SUPERCONDUCTING CAVITY PRODUCTION AND PREPARATION AT ACCEL INSTRUMENTS GMBH

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Abstract

The series production of 35 medium beta and 74 high beta cavities for the Spallation Neutron Source Linac allowed us to improve our cavity manufacturing and processing facilities. We are now able to produce one SNS cavity per week including chemical treatment and field flatness tuning. The SNS project occupies our two electron beam welding machines to about 70 % in a one shift operation ensuring completion of the cavity production within the contractual foreseen three years period (140 weeks). In addition two TESLA cavities were produced within 6 months after provision of niobium. The preparation including tuning to field flatness, closed loop chemistry, high pressure water rinsing and clean room assembly is within our scope and is foreseen for the end of this year. A new high-pressure water rinsing system was developed and is currently built with the goal to achieve gradients in the 20 MV/m regime. A superconducting CH-mode cavity for acceleration of ions for University of Frankfurt and two prototype half wave resonators are under production. Also those three cavities will receive chemical treatment, high pressure rinsing and clean room assembly with vertical test equipment at our facilities. For Cornell University we are producing two Nb/Cu 500 MHz cavities by further developing our sputtering techniques used during the LEP and LHC cavity production.

SNS CAVITY PRODUCTION

The contract for the SNS cavity production was awarded in August 2001. In total 109 6-cell 805 MHz cavities (34 cavities of the medium beta type optimised for β=0.61 particles and 74 cavities of the high beta type optimised for β=0.81 particles) needed to be produced within a 3 years period.

At the time of contract award prototype cavities of both types were already produced at Jefferson Laboratory. The first task of the series production was to review the manufacturing procedures of the prototype cavities and develop production drawings to reflect different manufacturing methods. In addition weld parameters, tooling for metal forming, turning, milling and electron beam welding needed to be developed. Main alterations performed were:

- Deepdrawing of half cells using a stamp and a cushion instead of inner and outer die. This technique is faster and results in better tolerances.
- Production of the “raw end groups” (see Figure 1) out of one sheet by deep drawing and nipple pulling.

Figure 1: Raw end groups produced for SNS cavities by deep drawing and nipple pulling from one sheet.

The production of the first article medium beta cavity was finished one year after contract award (August 2002). During that time, already single parts for series medium beta cavity production were produced. The manufacturing of the remaining 33 medium beta cavities was then finished within another 8 months (Last medium beta cavity delivered in beginning of April 2003).

In parallel to the work on the medium beta cavity series production, the first article high beta cavity was produced. The first article high beta cavity was delivered to JLAB for the vertical test 17 months after contract award (February 2003). At that time also the series production of the high beta cavities started. Since June 2003, we are shipping cavities to JLAB with a rate of one cavity per week. The last cavity is being scheduled to be delivered to JLAB in August 2004.

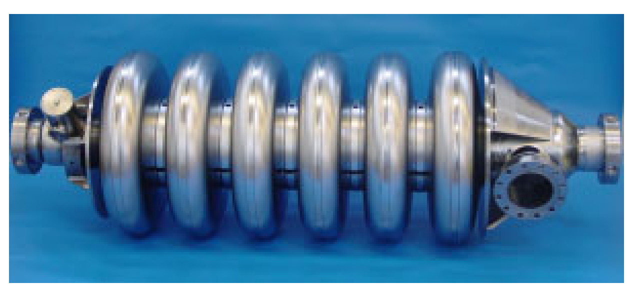

Figure 2: Medium beta 6 cell 805 MHz cavity produced for the Spallation Neutron Source Linac. The production of the 34 medium beta cavities is finished.

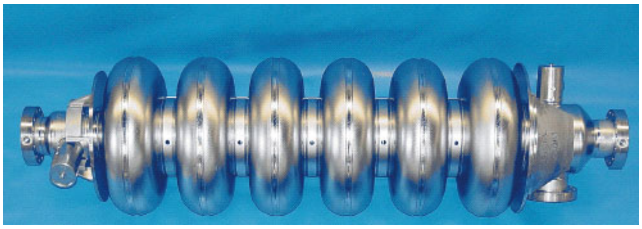

Figure 3: High beta 6 cell 805 MHz cavity for SNS. The series production of the 74 high beta cavities is scheduled to be completed in August 2003.

Beside the production of the cavities, the removal of 30 µm from the outside and of 100 µm from inside by buffered chemical polishing is within the scope of the contract. The removal is performed by closed loop chemistry with temperature control of the acid below 15 °C to minimize hydrogen diffusion into the niobium.

