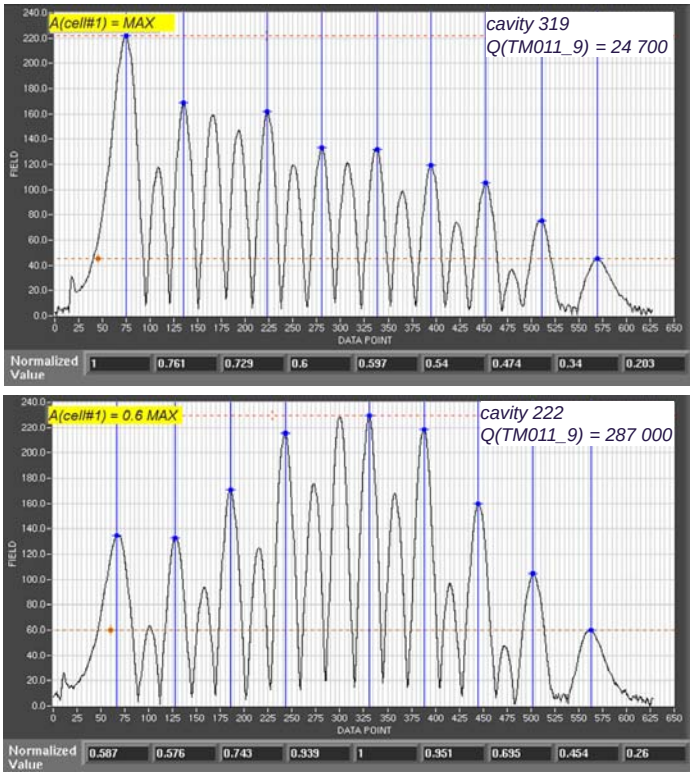


Figure 7: E-field distribution of the TM011_9 on axis for two examples:
cavity 319 with asymmetrical field and cavity 222 with symmetrical "trapped" field.

Summary

- No considerable dependences of HOM suppression efficiency on the accuracy of cavity subcomponents shape or on positioning of HOM coupler were found.
- Stability of EW for major amount of cavities was confirmed by both mechanical measurements and RF analysis.
- Irregularity of eigenfrequency changes due to EP was compensated by planed additional trimming of the end groups before EW.
- Measurements of the spectra and field distribution for TM011_9 at room temperature after fundamental mode tuning allowed us identification of the critical geometry changes, which cause the trapping of TM011 mode.
- Significant damping correction for TM011_9 was provided by:
  - increasing of TM011-field asymmetry due to correction of end group trimming;
  - intensive R&D collaboration between RI and DESY.

References:
[1] A. Sulimov et al., "Efficiency of High Order Modes Extraction in the European XFEL Linac", Proceedings of LINAC 2014, Geneva, Switzerland, 2014, p. 883
[2] A. Sulimov, "RF Analysis of Equator Welding Stability for the European XFEL Cavities", Proceedings of SRF2015, Whistler, BC, Canada, 2015, p. 1272
[3] A. Sulimov et al., "RF Analysis of Electropolishing for EXFEL Cavities Production at Ettore Zanon Spa", [TUPL035], These Proceedings, East Lansing, MI, USA, 2016
[4] A. Sulimov et al., "Practical Aspects of HOM Suppression Improvement for TM011", Proceedings of SRF2015, Whistler, BC, Canada, 2015, p. 1277