FABRICATION TECHNIQUE OF ACS CAVITY FOR THE JHP

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Abstract

A high-power model of the ACS (Annular Coupled Structure) cavity has been fabricated and tuned to an operating frequency of 1296 MHz for the JHP (Japanese Hadron Project). The nose cone region is cooled by water flowing through channels in the septum in order to match the high-duty operation.
Some details are described for machining high-Q, ultra-precision cavity segments including coupling slots.
Detailed tuning procedures and brazing techniques are also presented.

大型ハドロン計画ＡＣＳ型空洞の試作

Introduction

A high-power model (see Fig.1) consisting of two accelerator tanks (each 0.5m long, 0.4 m dia. with 5 accelerating cavities) with a bridge coupler in the center of each has been fabricated recently.
Considerable development work has being carried out on the design and fabrication of 1296 MHz ACS resulting in the establishment of fabrication criteria and procedures.

Recent measurements have shown that potential advantage of the axially symmetric structure of the ACS will compensate only 5～10% inferiority of the quality factor of ACS to that of side-coupled strucure.
Its high stability and ease of fabrication make it an attractive alternate.
Some of the techniques developed for side-coupled structures were applied to the ACS very usefully.
Structural differences necessitate more development work to establish economical and suitable fabrication procedures hereafter.

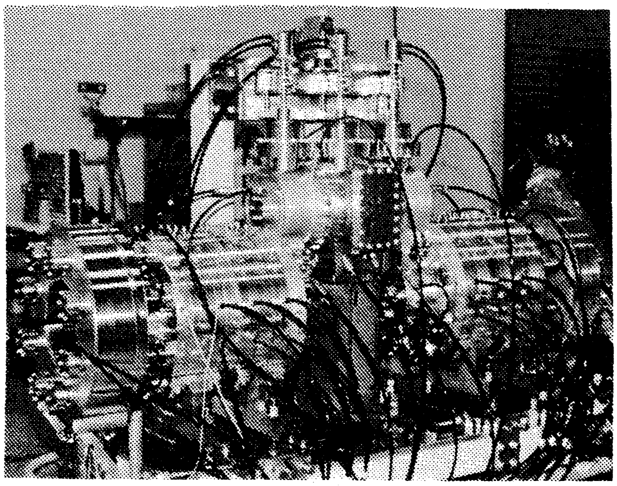

Fig. 1 Annular coupled structure

Design, Fabrication, and Tuning

Design

The major design feature is in the ACS (see Fig.2), which has half an accelerating cell, half a coupling cell and the cooling, vacuum channels all machined into the same segment, minimizing the number of brazing operations.

A cooling water system (5ℓ/min./cell) removes the heat loss (1 kW/cell), and it controls the average cavity temperature to within ± 0.4 ℃.
Careful design of these parallel-path channels minimizes the pressure drop and the number of tube fittings, consistent with maintaining vacuum integrity and cavity shape.
The nose cone region is cooled by water flowing through channels in the septum in order to match the high-duty operation.
The thicker wall between the accelerating cavity and coupling cavity is used for drilling cooling channels in it to conduct water near the nose.
The coupling factor depends on the arc length of the coupling slot and the wall thickness between the coupling cell and the accelerating cell.
The thicker wall reduces the coupling, therefore the both edges of the coupling arc is taper-bored from the coupling cell side to increase the coupling.

Machining

Fabrication begins with a forging from cast material to the required accelerating cavity profile.
The forged segments are rough machined ; one-half an accelerating cell is machined into one side of each segment, and one-half a coupling cell and the vacuum channels are machined into the other side.
The rough-machined half-cell bodies are annealed to remove residual stresses before finish machining.
The annealed, rough-machined, half-cell bodies are finish machined ; The cooling water passages are machined into the both sides and the four-coupling slots, dimpling holes are finish machined.
Next, ultra-precision machining for all internal and brazing surface is performed (see Fig.2).

A cutting tool of natural diamond was used for all cavity finish machining.
A special fixturing tool for machining was developed because the extremely soft copper easily deforms when clamped.

It was established that profiles could be machined with a surface finish of 0.1 - 0.2 μm Rmax (peak to valley) to dimensional tolerances of ± 5 μm.
While plane surface to be brazed was flat within 10 μm after pre-braze tuning.

