FABRICATION OF NORMALCONDUCTING CAVITIES FOR ACCELERATOR APPLICATION

D. Kiehlmann, U. Klein, M. Peiniger, H. Vogel
Interatom GmbH
5060 Bergisch Gladbach, FRG

Abstract

Since more than ten years Interatom is working in the field of normalconducting rf-cavities for accelerator application. Having supplied 128 pieces of 350 MHz five-cell cavities for LEP we are now working on a variety of cavities for different storage-rings, synchrotrons or FEL-projects. 500 MHz single cell cavities are manufactured for the Advanced Light Source at Lawrence Berkeley Laboratory. For the CESR upgrade five-cell cavities will be supplied. A complete buncher section with 1 GHz and 3 GHz cavities and a focussing coil system for the FOM Free Electron Laser Project FELIX is under fabrication. The scope of activities including design, fabrication, rf-optimisation and test is presented.

Introduction

The production of 128 pieces of 350 MHz five-cell cavities for LEP was the basis for Interatoms activities in the field of normalconducting accelerator technologies. Today normalconducting accelerating cavities are still the choice for various projects besides the application of superconducting cavities which are also supplied on industrial scale [1].

Interatom is active in the field of normalconducting cavities and depending on the customer specification we are performing

. research and development

. layout and design

. manufacturing

. rf-measurement, tuning

. assembly

. test

of complete accelerating cavities with high power couplers, tuners, fieldprobes and cooling systems with flow- and temperature monitoring. In the following some projects are reviewed and Interatoms facilities for this work are described.

Normalconducting Cavity Projects

Lawrence Berkeley Laboratory

The construction of the Advanced Light Source at the Lawrence Berkeley Laboratory asked for 500 MHz single cell cavities with an increased power handling capability compared to operational experience with cavities of similar design. The dissipated rf-power of about 70 kW and the temperature specified to be stable within ± 1° C made a new design of a cooling concept necessary.

Calculations of flow and temperature distributions (dissipated power taken from URMEL) showed that the whole outer cavity surface had to be covered with a highly turbulent flow of cooling water.

While the cavity body was machined from solid copper and electron beam welded, the cooling system of the cavities was realized by electroforming a cooling jacket close to the cavity [2]. The electroformed jacket provided cooling channels with 2 mm in height covering the whole surface. Special designed water distribution lines provide for uniform water flow.

Further components of that cavity were designed at Interatom:

. A non contacting plunger tuner complete with driving electronics

. A high power input coupler with a tubular ceramic window

. A monitor pick-up loop

. A plane ceramic window for the HOM coupler port

The basic data of the LBL single cell cavity are summarized in the following table 1

overall length	580 mm
frequency	499.654 MHz
shunt impedance	6 MΩ
input power with/ without beam	150 kW/70 kW
plunger tuner range	- 0.8 MHz + 3.0 MHz
power coupler	magnetic bore coupling from narrow side of waveguide; tubular ceramic window variable coupling by movable wave-guide short between ß = 1 and ß = 4

Tab. 1 main parameters of LBL single cell cavity

FOM, FELIX-project

A complete buncher section of an electron injector for the Free Electron Laser project at the FOM Institute (Netherlands) [3] was designed and built by Interatom. The buncher is located between the gun and the first section of the linac and comprises a 1 GHz single cell, a 3 GHz 14 cell tw cavity and the focussing coil system.

The 1 GHz single cell cavity serves as a prebuncher equipped with a plunger tuner, input and monitoring loop couplers. The tuning range and coupling strength were checked and adjusted during fabrication.

The 3 GHz 14 cell travelling wave structure utilizes the general design of S-band cavities. The determination of the final cavity dimensions was done with model measurements to achieve the desired values of coupling strength and phase velocity which are summarized in table 2.

Frequency	2998.150 MHz
Phase-Shift/cell	$120^\circ \pm 1^\circ$ ($2\pi/3$)
Phase velocity	increasing from $\beta = 0.68$ to $\beta = 0.989$
Group velocity	constant
Reflection coefficient of input and output coupler	< 1 %

Tab. 2 basic data of Felix S-Band structure

The focussing coil system was designed with the inhouse computer code MOPTSE [4] to provide the specified focussing field configuration. A plot of the field profile along the electron beam axis is shown in Figure 1.

