RF ASPECTS OF QUALITY CONTROL FOR INDUSTRIAL XFEL CAVITIES FABRICATION

A. Sulimov, V. Gubarev, S. Yasar, DESY, Notkestrasse 85, 22607 Hamburg, Germany

Abstract

Quality control of European XFEL serial cavities allows us not only exception of the use of rejected cavities for the linac, but also giving a feedback to industry in case of cavity parameters come to their limits. RF check assays not only the electro dynamical characteristics (as frequencies, Q-factors and fields), but also provides the mechanical revise with a very high accuracy.

Automation of this quality control in XFEL data base gave us a powerful tool necessary for big projects such as the European XFEL

INTRODUCTION

The planned fabrication rate for the European XFEL is 8 cavities per week. Taking into account that RF quality inspection requires 39 inspection sheets for each cavity, 312 documents have to be read and analyzed during a week. The results have to be combined or compared to calculate the specified criteria.

During cavity fabrication different kinds of inspection sheets [1] (see figure 1) are stored in the XFEL DB [2] for RF verification. They can be separated by control levels and production steps:

Acceptance Level 1 (AL1)
- cavity parts fabrication (V_F01/2/3, W_01/2/3),
- cavity welding (X_HCP, X_M01, X_F01),

Acceptance Level 2 (AL2)
- cavity tuning (X_M02/3, X_F02/3, Y_F01,Y_M01),
- welding in the helium tank and a pressure test (Y_F02),

Acceptance Level 3 (AL3)
- cavity transport (Y_F03).

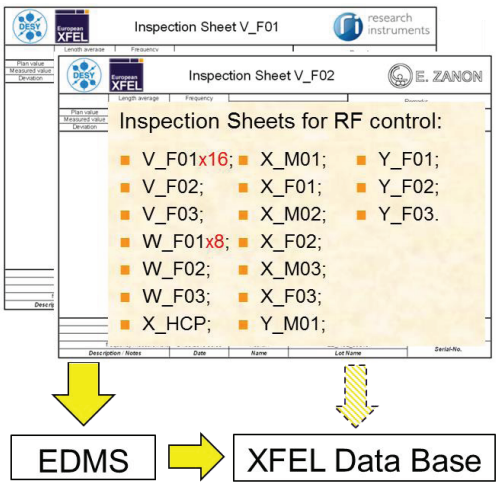

Figure 1: List of different protocols, required for RF quality inspection

The planned data flow involves inspection sheets transmission to the data base through DESY Engineering Data Managements System (EDMS) [1].

The RF measurements procedure [3] and first results for pre-series European XFEL cavities [4] were already described. The industrial fabrication of 800 cavities however, required further development and automation of quality control.

Integration of existing tools for RF analysis in automatic system for different controls levels and their descriptions will be presented in this paper.

ACCEPTANCE LEVEL 1

The most important parameters and information for newly produced cavities are presented in one window of the XFEL DB visualization panel – "RF control after equator welding" (see figure 2):

- cavity name;
- pi-mode frequency (from X_F01),
- cavity length between connecting flanges (from X_M01);
- expected cavity length after the tuning and its deviation (according the XFEL specification XFEL/014);
- maximal deviation of parts rest trimming and dumb-bells symmetry (calculated by HAZEMEMA [5] formulas);
- welding parameter – shrinkage;
- material supplier: (P – Plansee, T – Tokyo Denkai and N – Ningxia).

If all these parameters are in tolerance (according to the XFEL specifications XEL/014 and XFEL/ABCD), the cavity name is presented on white background, else – on red (the out-of-tolerance values are highlighted with red).

One can open the "RF Parts Control" panel by pressing the "Cavity parts" button and will find there the following parameters from X_F01, X_M01, X_HCP and W_01/2/3 (see figure 2):

- cavity name;
- name of producer;
- part serial numbers;
- pi-mode frequency for these parts;
- parts lengths;
- dumb-bells symmetries (Asym.-1), and their maximum;
- rest trimming values, calculated for real shrinkage, their average value and maximum of their magnitudes;
- real shrinkage, calculated as a difference of real length and sum of the parts lengths;
- cavity pi-mode frequency;
- cavity length after welding.