The last step before delivery is field flatness tuning of the π-mode to accuracy better than 5% in amplitude and adjustment of the external Q of the fundamental mode of the HOM couplers.

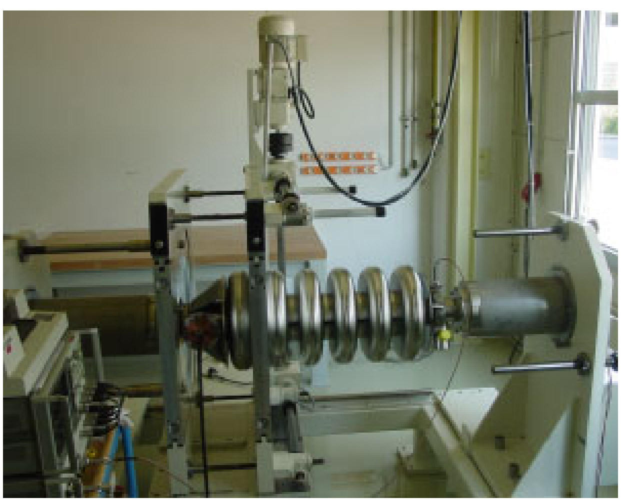

Figure 4: Tuning apparatus for SNS medium and high beta cavities. This machine now also allows tuning of TESLA cavities.

The test results of the delivered cavities are encouraging. Except one cavity, all medium beta cavities passed meanwhile the SNS design values in view of accelerating gradient and unloaded Q. Test results are presented in [1]. The tests of the high beta cavities just started at JLAB. The first article high beta cavity however safely exceeded the design specification.

TESLA CAVITIES FOR BESSY

Parallel to the SNS cavity production, two TESLA cavities were produced for BESSY. The production was finished 6 months after material disposal.

After manufacturing, the field profile of the welded cavities was measured and similar to the SNS contract, the outer (30 µm) and inner (100 µm) surface removal was performed in the closed loop chemistry plant. The cavities were then send to DESY for 800 C heat treatment and returned to ACCEL. At ACCEL the cavities were tuned to field flatness. For this purpose the SNS cavity tuning apparatus was slightly modified to allow tuning of TESLA cavities. Figure 4 compares the field flatness of a tuned cavity with the filed flatness of the cavity after final welding.

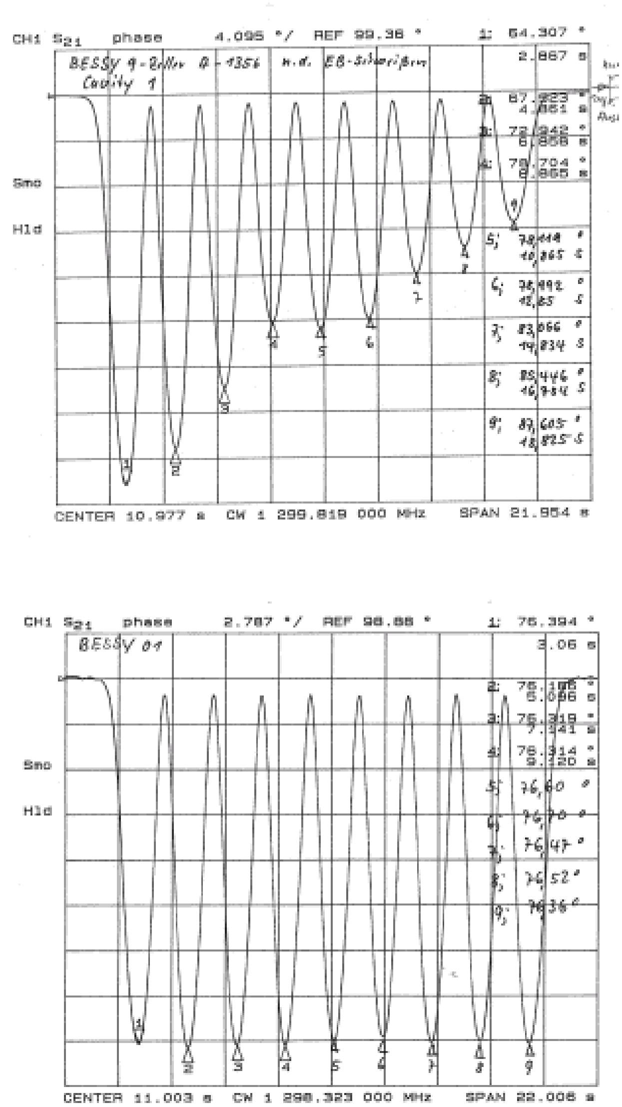

Figure 5: Field flatness of a TESLA cavity for BESSY after final welding (above) and after tuning (below).

