POSSIBLE CAVITY CONSTRUCTION TECHNIQUES FOR THE DIAMOND STORAGE RING

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Various cavity construction techniques are being investigated for the future UK light Source DIAMOND. As well as the usual techniques involving machining, brazing and/or e-b welding, sputtering onto an aluminium former and joining electroformed sections by electroplating are being considered. The results of preliminary test samples will be given.

I. INTRODUCTION

The construction technique used to manufacture an RF cavity is critical in terms of cost, construction time, ease of construction and reliability in the design of a synchrotron radiation source. Three techniques have previously been used by Daresbury. The SRS storage ring cavities used forged components, fitted on a mandrel and electroformed together]. The present booster synchrotron cavity components were e-b welded while the spare was vacuum brazed [1]. Before deciding on any construction technique for the future UK Light Source DIAMOND, complete construction by an electroforming process, and sputtering copper onto an aluminium former are being assessed.

II. DIAMOND Cavity

The preliminary design for the future 3rd generation light source DIAMOND has a 500 MHz cavity without nose cones to give good HOM characteristics [2] [4] [5]. Multipoint temperature sensors will help to control the temperature of the cavity body to better than 0.05°C. Tuning is likely to be of the plunger type, but the method of coupling to the waveguide is undecided.

III. ELECTROFORMED DESIGN

A. SRS Cavity

The Present SRS Storage Ring cavity is a 500 Mhz reentrant solid copper cavity, it has plunger type tuning and is aperture window coupled to the waveguide. The cavity is water cooled, with the temperature controlled to 0.1°C to shift any potentially dangerous higher order modes (HOM's) outside the critical operating region. [10] It was constructed using a combination of electroforming, machining, brazing and E beam welding.

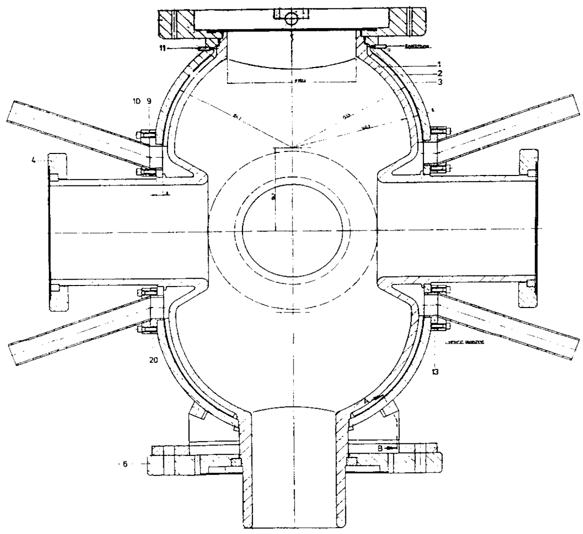

Figure 1. Daresbury SRS cavity

B. Construction method

The objective is to maximise the proportion of the structure electroformed and minimise the proportion that requires machining and other techniques such as welding.

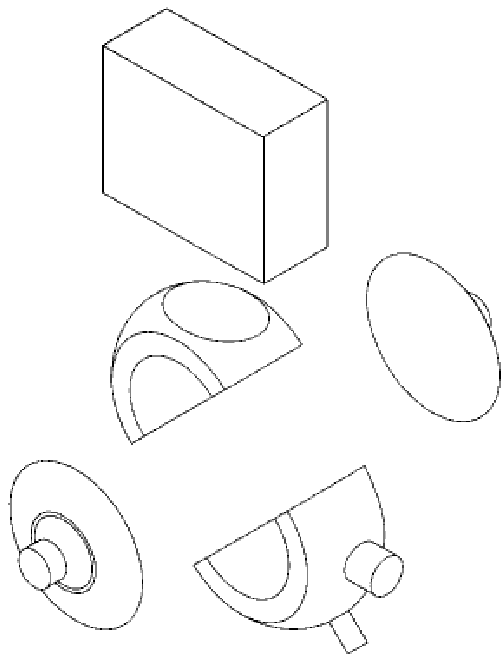

Figure 2. Electroformed Sections before joining

1) A stainless steel master of the cavity is produced and split into logical sections by wire EDM.
2) Electroforming tools are prepared which also include features to locate flanges and other components which will be grown into the structure to avoid the need for other forms of joining.
3) The components are electroformed onto the tools and when the required thickness is reached, the component is removed by pressing and/or heating.
4) The completed components are machined to ensure a sound joint when they are grown together.
5) The components are then assembled onto a jib and grown together (see fig 2).
6) The central supporting spindle is removed and the sacrificial aluminium mandrel is etched out.
7) The cavities are then assembled onto the perturbation test rig where the primary frequency is measured and corrected, if necessary, by axial deformation of the cavity.
8) Copper baffles are attached to the cavities, wax is placed between the baffles and silver conducting paint is used to coat the wax. Copper is grown over the baffles and wax, which is removed through heating thereby creating cooling channels [7].
9) The mechanically complete cavity is assembled onto its support stand and sent for testing under power.

