TEST RESULTS OF THE DORNIER SINGLE CELL CAVITY

DO 500-1-1-Nb

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Test results and technical datas of the Dornier single cell cavity (500 Mhz) will be reported. Layout , machining and final preparation of this cavity with an rf. surface of about 1 m is done by Dornier and will be reported briefly . For the test at 4.2 K the experimental set up of DESY was used. These facility includes a Quench detection system and appartus for free electron current measurement.

The following general characteristics of the cavity were observed: At 4.2 K an acceleration field of 8 MV/m was achieved. No quench was observed at high field. The resonator was limited due to electron loading. At field levels exeeding 5 MV/m non resonant electron current stared to load the cavity Q. At the design acceleration field of 5 MV/m the cavity performed a Qo of $2.7 * 10^9$. The emitter of the non resonant electrons was not detectable.

I. Introduction

At DESY/Hamburg the installation of the storrage ring HERA is under way. To upgrade this the installation of 64 rf superconducting (sc.) cavities is planned. In order to study the beam performance of the rf sc. cavity design the installation of two 4-cell cavities is planned to take place in 1987.

In September 1986 all basic design of the 4 - cell acceleration cavities with spherical geometry was done. To prove the construction, the fabrication cycle , preparation technic and to show the Dornier know-how as well as to test the higher order mode coupler (HOMC) Dornier decided to build up a single cell cavity on it's own costs before fabrication of the sc.4 - cell unit. Layout of the single cell cavity was done by Dornier and yields in a resonator whose performance gives results that can lead to conclusions valid for the 4-cell resonators.

II. The cavity

II.1 Design

Computations of the 4-cell cavity at DESY lead to a spherical design (Ref.1) The main dimensions are given in figure 1. Two types of cup geometries are in use. The endcells consits of one typ A and one typ N cup while the normal cells are made from two typ N cups. Tapered cut-off-tubes with two HOMC on one side and one HOMC plus one power coupler at the other tube are designed.

The single cell resonator is fabricated from two typ A cups. One HOMC for TE and one for coupling of TM modes are installed at one cut- off-tube while the other tube is supplied with one power coupler. The use of this original design makes one able to prove the sc. performances of the coupler under the same conditions like they are found in the 4 cell resonator.

To reduce the amount of He as well as the mechanical vibrations of the 4- cell resonator the first version of Dornier includes some aluminium elements that are integrated in the helium vessel (see figure 2). The flange connections of the beam tube, HOMC and power coupler are machined with a Nb - Steel connection. This constuction allows you to weld the helium vessel direct on to the resonator. All sealings are settled outside of the liquid healium. The sealings are designed for the use of HELICOFLEX (Ref.2) or copper sealing discs.

For the single cell cavity the same connection system is in use. Here they are exposed to the liquid helium for testing the reliability of these technic . For all niobium parts Niobium of RRR 100 is in use. Cups, beamtubes and outer conductor of the HOMC are machined from sheet material while the inner conductors are fabricated from niobium tubes and rods .

II.2 Physical data and test set up

The use of typ A cups reulted in a frequency of 499 Mhz at 4.2 K. The computed dimensions of the single cell cavity are given in figure 3.

Final tuning of couplers was done at DESY. Antennas as well as rf windows were supplied by DESY . For detection of quenches 60 carbon resistors were mounted.

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PHYSICAL DATA OF THE SC. DESY/HERA CAVITY

Fig 1.

Frequency	:	500	(MHZ)
No. of cells	:	4	
r/Q	:	228.8	(Ω)
electrical length	:	1.2	(m)
Epeak / Eacc	:	2.19	
Hpeak / Eacc	:	47	(Oe/MV/m)
RF. surface	:	4	(m^2)

The test was done in a vertical test cryostat (Ref.3) which is supplied with an magnetic shield. Inside of the helium tank no magnetic shield is installed. The test set up at DESY include all rf power supply and con- troll systems like they will be used for the HERA tests.

The 60 carbon resistors for quench detection are fixed on the cavity by copper - beryllium springs like shown in figure 4.