For BESSY, the preparation of the TESLA cavities for vertical test and for horizontal test is within our scope. The preparation for vertical test includes final BCP, high-pressure rinse and clean room assembly of vertical test equipment. The vertical test will be performed by a common effort of ACCEL, BESSY and DESY. A new high pressure rinsing system was built inside a clean room at ACCEL. Figure 6 shows the TESLA cavity mounted on the new high pressure rinsing system.

Figure 6: TESLA cavity for BESSY mounted on the new high pressure rinsing system inside the clean room.

Our aim is, to achieve gradients in the 20 MV/m regime at unloaded Q values above 5 x 10^9. After vertical test, the welding of the helium vessel and the preparation of the cavities for horizontal test including high power coupler assembly will be performed. The TTF III coupler will be used which was produced in our premises in parallel to the cavities.

HALF WAVE RESONATORS FOR SOREQ AND FORSCHUNGSZENTRUM JÜLICH

In a close collaboration with Forschungszentrum Jülich, a 160 MHz half wave resonator design for acceleration of protons/deuterons with velocity 0.11c was developed. This cavity is currently under production. A second cavity was designed with a resonance frequency of 176 MHz and is optimised for acceleration of particles with velocity of 0.09 c. Both cavities will receive final preparation (BCP, HPR, assembly) for vertical test at ACCEL. The cold RF test of the 176 MHz cavity will be performed by our personnel at a new cavity test facility at our premises. This test facility is scheduled to be in operation in May 2004.

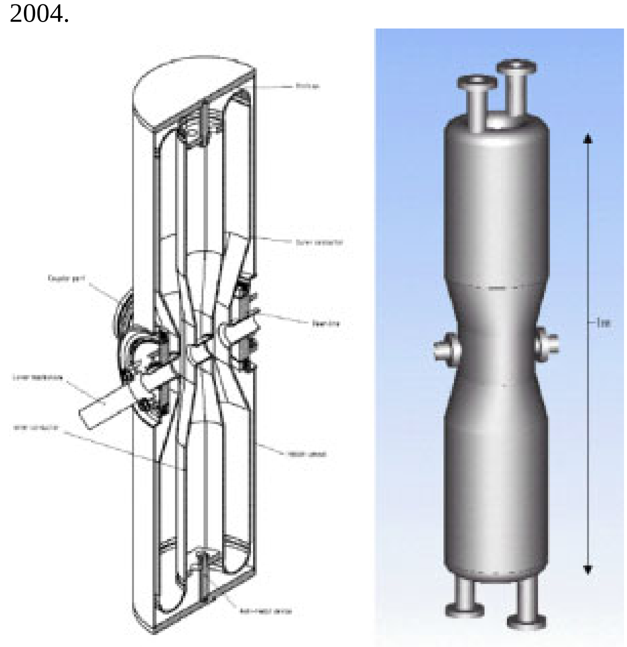

Figure 7: Design of 176 MHz half wave resonator (left) and 160 MHz half wave resonator (right).

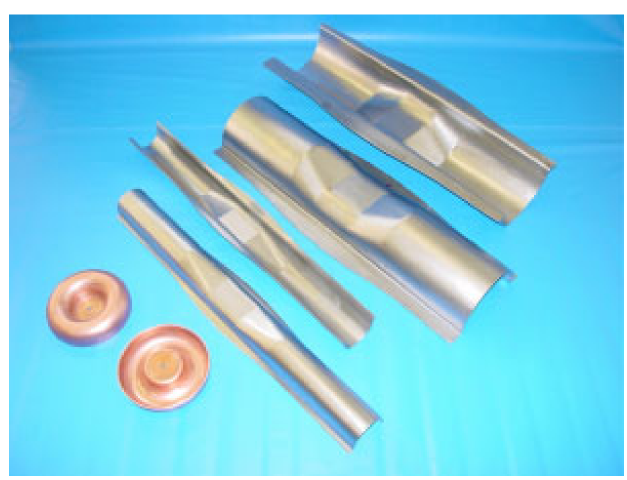

Figure 8: Single parts of the half wave resonators.

CH MODE CAVITY FOR UNIVERSITÄT FRANKFURT

For University of Frankfurt a CH mode cavity was designed. We have now almost finished the required tooling for production. Also this cavity will receive final surface preparation for vertical test at our premises.