III SPUTTERING

Aluminium cavities although commonly used to evaluate new designs, are rarely used in accelerators because of ther inferior performance, they suffer from multipacting and have poorer electrical properties than copper cavities [8]. However aluminium is less expensive and easier to form into a cavity than copper, and by coating with copper will have the same operating performance as a solid copper cavity [11].

Unfortunately aluminium cannot be electroplated directly with copper but requires a precoat with zinc, and this is incompatible with UHV.

Fortunately the development of superconducting cavities has provided the impetus to develop sputtering techniques using cylindrical magnetrons (see Figure 3) which can be used to sputter copper as well as niobium [9] [3] [6].

An aluminium cavity will be constructed by spinning two halves, after maching they will be joined and the ports added by welding or diffusion bonding. Work is continuing on the mechanical design of such a cavity.

After pre-tuning, copper to a thickness of several skin depths will the sputtered on to the inner surface of the cavity. At present there are no results to report but work is in progress.

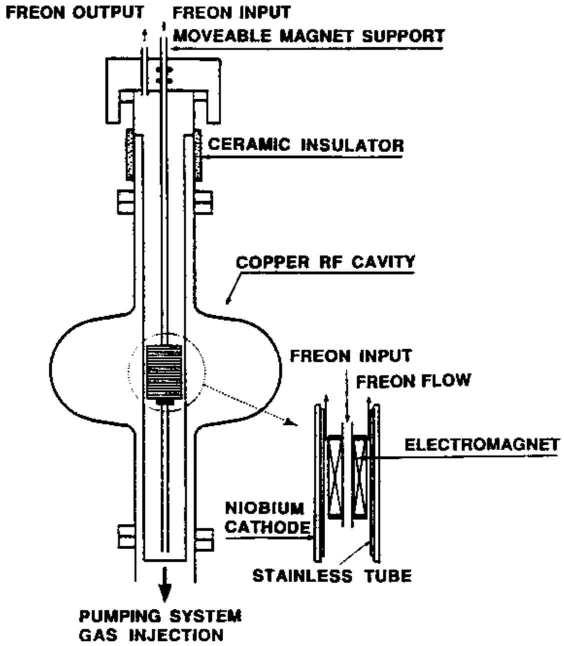

Figure 3. Sputtering Rig (copied from CERN RF School Proceedings ‘Cavity Construction Techniques’ by I. Wilson)

IV EVALUATION OF MATERIALS AND TECHNIQUES

In order to gain confidence in the manufacturing techniques that we intend to use, the following samples are being prepared and evaluated.

1. electroformed copper sheet (outgassing and microstructural assessments).
2. Electroformed copper to copper vacuum joint (to assess strength, vacuum leak rate and effect of baking).
3. Electroformed copper to stainless steel joint (as for 2).
4. Electroformed copper-gold-stainless steel joint (as for 2 and 3 above).

Outgassing Results of Test Sample

Sample :	Grown Copper Plate.
Sample Form :	Thin copper sheet 14 cm by 14.7 cm.

	Blank Run	Copper Sample
Conductance (l/s)	2.34	2.34
Surface Area Copper (cm^2)	0	412
Q (mbar l/s)	2.6×10^{-09}	4.6×10^{-09}
QT (mbar l/s /cm^2)	-	4.9×10^{-12}
Principle Outgassing Species	CO,H_2,CO_2, H_2O	CO,H_2,CO_2, H_2O

Table 1 Outgassing Rates (Copper Plate)

The outgassing rate Q is the total outgassing rate of the sample chamber and sample. The outgassing rate Q_T is the net outgassing rate of the copper sample. Both outgassing rates are determined after a 24 hour bake at 250 ^{o}C.

Gas Species	Partial Outgassing (mbar l/s) Blank Run	Partial Outgassing (mbar l/s) Copper Sample
CO	5.1×10^{-10}	7.5×10^{-10}
H_2	2.3×10^{-10}	2.8×10^{-10}
CO_2	7.5×10^{-11}	1.3×10^{-10}
H_2O	2.3×10^{-11}	4.7×10^{-11}
CH_4,O	1.4×10^{-11}	2.3×10^{-11}
C	1.4×10^{-11}	1.9×10^{-11}

Table 2 Outgassing Rates (Copper Plate)

These partial outgassing rates are total rates for the system, again after a bake cycle, and taken about 10 hours after the system temperature reached ambient.

Leak Chase of a cylindrical sample of the same material with two joints grown together was satisfactory, with a leak rate better than 1×10^{-9}.

V.CONCLUSIONS AND FUTURE WORK

So far both the electroforming and the sputtering techniques appear promising although the sputtering technique is more expensive.

Work is about to start on testing outgassing rates of joined electroformed copper after the sample has been baked to 250^{o}C.

Sputtered samples are being prepared for outgassing rate tests.

After evaluation, model cavities, probably at frequency of 1GHz., will be constructed for full evaluation.

VI. REFERENCES

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