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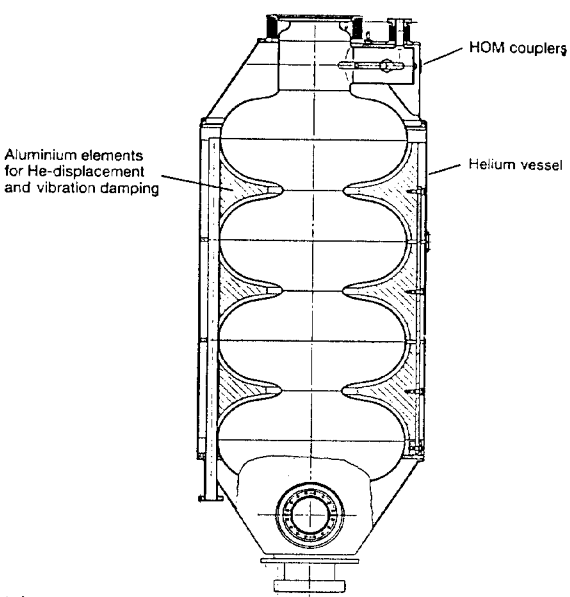

Fig 2.
4-cell Niobium cavity for HERA (version 1)
sectional view of cavity with Helium vessel

II.3 Fabrication and Preparation

Cells,cut-off tubes and the outer conductors of the HOMC are machined by spinning of sheet material while the inner conducters of the HOMC are made from niobium rods and tubes. Surface treatment was done by soft abrasives after optical inspection. After final welding tumbling took place. Chemical treatment was done by buffered chemical polishing acide (BCP). 10 liters of this acide were filled into the cavity volume. The over all volume of the resonator is about 80 liters. During BCP the cavity was sheked. Rinsing of the surface after BCP was done with dust free water (R $\geq$16 MΩcm). The cavity volume can be filled with water within 1/2 a minute. A two hours lasting drying procedure followed the chemical treatment.

After this dust -free treatment the cavity was delivered to DESY and imidiately mounted .

III. Test results

After cooling down a Qo value of $2.5 * 10^9$ was measured. From 3.8 MV/m on non resonant electrons stared to load the cavity Q. A power limitation was reached at 5.5 MV/m. Rf processing started to improve this value. Helium processing lasting for about 3 h improved the maximum acceleration field to 7 MV/m. During a second helium processing procedure of 3 h this field was improved to 8 MV/m. After processing a Qo of $2.7 * 10^9$ was observed. Figure 6 gives a comparison between Qo versus E before and after the Helium processing procedure. No Quench is detectable

PHYSICAL DATAS OF THE DORNIER SINGLE CELL CAVITY

Fig 3.

Frequency	:	500	(MHZ)
No. of cells	:	1	
r/Q	:	53.3	(Ω)
electrical length	:	0.3	(m)
Epeak / Eacc	:	2.0	
Hpeak / Eacc	:	47	(Oe/MV/m)
RF surface	:	1	(m^2)

even at the upper field level. The design value for a 4-cell resonatores is set out for Qo of $2.0 * 10^9$ at 5 MV/m . At the design field the single cell cavity reached a Qo of $2.7 * 10^9$. This value corresponds to a dissipated power of $\leq$ 10 Watt per cell.

For the electron emitter a field emission factor of 100-200 can be calculated from a Fowler Nordheim plot (Ref 4).

The results of the HOMC performance are given in fig. 5 (Ref 5). The external Q for the individual modes are in the calculated region (Ref.6). The coupling of the HOMC to the fundamental mode was even for the maximum field of 8 MV/m in a region where the sensitivity of the test set up is limited.

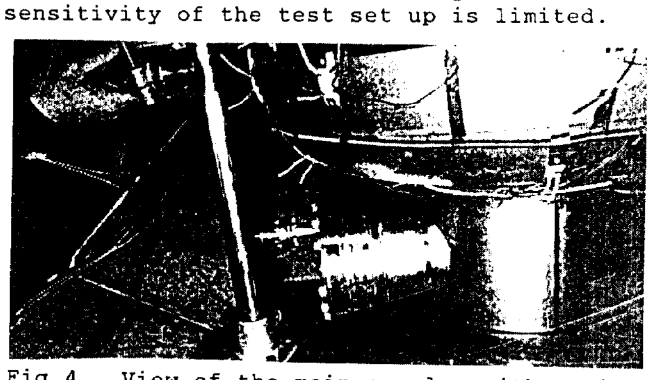

Fig 4. View of the main coupler with springs for carbon resistor fixure

Measured values of a 500 MHz single cell cavities with TE and TM couplers. Fig 5.