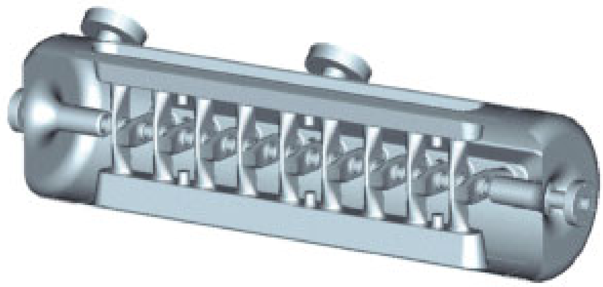

Figure 9: Design of a CH mode cavity under production at ACCEL for Universität Frankfurt. Parts out of copper for testing of production procedures are produced by deepdrawing already. Production of niobium parts has started.

NB/CU CAVITIES FOR CORNELL UNIVERSITY

For Cornell University two 500 MHz copper cavities were produced. Cornell supplied the cavity cells, which were produced from INFN Legnaro by spinning.

The existing sputtering apparatus used for the CERN and LHC production was adopted to allow sputtering of this cavity type. The first cavity was coated using the CERN method of magnetron sputtering.

For the second cavity a different coating method will be applied, using preferably bias magnetron sputtering. The aim is to further develop in a collaboration with Cornell University the sputtering techniques and to study the slope of the Q(Eacc) curve of Nb/cu cavities in view of future applications like cavities for muon colliders.

a)
b)
c)

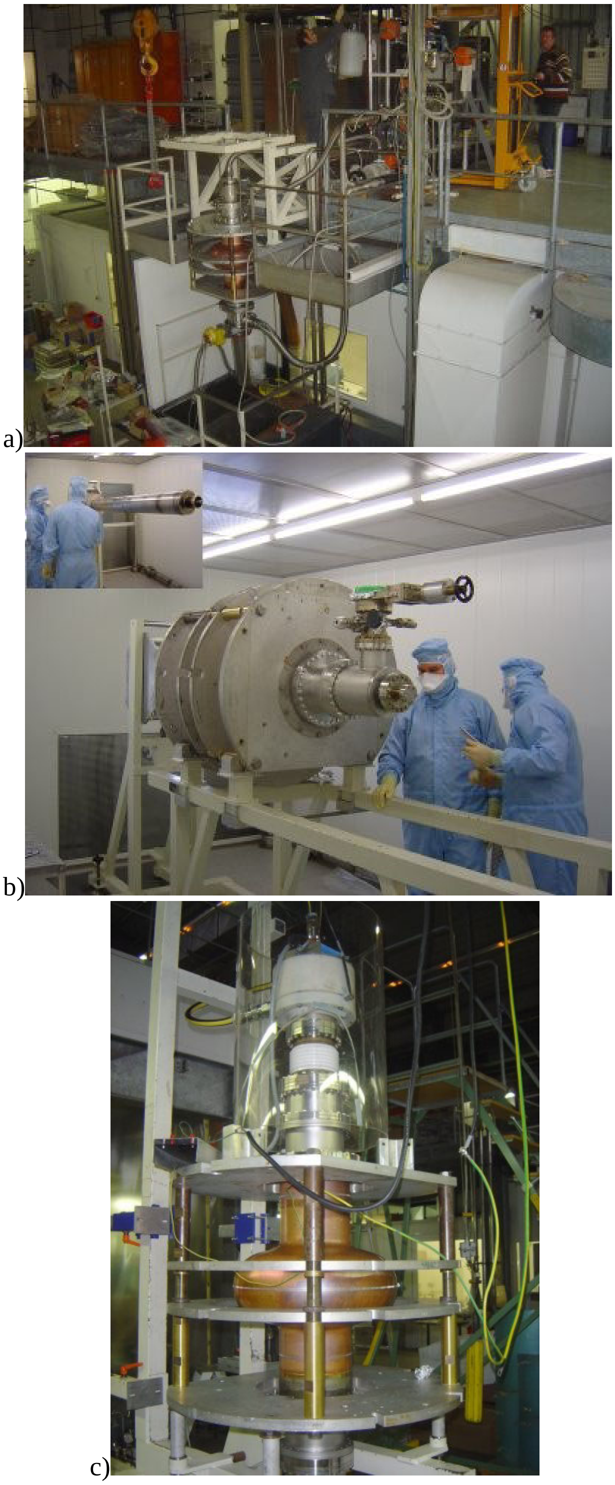

Figure 10: 500 MHz cavity for Cornell University a) in the chemical plant receiving surface preparation for sputtering, b) in the clean room during liner assembly, c) on the sputter apparatus.

REFERENCES

[1] John Mammosser: Status of the SNS superconducting cavity testing and cryomodule production, this proceedings