PRACTICAL ASPECTS OF HOM SUPPRESSION IMPROVEMENT FOR TM011

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Abstract

Some Higher Order Modes (HOM) pass bands were controlled during cryo-tests at DESY for the European XFEL cavities. The second monopole mode (TM011) showed most instabilities and suppression degradation.

The authors will explain this phenomenon on the example of cavity CAV00553 and present the practical method of TM011 damping improvement.

INTRODUCTION

Suppression of the TM011 (zero mode) in the cavities was a challenging task for the European XFEL mass production. Our investigation [1] determined that damping efficiency degradation is caused by critical changes in the field distribution.

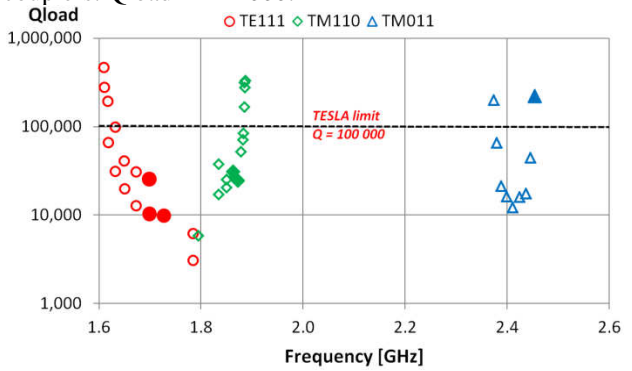
RF simulations showed that these changes are possible for geometry deviations of about ± 0.2 mm in the equator radius within specific cells.

Almost all cavities, that were produced by company E.ZANON for the European XFEL, correspond to the criteria (see Fig.1), which was achieved during pre-series production (Q load values below the "TESLA limit" of 100 000).

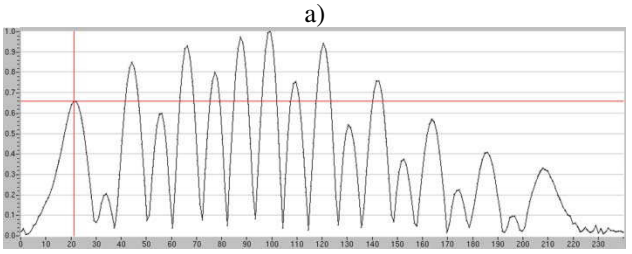
It was found that one sub-component of cavity CAV00533 was not trimmed to the correct length at the equator before welding and cell #1 becomes about 2 mm longer after field flatness tuning of fundamental mode. A similar situation was simulated in [1] and the measurement of HOM suppression at 2 K (see below) indicates the necessity of TM011 damping improvement.

HOM SUPPRESSION IMPROVEMENT

The detailed analysis of HOM suppression for CAV00553 shows that the most critical dipole modes (see Fig. 2 a) are damped well (points filled with red and green colours). But the second monopole mode (filled with blue) coupled not strong enough with both HOM couplers: Qload = 222 000.



a)



z – position on cavity axis

b)

Figure 2: HOM suppression (a) and normalized field distribution of TM011 $|E|_{r=0}$ (b) for CAV00553 after welding

The necessary field asymmetry is lost (Fig.2 b) and the amplitude in the first cell is 35 % less than in cell #4. It also correlates with simulations in [1] for length deviation (first cell elongation) about 2 mm relative nominal value.

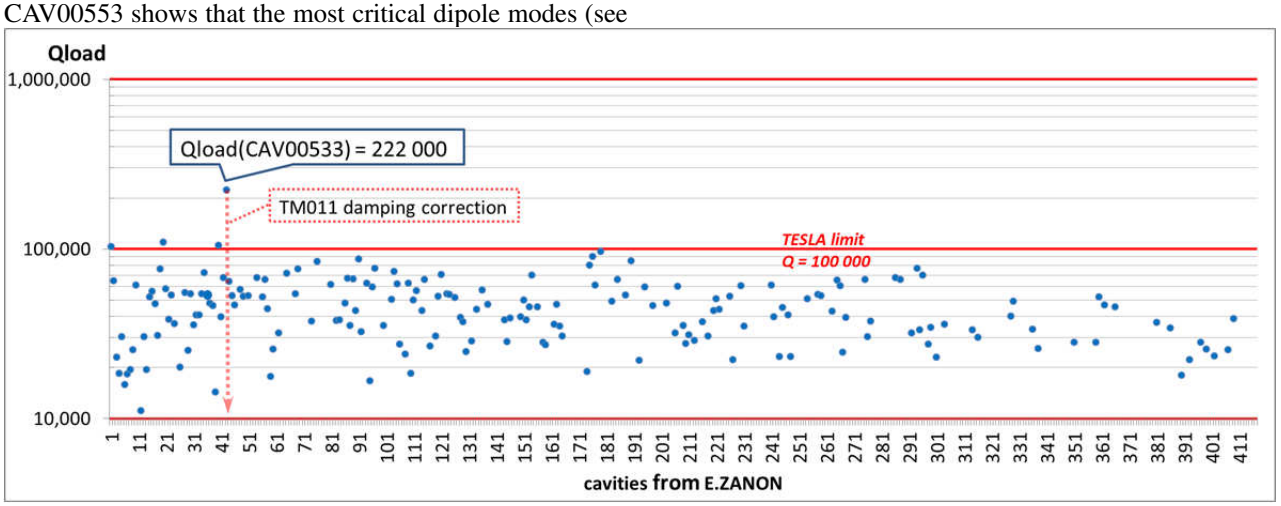
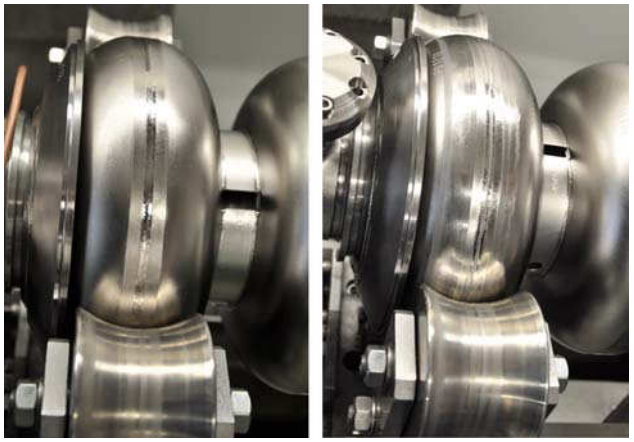