Q_0 at 5 MV/m, 4,2 K		2,7 x 10^{9}
Max. accelerating field		8 MV/m
Acc. field limitation		Field emission
Q_{ext} of HOM-couplers		
TM_{010}, fundamental mode	500 MHz	> 10^{12}
TE_{111}, one polarisation	638 MHz	4000
TM_{110}, one polarisation	710 MHz	3000
TM_{011},	909 MHz	< 300
TM_{012},	1428 MHz	300

IV. Conclusion

In the Dornier single cell cavity DO-500-1-1-Nb a surface resistance of 1 nΩ was reached after a standard treatment . The transport over a distance of about 900 Km in the ready for testing state was successfully done. Non resonant electrons loaded the Dornier resonator during the test and lead to the high field limitation at 8 MV/m. By a Helium processing of about 6 h the threshold where the lelctron loading appeared could be set up from 4.5 MV/m to 5.5 MV/m. The maximum acceleration field was influenced by this procedure so that the limitation was shifted from 5.5 to 8 MV/m. Design values set out for the HERA project at DESY were reached in the single cell cavity of DORNIER.

HOM coupler adapted to the resonator showed that at low temperatur the calculated results were obtained and that these construction is usable in the forseen application in storrage ring accelerator cavities.

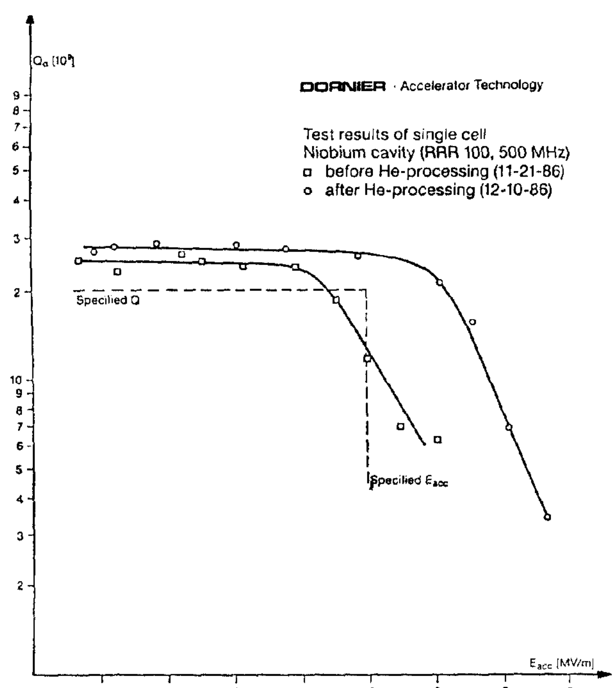

Fig 6. Q versus Eacc shift due to Helium processing at test 1

As a final conclusion for application purpose it can be stated that it is possible to reach the design values set out by DESY. Qualified fabrication, preparation and mounting technic is preequisite for this.

The test of the first 4-cell resonator with bath cooling is presently under way at DESY and the results of the Dornier single cell resonator show that no basic limitation can be found in the constuction.

The test results of the Dornier cavity DO-500-1-1- Nb show that the surface treatment and preparation technic of Dornier makes you able to get cavity performances that reach the design values set out to day. By using qualified fabrication and preparation technic as well as Niobium of high thermal conductivity it is shown that even in 500 Mhz resonators with a surface of more than 1 m^2 it is possible to reach resonable field gradiends.

We want to thank the technics and engineers of the DESY group MHF for their enthusiastic and untired support during installation and test of our cavity.

Ref.1 DESY to be published
Ref.2 Helicoflex Trademark
Ref.3 D.Proch DESY Hamburg priv. com.
Ref.4 D.Proch DESY Hamburg priv. com.
Ref.5 J.Sekutowicz DESY Hamburg to be published
Ref.6 E.Haebel/J.Secutowicz DESY lab note M-86-06