Development and Design of a RF-Measurement Machine for the European XFEL Cavity Fabrication

DESY, 22603 Hamburg, Germany

Abstract

Radio frequency measurements on parts and subassemblies of superconducting cavities during their fabrication are a proper method of quality management and quality assurance. During the fabrication of 1.3 GHz cavities for FLASH, a simple device was used for measuring the half cells, dumb-bells and end groups. This machine performs an easy load of the parts, consistent RF contacts, automated RF measurements and documentation. We describe the functionality of the RF-measurement machine and performance of the prototype during fabrication of 40 cavities for FLASH.

Figure 1) A simple device was used for the production of 72 Cavities for FLASH, manual clamped, undefined contact

Figure 2) Measurable parts and subassemblies of the 1.3GHz cavity

Figure 3) Prototype machine (called HAZEMEMA)

Figure 4) Clamping of a dumb-bell

Figure 5) Detailed view of the clamping situation

Table 1) Main differences

<table>
<thead>
<tr>
<th>Clamping</th>
<th>Test duration for dumb-bell</th>
<th>Required manpower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple device</td>
<td>manual</td>
<td>5 min</td>
</tr>
<tr>
<td>New machine</td>
<td>automated</td>
<td>2 min</td>
</tr>
</tbody>
</table>

Table 2) Experiences (amount of measurements done during the fabrication of 41 cavities)

<table>
<thead>
<tr>
<th>Parts per cavity</th>
<th>Measurements done for 41 cavities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal half cell</td>
<td>16</td>
</tr>
<tr>
<td>Short half cell</td>
<td>2</td>
</tr>
<tr>
<td>Long half cell</td>
<td>8</td>
</tr>
<tr>
<td>Dumb-bell</td>
<td>2</td>
</tr>
<tr>
<td>End half cell</td>
<td>2</td>
</tr>
<tr>
<td>Long end group</td>
<td>2</td>
</tr>
<tr>
<td>Summary</td>
<td>30</td>
</tr>
</tbody>
</table>

Development phases

- Developed and designed in 2006
- Fabricated in 2007
- Used during the production of 41 cavities for FLASH in 2007 and 2008
- Improvements and redesign done in 2008/2009 because of e.g. safety aspects and CE declaration of conformity in accordance with the EC directive of machinery for the application for mass series production
- Fabrication of two machines for XFEL cavity fabrication in 2009 (not completed finally)

The challenge

- Clamping of the half cells with appropriate electrical contact!
- Clamping of the half cells without deforming the RF-geometry!

The solution

- User software interface: Complete system control, Measurement of the Frequency, Check of the "Q"-value, Test documentation
- User PC
- Network analyzer
- Safety interlock system
- Motor control unit
- Pneumatic equipment
- Moveable base frame
- PLC - Programmable logic controller (backside)
- RF-Antenna
- Perturbation bead for asymmetry measurement
- C-Ring
- Contact plate (Niobium)

Summary

- The prototype machine was successfully used for the recent cavity production for FLASH
- "one-man" operation realized
- Considerable decreased test duration
- Software automated measurement and documentation
- Minor changes of the design are necessary for industrial use during series cavity fabrication for European XFEL
- Requirements in accordance with EC directive of machinery are fulfilled
- EC conformity operation is running
- Two more machines are under fabrication