COLD-FORMING OF 1.5 GHz MULTICELL CAVITIES OF THE SEAMLESS TYPE OBTAINED BY SPINNING A CIRCULAR BLANK OR A TUBE

V. PALMIERI, R. PRECISO, V.L. RUZINOV^, S.Yu. STARK^, and I.I. KULIK*

ISTITUTO NAZIONALE DI FISICA NUCLEARE
Laboratori Nazionali di Legnaro, Legnaro (PD), Italy

Abstract

We applied the spinning technique to the forming of 1.5 GHz seamless multicell resonators. Starting from a tube or from a circular blank, it is possible to obtain multicells resonators having uniform thickness along a whole meridian. If the right sequence of forming steps is respected, both pure Niobium and OFHC Copper can be cold-formed without any intermediate annealing.

A first RF test of a Niobium monocell was performed.

Introduction

No matter if bulk niobium or niobium-sputtered copper is chosen, beta 1 superconducting resonators are traditionally formed by spinning or deep drawing half-cells and electron-beam welding them together all around the equator. Then cells are welded one to the other at level of the iris. After several years of research this manufacture procedure has become well-established at industrial level both for niobium and copper cavities. However due to the fact that for one nine-cell resonator at least 19 EB-welds are needed, several drawbacks become evident for the production of about 20,000 pieces, that is the quantity required for TESLA.

Electron beam welds bring long fabrication times and make levitating manufacture costs. Especially in the case of high RRR niobium the fabrication of 18 halfcells produces a too large swarf of material. Severe mechanical tolerances are required whenever going to weld two cups that have a wall thickness at least 60 times smaller than diameter.

Apart parasitic defects as projections, microbubbles or craters, welds inherently possess compositional and microstructural heteregeneities due to a transition from wrought metal to solified weld metal, through a Heat Affected Zones (HAZ). Electron Beam Welding, even if it can produce in a single pass deep, narrow, and almost parallel-sided welds with low total heat input and relatively narrow HAZ, at the moment it is the main source for defects production in resonators.

---

^ INFN and Moscow Institute for Steel and Alloys, Moscow, Russia.
* INFN and Institute for Low Temperature Physics and Engineering, Kharkov, Ukraine

Seamless spun resonators

We have applied an already well-known cold forming technique to the problem of fabricating seamless 1.5 GHz multicell resonators starting from a simple circular blank or from a tube. Both niobium and copper can be easily manufactured with high reproducibility and significant savings in material and manufacture costs.

The technique simply consists in lathe-spinning the workpiece onto a suitable mandrel that is made collapsible.

