HIGH POWER TESTS OF THE PROTOTYPE 352 MHZ BETA 0.85 FIVE CELL CAVITY FOR THE TRASCO PROJECT

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Abstract

The Five-cell beta 0.85 cavities built at CERN for the development of the TRASCO project is fully tested at the CERN SL-CT Test Bench.

The cavity, built using the standard Niobium on Copper technique, was previously tested in a vertical cryostat, showing Qo and Field exceeding the design goal for the Trasco Project ($2.5 x 10^9$ and 5.5 MV/m @ 4.5 K).

After the successful test we decided to check the performances of the cavity installed in a horizontal Cryostat and equipped with a LEP-II Type high power main coupler and HOM couplers.

The cavity was equipped with the Helium Tank, Tuners and couplers at CERN and tested at the SL-CT facility at Cern under a collaboration agreement between INFN and CERN.

The behavior of the fully equipped cavity substantially confirmed the results of the preliminary production tests in the vertical Cryostat.

The quality factor at low field was substantially unchanged.

No MP activity was detected confirming the soundness of the design and the quality of the surface treatment.

1 INTRODUCTION

The TRASCO project is R&D effort jointly supported by ENEA (the Italian Agency for the development of new energy sources) and INFN (the Italian organisation for the research in the field of the Subnucleare and Nuclear Interactions). The project is granted from the Italian Government trough a grant for the technological transfer to the Italian industries.

The aim of the project is the design, test and production of critical components of an Accelerator Driven Sub-critical Nuclear Reactor for the transmutation of long-lived radionuclides produced in standard light water nuclear power plants.

INFN is responsible for the design of the High Current (30 mA), High energy (500Mev to 1GeV) Proton accelerator driving the Intense Neutron source used to keep running the fission Process in the sub-critical Nuclear reactor.

As a first step in the development process we decided to use already existing components for the RF system and to use for the cavity construction the state of the art techniques proven in mass production.

For the aforementioned reasons the first cavity prototypes were designed at the frequency of 350 MHz.

Therefore we signed an agreement with the CERN for the construction and test of a five-cell prototype cavity to take full advantage from the experience gained by the SL-CT group at CERN.

The SL-CT group is responsible for the development, testing and installation of the LEP Superconducting RF modules.

Under the agreement CERN built and tested a full scale prototype of the β=.85 accelerating cavity on the geometry defined by INFN; for this reason the sputtering process for the cavity needs to be modified to cope with the cavity geometry of the proton linac.

INFN provided the design of the accelerating cavities[1] and the needed support for the ESCA_Auger analyses eventually needed in the process of adapting the sputtering process to the new cavity geometry.

We decided to build a cavity equipped with LEP Type cut-off tubes having a main coupler port and a full set of ports for the High Mode couplers.

After the performance test of the cavity in a vertical cryostat [2], we decided to extend the INFN-CERN agreement to the test in a machine ready configuration.

2 CAVITY PRODUCTION

The cavity was built forming half cells by spinning starting from a OFHC copper sheet 3.5 mm thick following the standard LEP cell production.

The full cavity is built using 8 equal half-cells for the body of the module plus two different half-cells to get the needed field flatness for an optimum acceleration.

The half-cells of both types were formed then deep electro-chemically polished to remove the first layer of the copper.

This heavy polishing removes the surface layer of the copper sheet having a heavily distorted crystal lattice.

This lattice distortion is produced both by the Cross Rolling process leading to the final thickness of the copper sheet, and by the spinning procedure leading to the half-cell production.

The LEP Cavities production has shown that poor copper crystal lattice will always lead to sputtered

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Niobium films with poor RF quality (mainly producing high RF Losses and low accelerating fields)

This procedure will minimise the amount of tuning

The assembled cavity is shown in figure1.

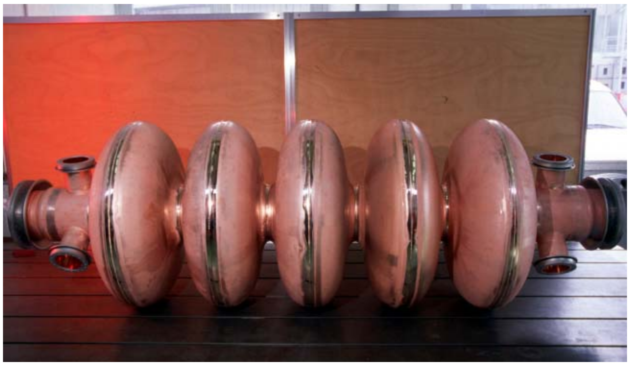

Figure1, The Trasco cavity after construction

3 NIOBIUM FILM COATING

The coating of the accelerating structure was done using a slightly modified LEP_Cavity procedure.

Minor modifications are needed to adapt the sputtering process and to deposition magnetron to cope with the shape of the shortened B=.85 cavity.

This step of our program was greatly helped by the experience gained by the SL_CT group in the reduced beta program developed at CERN in the previous years.

The sputtering magnetron was shortened to reduce the dimension of the sputtering source and increase the landing angle of the Niobium atoms on the copper surface.

To even more improve the deposition angle, and improve the quality of the film in the cavity transition region the cavity shape was optimised to avoid cavity regions seen at grazing angle by the Niobium atomic beam.

Sure, as usual, you can have nothing without loosing something. The price for this optimisation was again a small decrease of the cavity volume giving a lower amount of stored energy for the same frequency.

This fact gives higher wall dissipation for the same accelerating field. In our geometry if compared with a non-optimised geometry a 10% lower Qo value is obtained for the same value of Surface Resistance of the Niobium.

Figure 2 shows the 5-cell cavity in the CERN Clean Room waiting for the installation of the sputtering cathode.