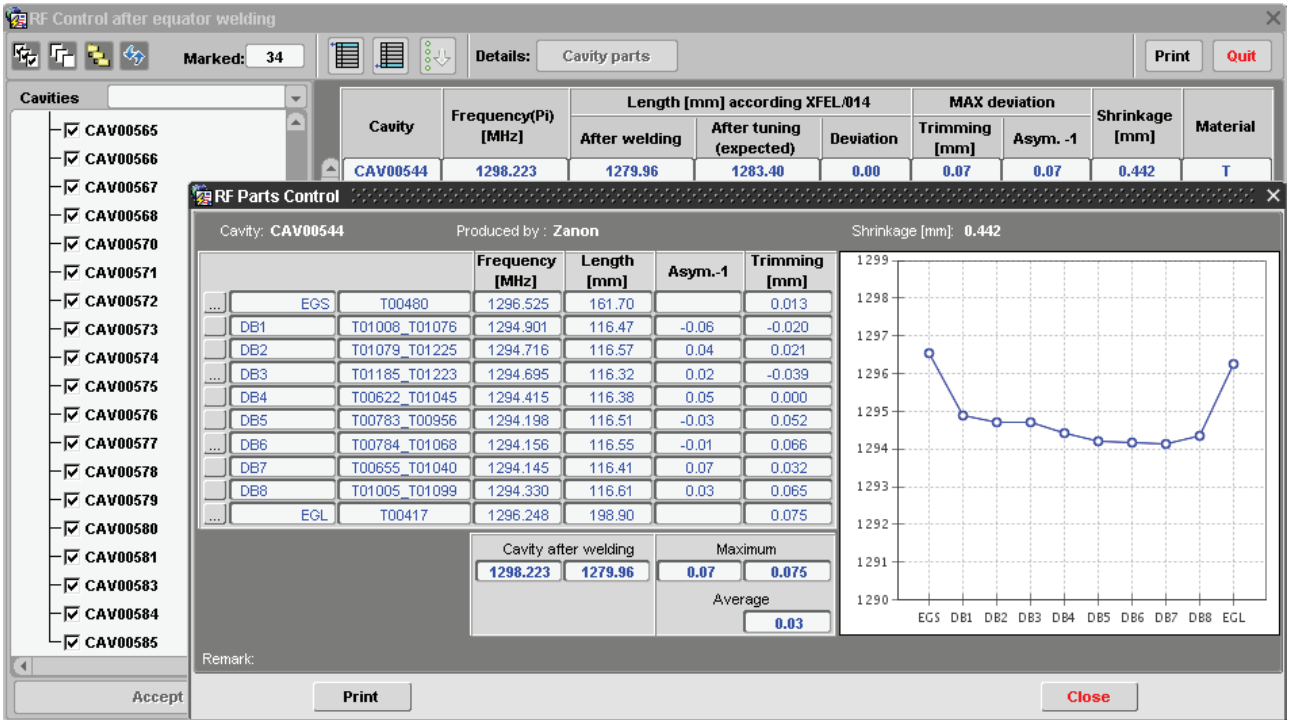

Figure 2: RF quality control panels for Acceptance Level 1.

Frequencies of parts are also presented graphically, for easier control of dumb-bells sorting [3].

Dumb-bells asymmetry "Asym." is calculated as ratio of the half cells volumes, estimation is based on frequency control by HAZEMEMA [5]. The absolute value of symmetry (Asym.-1) should be less than 0.1.

Rest trimming values are limited by mechanical accuracy of parts cutting 0.3 mm, so the absolute value should be less than 0.15 mm. Besides it allows achieving the nominal cavity length using all cavity parts without additional compensation.

The original inspection sheets and more for all end groups (EGS - short side, EGL - long) and dumb-bells (DBs) can be found by pressing the "…" button on the left in each line.

ACCEPTANCE LEVEL 2

After a set of treatment procedures, several tunings, integration in the helium tank and a pressure test the cavity reaches Acceptance Level 2.

The most important parameters and information for cavities at this level are presented in one window – "RF control after Acceptance Level 2" – similar to presented at figure 3:

- cavity name;
- pi-mode frequency (from Y_F02),
- cavity length (from Y_M01) measured before welding in the helium tank;
- field flatness;
- maximal (from 9 cells and 2 flanges) eccentricity value;
- warnings at any production step after AL1.

If all these parameters are in tolerance (according to the XFEL specifications), the cavity name is presented on white background, else – on red (the out-of-tolerance values are highlighted with red).

One can open "Detail RF Data Controls" panel by pressing the "Results from protocol" button and will find there frequencies, field flatness's, lengths, maximal eccentricity values and comments for the cavity after different tunings and/or measurements on the cavity tuning machine – CTM [6] (see figure 3):

- X_F/M02 – first cavity tuning after main electro polishing (EP) procedure and backing at 800ºC;
- X_F/M03 – after fine EP (for Research instruments only) and installation of field measurement system (FMS);
- Y_F/M01 – after the welding of rings and bellow;
- Y_F02 – final full RF measurements.

The original inspection sheets and more details for each measurement can be found by pressing the "…" button on the left in each line.

ACCEPTANCE LEVEL 3

After a final 10 µm buffered chemical polishing (BCP – only by E.ZANON) and cavity preparation for the transport to DESY (installation of High Q and HOM coupler antennas, vacuuming, and so on) the cavity reaches Acceptance Level 3.

The most important parameters and information for cavities at this level are presented in one window – "RF control after Acceptance Level 3" (see figure 3). Some of them were already described in the previous chapter.

