THE TECHNICAL REALISATION OF RF KICKERS FOR CLIC TEST FACILITY CTF3

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Abstract

The bunch train compression scheme in CLIC Test Facility CTF3 includes two fast RF kickers operating in deflecting mode on 3 GHz frequency. The kickers designed by common INFN-Frascati/INS-Swierk effort were produced in Institute for Nuclear Studies in Swierk and are successfully operated at full power in CTF3 experiment in CERN. The details of fabrication procedure and low power RF measurements are presented in this paper.

INTRODUCTION

In CTF3, 30 GHz high power generation experiment, two fast kickers are needed [1] for injection of electron beam bunches to combiner ring.

The kickers [2] are disk-loaded, backward type waveguides working in the $2\phi/3$, EH_{11} hybrid mode. They are essentially based on formerly optimised at CERN waveguide for beam deflection[3].

BASIC PARAMETERS OF DEFLECTOR

Type: Travelling wave RF structure working in EH_{11} deflecting mode, $f = 2998.55$ [MHz]
No of active rf cells $N = 10$
Phase shift/cell $2\phi/3$
Length including 2 coupling cells 46cm
I/O ports SLAC type flanges, WR -284
RF power in pulse $P = 8$ [MW]
average less than 5kW

Fig.1 Full scale aluminium model of TW, 2998.5MHz deflecting structure

On the basis of 3D calculations performed in LNF-INFN Frascati , the full scale, n-cell (n=2...10) aluminium model shown in Fig.1 was build and measured in INS in order to acquire the necessary experimental knowledge on deflecting mode. The influence of mode polarisation rods as well as frequency dependence on coupling measuring antennas size and structure temperature were verified. Also the size of matching iris apertures in coupling cells was experimentally verified.

The results of calculations, MAFIA and HFSS simulations and model measurements, were reported at EPAC 2002 Conference [3]. Also the phase shift per cell method of measurements to be used in ready made RF copper deflectors was mastered on this model (detuning plunger method).

FABRICATION OF COPPER DEFLECTORS

The components of deflector are fabricated from certified OFHC copper delivered by Outukumpu Enterprise*. The measured Cu content was 99.998% and oxygen content below 1.0 ppm. This last number is extremely important when technology of hard soldering (brazing) in hydrogen atmosphere is used, which was the case of our RF deflectors manufacture in 2002. Unlike in the old CERN procedure, the single cells of deflector were designed in the form of cups (Fig.2).

The cups are brazed together to form a disk-loaded circular waveguide structure of deflector. Such solution is a little more difficult in machining but

Fig. 2 The pilot series of 4 cells after hydrogen furnace brazing with 880^0C LV30P filler alloy.

reduces by factor 2 the number of brazed joints.

Pilot series of cells was produced to check the repeatability of machining (numerical lathe and milling

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machines with typical tolerance of ±0.01mm). This series was used next, to experiment the brazing procedure in hydrogen furnace.

All along the deflectors manufacture process, the procedure of lubrication, chemical cleaning and vacuum out-gassing at elevated temperature was chosen such as to reach in ready made deflectors, the vacuum better than 10^{-9} Torr after few hours of pumping.

During machining, MOBIL-SOLVAC 1535GD lubricant (liquid containing sodium sulfonate and boric acid esters)[†] was used.

The chemical cleaning before brazing involved following steps:

-washing in trichloroetylen(before rf checks of cylinders),
- etching (ortophosphoric acid or mixture of sulphur and nitric acids),
- washing in alkaline detergent liquid followed by hot tap water,
- washing in hot distilled water and drying in vacuum oven.

The brazing was made in several steps with three brazing alloys: LV30P(30%Cu,60%Ag,10%Pd) at 880^0C, copper silver eutectic LV28(28%Cu,72%Ag) at 780^0C, and Incusil-15 at 700^0. Intermediate measurements of frequencies (single cells, dispersion curves before and after soldering) are executed in order to have full control of prototype production. The measured dispersion curve of soldered 8 internal cells is shown in Fig.3. Side half-cells were attached at both ends of the set to enable the excitation of 2ϕ/3 mode. As it is seen from the measurement ,the rod splitters shift the lowest frequency of vertical polarity by 38.9MHz above the 2ϕ/3 working horizontal polarity of mode .