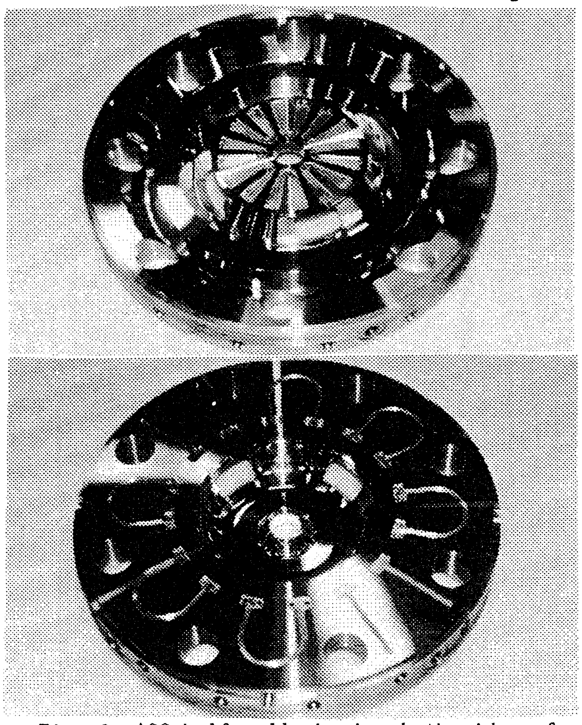

Fig. 2 ACS half-cell showing both sides of the final machined cavity.

Measurement on a single cell with no coupling slots was done to evaluate the effect of surface finish. This surface finish was sufficient that the measured Q was 96 % of theoretical.

Pre-braze tuning

The tuning method used for the accelerating cells is to progressively machine down the nose contours of each half-cell raising the freguency to the desired value, or slowly remove the cell outermost circumferential ridge prepared to lower the frequency.
Depth of each succeeding tuning cut is determined by measuring the rf frequency of the half-cell based on previous data, an estimate is made of how much more material must be removed to shift the frequency to the required value.
Similarly, the coupling half-cells are tuned by removing material from the cell center gap.

All cavities then have their profile machined until their resonant frequency is within 100 KHz of the desired frequency.

Brazing

Particularly, final step is taken to minimize the blushing and run off with filleting on the interior surface by keeping the foil thickness thin and providing a base metal brazing surface flat.
Fig. 3 shows one of the complete tank sections arranged for the final step braze.

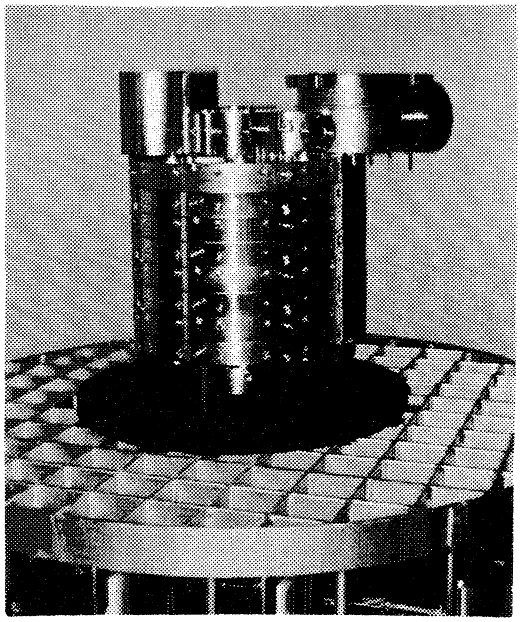

Fig. 3 ACS stack arranged for the braze

Final tuning

Final accelerator tuning is done by first measuring the frequency of each cell.
The accelerating and coupling cells can then be tuned by raising the frequency of each cell an appropriate amount by deforming the outer cavity wall.
This deformation is accomplished by dimpling the copper at the bottom of a hole to a depth near the interior surface of the cavity.

Conclusions

First step has been made to fabricate the ACS.
Development work on ACS has led to reliable production techniques which may be useful for other types of structure.

References

1. T.Kageyama et al., Proc. of the XIV International Conf. on High Energy Accel. 1989, Japan, Part. Accel. 32 (1990) 33, KEK Preprint 89-94.