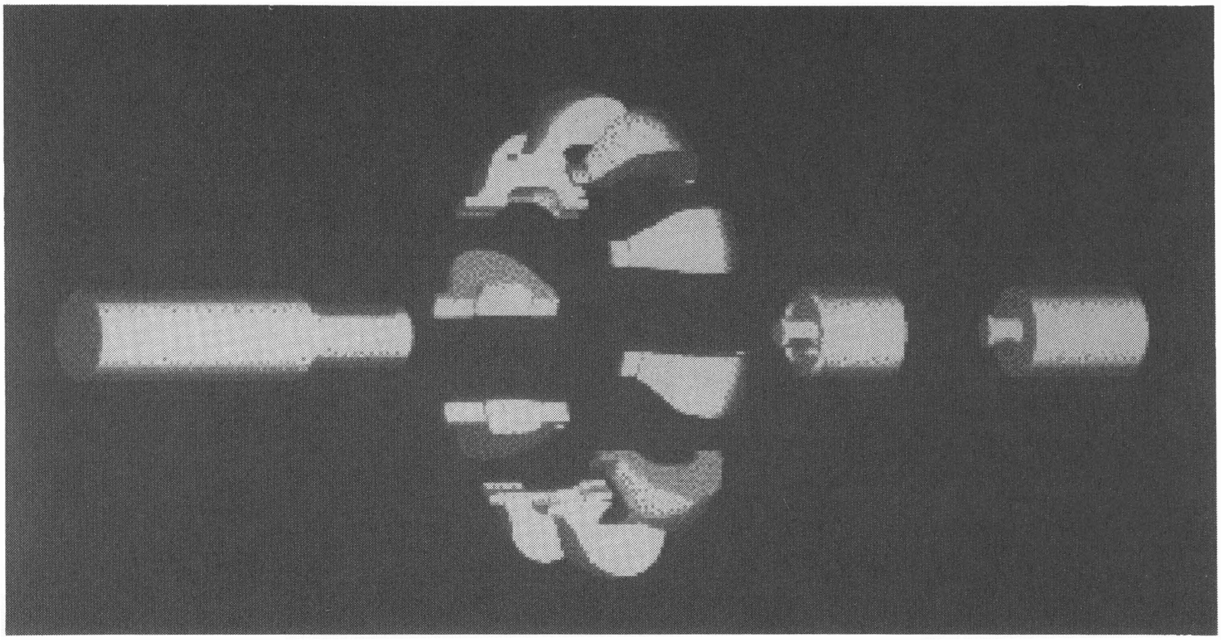

Fig. 1 Schematic view of the collapsible internal mandrel

The technique is based on the idea that much higher elongation can be obtained, when applying a plastic deformation that makes material flowing on the third dimension (thickness). For simple hydroforming indeed it is extremely difficult to overcome the elongation limit resulting from tensile tests. By forcing material to slide on slip planes across thickness, as it is done by spinning, it is possible instead to achieve elongation limits ten times higher without great difficulties.

We encountered no particular problems in spinning seamless monocells and multicells resonators of different frequencies in different materials as alluminum, copper, iron and niobium. Seamless cavities were made by applying in an original way the well-known spinning technique. Spinning a cavity from a blank is something more difficult to imagine than spinning from a tube. In the sequence of figures that follow, are displaied the most significant steps in our forming process. Pictures refer to the spinning of a monocell from a 3 mm thick Copper blank of 400 mm diameter, and the forming of an Alluminum pentacell from a 3 mm thick disk of 600 mm diameter. In order to have an idea of manufacture times, it should be taken in account that the full process of spinning a ninecell takes less than eight hours. In both cases