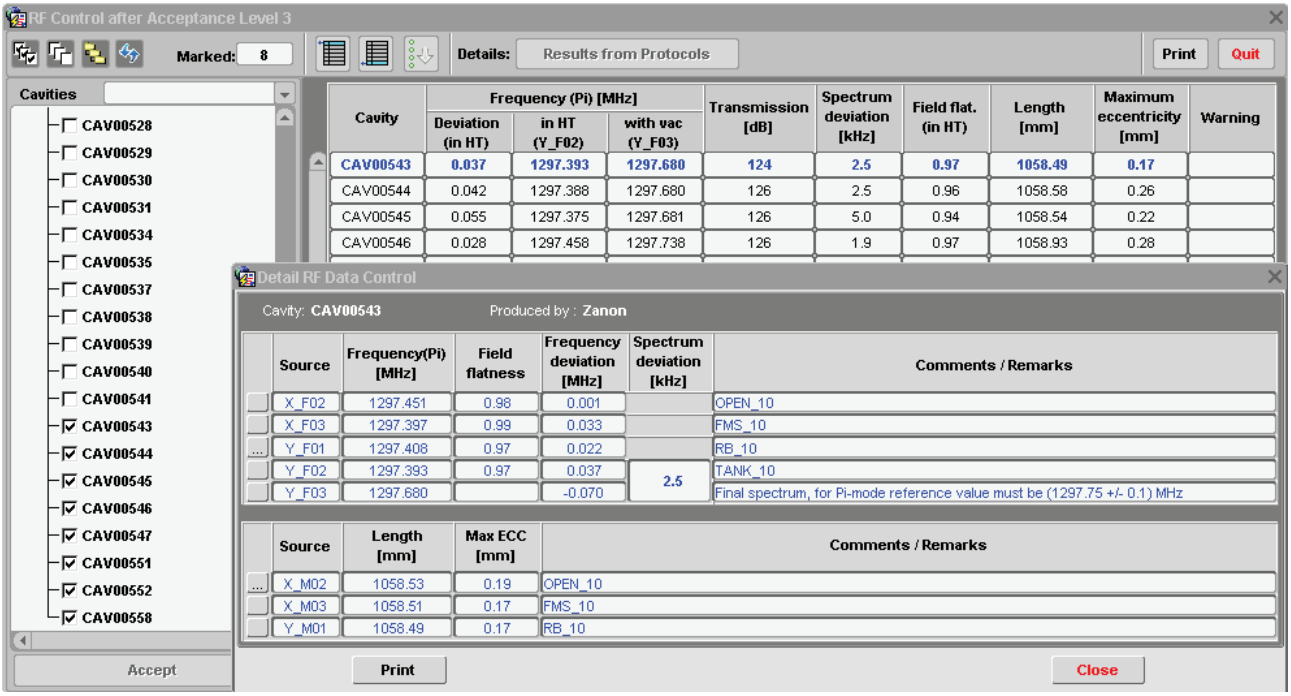

Figure 3: RF quality control panels for acceptance level 3.

New parameters (from Y_F03), which are presented also in "Details", are:

- pi-mode frequency for cavity with vacuum,
- magnitude of transmission between high Q and pick-up antennas;
- spectrum deviation, between two measurements Y_F02 and Y_F03.

Since FMS is dismounted after last full RF measurements (Y_F02), estimation of field flatness is possible only by comparison of cavity's spectra [4].

SUMMARY

The RF quality control for European XFEL cavities requires checking of 31 200 inspection sheets only from cavity producers. Automation of this process in the XFEL data base gave us a powerful tool which is required for such a big project.

The access to the fabrication data in the XFEL DB is limited – only for cavity producers and DESY experts. So this paper will be interesting mostly for them. But the analysis will be published and our experience can be used also for others projects.

ACKNOWLEDGMENT

We are thanking:

- all colleagues from E. ZANON and Research Instruments, for their important contribution to the measurements, as an integral part of cavity production and quality control;
- DESY colleagues and IPP group for supporting and development of the EDMS;
- personally Giorgio Corniani (E.ZANON, Project Manager) for giving the possibility to present the results of EZ cavities.

REFERENCES

[1] J. Dammann et al., "PLM-Based Quality Assurance in the Series Production of the Superconducting Cavities for the European Xfel", Proceedings of IPAC2012, New Orleans, Louisiana, USA, 2012, pp. 2209-2211.

[2] http://xfel.desy.de/cavity_database/cavity_production

[3] A. Sulimov et al., "Description and First Experience with the RF Measurement Procedure for the European XFEL SC Cavity Production", 2nd IPAC'11, San Sebastian, Spain, 2011, pp. 277-279.

[4] A. Sulimov et al., "First RF Measurement Results for the European XFEL SC Cavity Production" Proceedings of LINAC2012, Tel-Aviv, Israel, 2012, pp. 195-197.

[5] J. Iversen et al., "Development and Design of an RF measurement Machine for the European XFEL Cavity Fabrication", 14th SRF Conference, Berlin, 2009, p.786.

[6] J.-H. Thie et al., "Commissioning and Upgrade of Automatic Cavity Tuning Machines for the European XFEL", 15th SRF Conference, Chicago, 2011.