After the sputtering the cavity was mounted on the test Cryostat and Qo and maximum field measured.

In the vertical test the cavity meted the TRASCO goal at the first run, only needing a mild Helium conditioning to go to the maximum field.

The results of the vertical test are reported in figure 3.

Figure 2, five-cell cavity ready for the sputtering cathode insertion

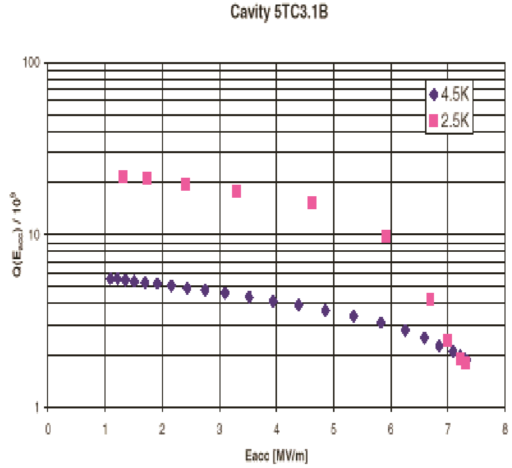

Figure 3, Qo versus filed @4.5 K and 1.8K for the five cell cavity (vertical test)

4 HORIZONTAL CRYOSTAT

After the completion of the vertical test, we decided to fully exploit the possibilities of the cavity testing the cavity in a Machine Ready condition using a modified LEP cavity Cryostat.

For this reason the INFN-CERN agreement was extended to include this part of testing and the needed development for the tooling.

The cavity, fully equipped wit a LEP200 Type main Coupler, HOM Couplers, fast and slow Tuners, was inserted in a Stainless Steel skin forming the helium vessel. (Figure 4).

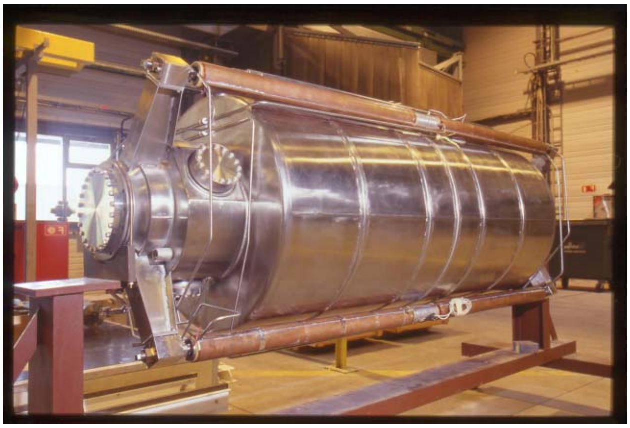

Figure 4, Five cell cavity inserted in the LHe vessel and equipped with the tree tuners

After the installation of the Couplers, in the Cern SL-division clean room, the module was inserted in a standard LEP 200 skin Cryostat, the thermal super insulation was added. And the completed module installed in the SM18 vault for the High power tests.

5 RF TESTS

The RF tests of the cavity were plagued by bad luck and quite long series of accident.

For this reason the test of the Module, scheduled for early may, where postponed twice; the latest date was August 15.

The latest accident in August was the burning of one of the tuner windings, preventing us from tuning the cavity sharp resonance to the operating frequency of the RF Klystron used for the Power Tests.

In this way the cavity operated slightly detuned, and a large fraction of the RF Power was reflected back to the Klystron’s output insulator preventing us from reaching full power in the cavity.

For this reason the preliminary tested does not succeeded to fully demonstrate the cavity ultimate field due to a lack RF power.

Despite the series of accidents the test were quite encouraging, as shown by the preliminary results shown on figure 5

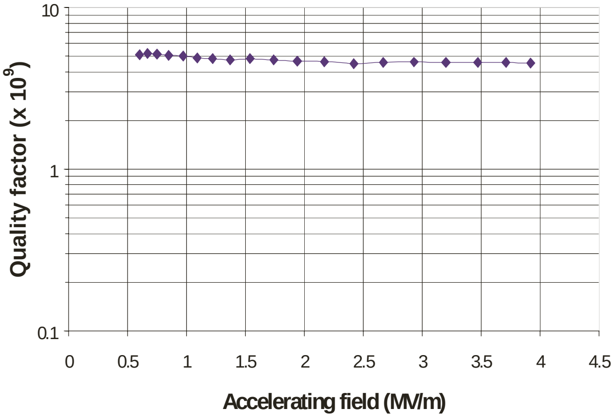

Figure 5, Preliminary Qo versus accelerating field measurements. The maximum available RF Power limited the accelerating field

The cavity Q0 at low field was the same of the vertical tests and the maximum obtained field was around 4 MV/m with only a small Qo versus field degradation, light electron emission and no need for cavity conditioning up to this field.

6 CONCLUSIONS

The first test of the Cavity module, although not definitive, is really encouraging, showing no degradation of the cavity RF characteristics from the preliminary vertical Cryostat test to the test of the complete LINAC module ready to be tested on a beam.

The conclusive test (full power) are foreseen for late November early December.

In this tests we plan to measure the ultimate field of the module and the to check the cavity behaviour under pulsed RF to gain experience gather information on the possible problems coming out in a so large cavity.

7 AKNOWLEDGEMENTS

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REFERENCES

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[2] E.Chiaveri, R.Losito, S.Calatroni, A.Dacca`, G.Gemme, R.Parodi, D.Barni, A.Bosotti, C.Pagani, G.Varisco, PRODUCTION AND TEST OF THE PROTOTYPE β= 0.85 FIVE CELL CAVITY FOR THE TRASCO PROJECT. RFSC99 Santa Fe NM, paper WEP034.