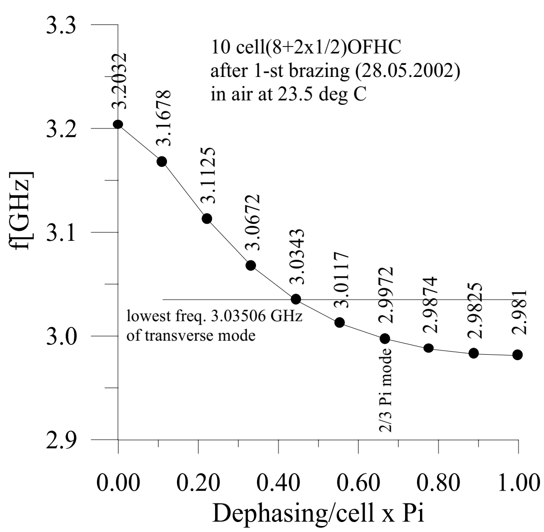

Fig.3 Dispersion curve of dipole mode measured in 8 brazed internal cells with added side half-cells.

The choice of hydrogen atmosphere brazing was forced by the lack of vacuum furnace of sufficiently large diameter. Biggest hydrogen furnace can accommodate the whole deflector including coupling waveguide chimneys.

After the last brazing operation the whole deflector is pumped and heated in vacuum chamber to the temperature 180^0C limited by aluminium vacuum seals used (the beam input/output tubes are sealed with aluminium vacuum gaskets). The last operation of fabrication procedure is the check of leak rate using helium leak detector after which the deflector is closed under the high vacuum till the RF final measurements. The helium leak detector ASM-181f / ALCATEL with the sensitivity better than 10^{-10} Torr ℓ/s was used for that purpose and no leaks were found in both deflectors. The deflector ready for safe transportation is shown in Fig.4.

Fig. 4 3 GHz deflecting structure after fabrication

Appropriate cooling in moderate average power rf cavities is provided by either water cooled tubes directly soldered to cavity body outside surface, or by special de-mountable cooling panels attached tightly to cavity body after high temperature out-gassing. As the cavity side wall is thick (inner diameter 11.2cm, outer diameter 12.4cm) the last solution was adopted. It consists of eight attachable mechanically (not soldered!) copper heat radiators, each made of 38mm wide rectangular pipes assuring good thermal contact on side surface of deflector.

MEASUREMENTS

During the fabrication procedure and after completion of each deflector thorough RF measurements were made in order to guarantee the designed parameters. After machining, the frequencies of all single cups were controlled in the known design frequencies test set. The test set consists of standard cell having exact internal dimensions of deflector cell coupled to measured cup, in aim to form two cell resonator. The dispersion curves of

[†] Producer: MOBIL OIL Corporation,Princeton,N.J.,USA

string of internal cells were measured before and after first brazing operation (vide Fig.3).
The last measurement was the control of phase advance per cell of ready made deflector. The method of "detaining short" developed at SLAC [4] was applied. The HP 8753C/85047A vector network analyzer was used to trace the phase advance corresponding to sliding short jump from cell to cell.

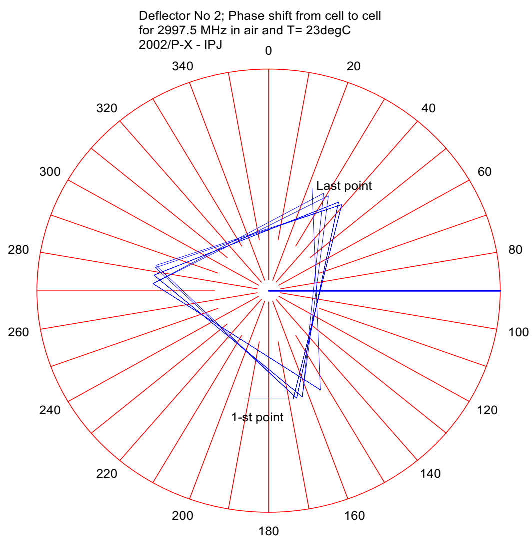

Fig.5 The measured phase advance per cell in second deflecting structure of CTF3

The measured result for deflector No.2 is shown in Fig. 5 , where in the polar co-ordinate the deviation of the phase shift per cell is illustrated. The VSWR for both deflectors was within 1.1 at the working frequency 2.9975GHz in air . The low power measurements finished, the deflectors were vacuum leak tested and next filled with dry nitrogen.

CONCLUSIONS AND AKNOWLEDGEMENTS

Two deflectors produced in INS Swierk underwent the additional vacuum tests in LNF-INFN Frascati and rf power tests at CERN. The tests were very satisfactory. The vacuum obtained was better than 10^{-10} Torr and RF power in excess of 10 MW can be fed without breakdowns. Actually deflectors are used in CTF3 experiment program. The authors wish to express their gratitude to the team of Dr E. Nietubyc of LAMINA Establishment for their deep interest and important help in successful realisation of deflectors.

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