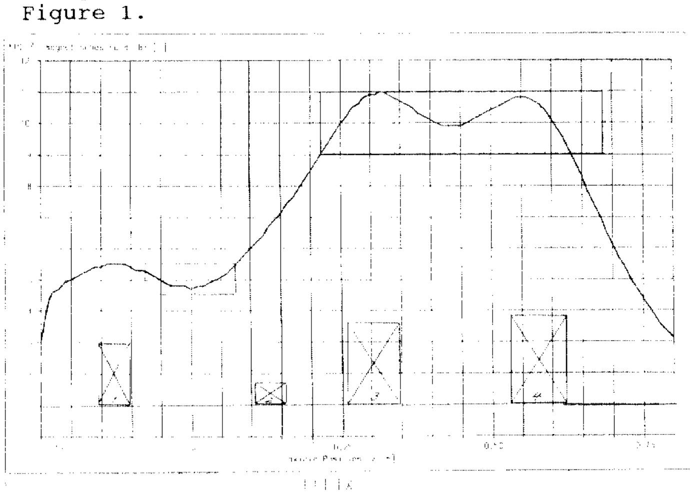

Figure 1: Focussing field profile B_z [T] vs axial position z [m] provided by a 4 coil system. Specified field to be within the values shown in the shaded boxes.

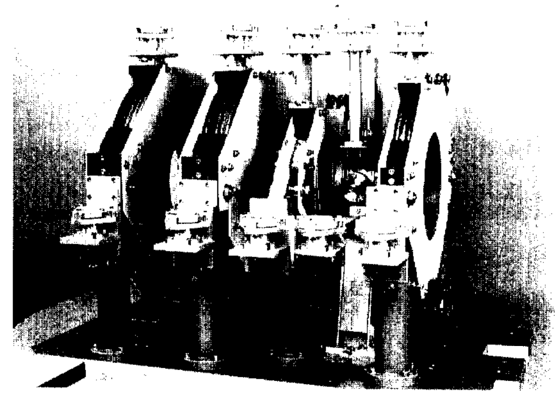

Figure 2: Buncher section for FELIX project completely mounted

ESRF

After the complete delivery of the LEP cavities we are today producing the cavities of the same type for the ESRF (European Synchrotron Radiation Facility) with an extended scope of delivery.

The cavities are completely equipped with rf-components like High Power Couplers, Tuners and Fieldprobes as well as cooling systems with flow and temperature monitoring.

Leak tightness measurement and UHV conditioning of complete cavities in our bake out facilities are further steps during the fabrication.

Inhouse measurement and tuning of fieldprofile, frequency and shunt-impedance according to customer specification make the cavity ready for operation.

Cornell

For the upgrading of the CESR storage ring at Cornell five 500 MHz five-cell cavities were fabricated by Interatom .

The cavities consist of five individual cells each coupled separately from a waveguide parallel to the beamaxis.

The complex structure of cells and the special shaped coaxial waveguide (lunatic line) is completely electron beam welded (fig. 3).

The customer given design of the five cell cavities allows only a tuning range of about ± 200 kHz (by inelastic deformation) after completion of the cavity which results in stringment requirements on the mechanical tolerances.

In order to keep the tolerances and to achieve the correct frequencies of the individual cells a model cavity was built before the production run. With this model (a single cell with a 1 m section of lunatic line) the following parameter were investigated:

- Frequency dependance on the distance of cavity nose cones
- Frequency dependance on the weld shrinkage
- Frequency change during welding of the lunatic line
- Frequency influence of all coupling apertures
- Frequency change with temperature

Carefull investigation of all these parameters by stepwise fabrication with accompanying rf measurements resulted in frequencies lying in a bandwidth of ± 150 kHz.

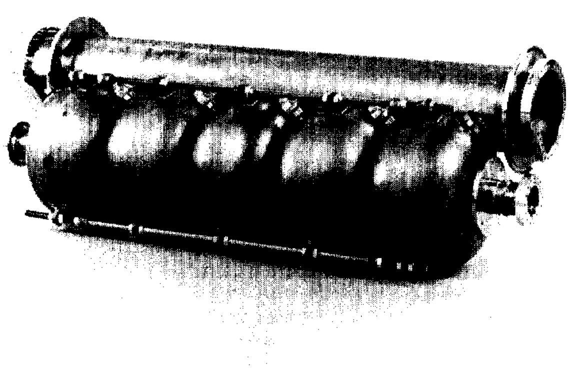

Fig. 3: Complete 500 MHZ five cell cavity with waveguide

Conculsion

Interatom is designing, fabricating and testing accelerating cavities equipped with all auxiliary components. New designs have been developed to comply with new or extended requirements. We could demonstrate that inhouse design and rf measurement and development capability offers complete accelerating systems built to customer specifications.

Acknowledgement

We would like to express our gratitude to all our partners worldwide in the universities and research laboratories and industrial companions for the enjoying collaboration in the field of accelerator technology.

References

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