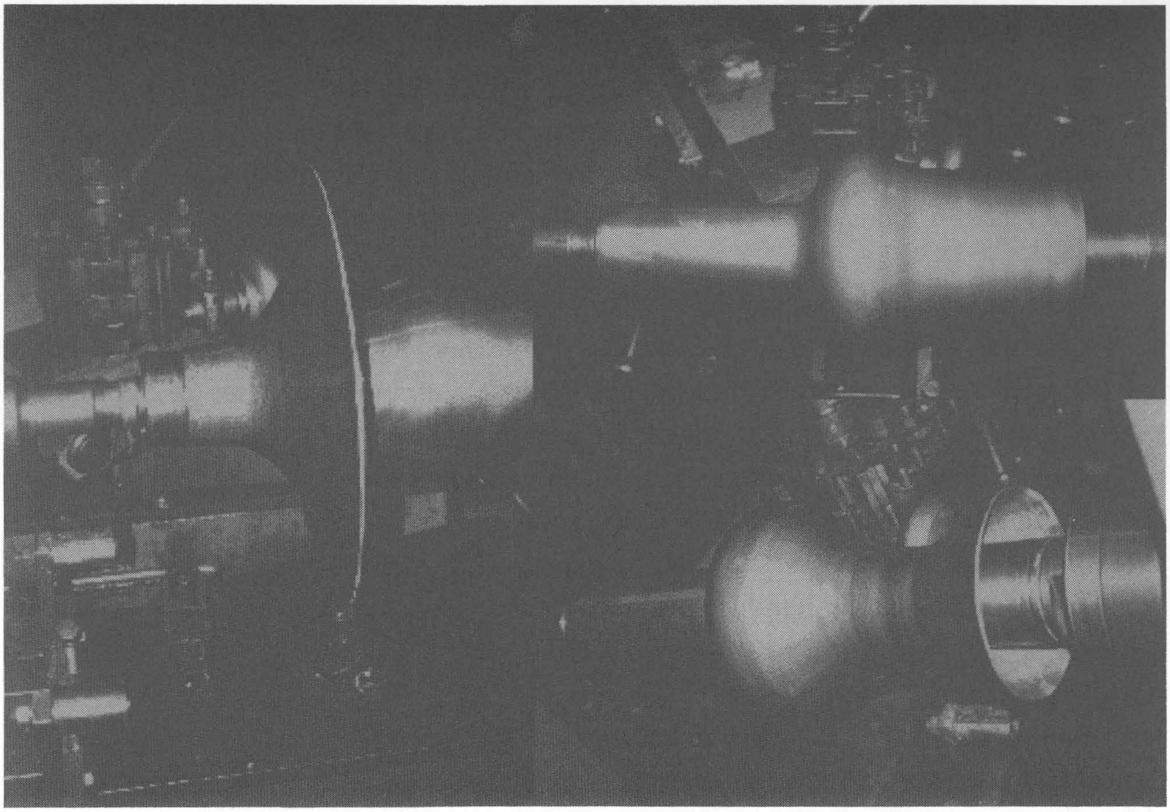

Fig. 2 Sequence of forming steps when spinning a monocell

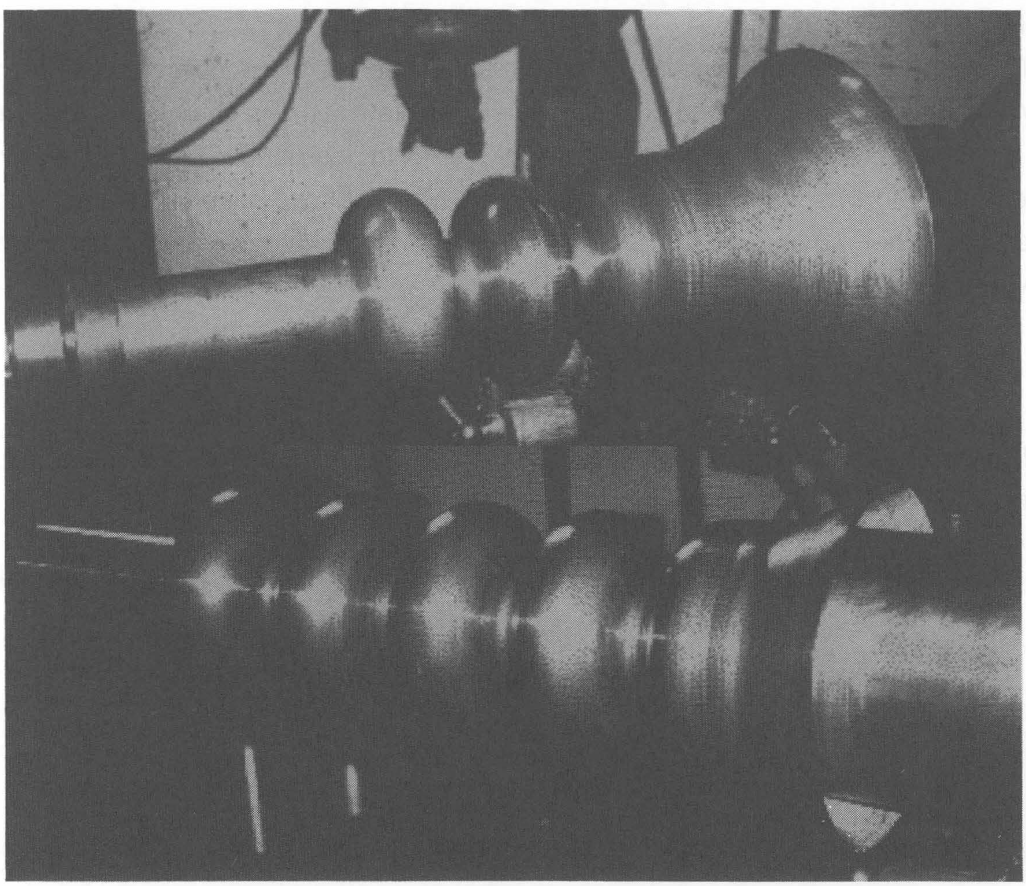

Fig. 3 Some steps of the multicell spinning proceedure.

if starting from blank and from tube, the whole operation does not need any intermediate annealing. Starting from a tube is obviously a more direct way and it has the advantage that the number of cells is limited only by the lathe size. On the other side starting from the blank is a more delicate process, however it has the unnegligible advantage that especially for high RRR niobium, tubes of the right diameter and thickness are commercially less common than sheets.

As shown in figure 2, the blank is initially deformed in a frustum of cone. The deformation is not done into a single pass. After each pass, the frustum becomes longer, up to when the first half of the cavity is formed. For the second part of the resonator, let us consider the section of the workpiece perpendicular to the axis of the cavity in the point of contact of the roller: the more the material is elongated the more the diameter of such section decreases. In such a way the material is forced to follow the internal mandrel profile. The internal mandrel is then extracted. Multicells are formed by applying this method by iteration cell by cell 4 (fig..3). No significant change in mechanical tolerances is seen if instead of using nine disclosable mandrels joined together by a central shaft, it is used only one mandrel moved cell by cell during spinning.

Thickness disuniformity was the main drawback of our method up to not long ago. This problem however has been recently solved by a more accurate control of the material flow during spinning. All over the resonator body indeed the wall thickness can be kept constant within only a 10% difference. And such a difference is practically independent of the number of cells.

The first Niobium monocell has been RF tested at low temperatures. After spinning the cavity was been degreased, and only slightly etched (few microns chemically removed). At 4.2 K the Q_0 was $4 \cdot 10^8$, and at 2 K the Q was $1.5 \cdot 10^9$. No degradation of the Q-factor versus accelerating field was found up to a gradient of 7 MV/m. Above such value, emission field appeared. Further measurements characterized by different values of thickness chemically removed are in program on the same resonator.

Acknowledgments

The work has been performed under grant of INFN Special Project on on Superconducting Cavities (CERN-INFN Collaboration).