Figure 1: Measurements results of TM011 at 2K for the XFEL cavities, produced by E.ZANON

Compensation of this elongation is possible only with a reduction of the first cell equator diameter by about 0.5 mm.

The necessary deformations were done in two steps:

1. Local equator diameter deformation with special equipment [2] at DESY (Fig. 3) allows us to increase the eigenfrequency and field of fundamental mode in cell #1 with fixed cavity length.
2. Compensation of fundamental mode RF parameters with the cavity tuning machine by length reduction of cell #1 increases the field asymmetry for TM011 zero mode.



a) before deformation b) after the final iteration

Figure 3: Equator diameter reduction of the cell#1, with rollers [2]

To reduce the risk of errors, planned deformations were decreased and done in two iterations. The frequency control, fundamental mode tuning and TM011-mode field distribution control were performed after each iteration. Nevertheless, equator diameter was reduced too much. Final length reduction for cell #1 is 4 mm.

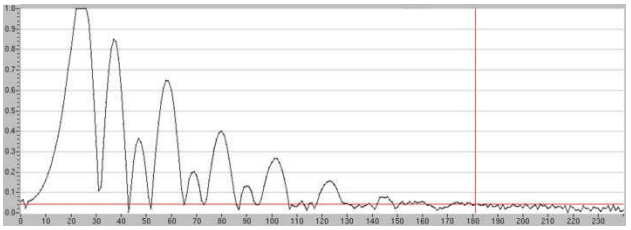
Field distribution (asymmetry) changes of TM011 zero mode (Fig.4 a) enhanced the coupling with HOM coupler and improved TM011 damping efficiency: Qload = 9 900.

The HOM measurements at 2K (Fig.4 b) show the good suppression of all critical modes (points filled with corresponding colours).

SUMMARY

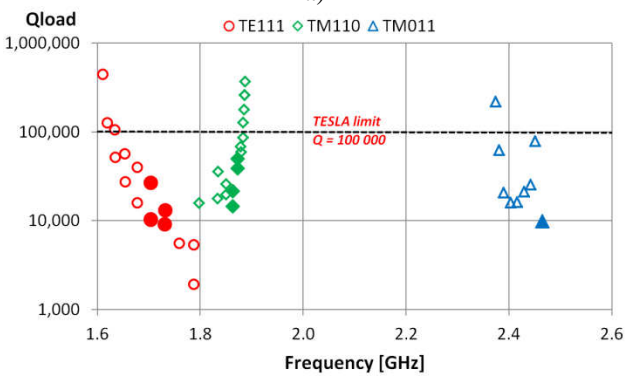
Almost all cavities from company E.ZANON correspond to TESLA HOM suppression criterion, but we found that operation of trimming for a cavity part was omitted and cell #1 of CAV00553 became 2 mm longer than usual after field flatness fundamental mode tuning.

This accident allowed us to check on our simulations and measurements done in [1]. Thus the influence of geometry inaccuracy and field distribution on HOM damping efficiency was practically approved.



z – position on cavity axis

a)



b)

Figure 4: Normalized field distribution of TM011 $|E|_{r=0}$ (a) and HOM suppression (b) for CAV00553 after the length reduction for cell #1

It was shown that TM011 suppression improvement is possible without damping degradation of dipole modes (TE111 and TM110).

The further work on the HOM damping improvement is going on in collaboration with cavities manufacturers.

ACKNOWLEDGMENT

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REFERENCES

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