DEVELOPMENT OF PRODUCTION TECHNOLOGY FOR WELDLESS COPPER SHELLS OF SC CAVITIES

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Abstract

Niobium-copper SC cavities make it possible to reduce the cost of SC RF structures, have a higher stability during operation at cryogenic temperatures, do not require special magnetic shields and allow one to apply not only Nb but also other SC materials on copper shells /1-4/.

The goal of this brief report is to show the first results on manufacturing weldless copper shells for SC cavities with the help of the technique of galvanoplastic shaping.

Plan of the report

1. Specific technological features of galvanoplastic shaping of copper cavities or shells of SC cavities.

2. Requirements imposed on the experimental equipment.

3. Manufacturing cavities using the technique of galvanoplastic shaping:.

   - development of the technology with the help of copper cavities for multiplying the RF power of linear collider VLEPP,
   - development of the production technology for copper shells of SC cavities having complicated geometrical shapes.

4. Conclusions.

SRF93I27

1. Specific Technological Features of Galvanoplastic Shaping

Galvanoplastic shaping is a complicated multifactor process that can be successful only with a certain combination of the following technological factors:

Parameters of the process of galvanoplastic shaping	Requirements on coatings and products
1. Current density	1. High accuracy of geometric dimensions
2. Voltage value & type	2. Electrophysical, thermal and mechanical properties close to those of commercially available Cu
3. Composition	3. High quality of the working surface in microwave range
4. Concentration of electrolyte	
5. Temperature	
6. Electrode or piece rotation rate	
7. Type of mixing	
8. Preliminary treatment	

Since the technological process is complicated and the requirements imposed on the finished products are stringent, the technology must undergo multifactor optimization.

2. Requirements on the Experimental Equipment

In addition to the technological parameters, the quality of the produced galvanoplastic coating is also affected by the properties of the mandrel, its texture, roughness and the conditions of the process.

The specific features of galvanoplastic shaping impose certain requirements on the technological equipment.

1. The setup should have:

- unit for rotating the electrode that should provide a stable rotation rate from 10 to 100 rot./min,
- electrolyte mixing by pumping it at a regulated speed or by bubbling through it compressed air,
- electrolyte temperature controlled with time in the temperature range 20-50 C according to a certain program,
- feasibility to work in nonstationary mode,
- electrolytic bath should be made from the material (fluoroplastic, rigid PVC) that would not contaminate the electrolyte,
- programmable power supply allowing the control of the process of deposition of galvanic coatings,
- special shields for equalization of fields in the electrolyte.

The structure scheme of the experimental setup is shown in fig.1 /2/.

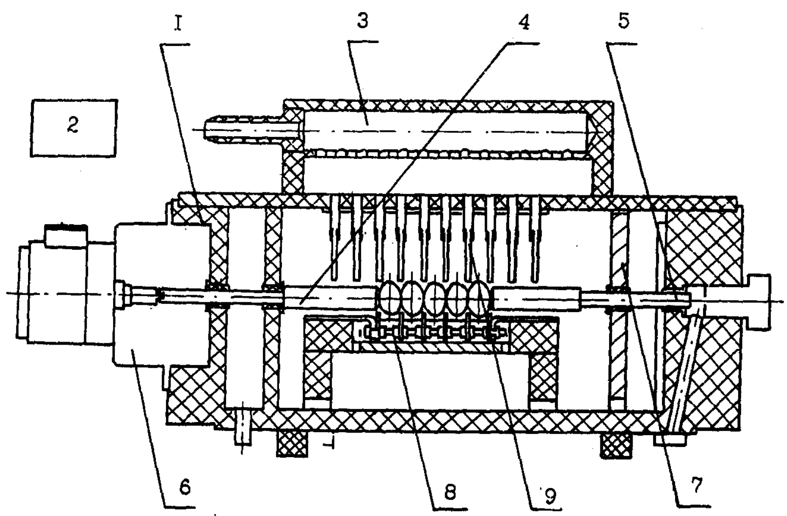

Fig.1. The structure scheme of of the setup for deposition of coatings.

The setup consisits of plastic galvanic bath (1), unit (2) charging electrolyte into the bath, device (3) for electrolyte circulation, holder (4) of the mandrel of SC cavity, device (5) for rotation of the mandrel during applying the coating, motor(6), device (7) for controlling the level of electrolyte, current leads (8,9).

3. Manufacturing Cavities Using the Technique of Galvanoplastic Shaping

3.1. The development of production technology for copper cavities for multiplying microwave power.

The production technology of cavities for multiplying microwave power which were described in paper /5/ has been under development at the Federative Problem Laboratory of Technology and Study of SC Cavities since 1990.

Figure 2 shows the sequence of manufacturing cavities.

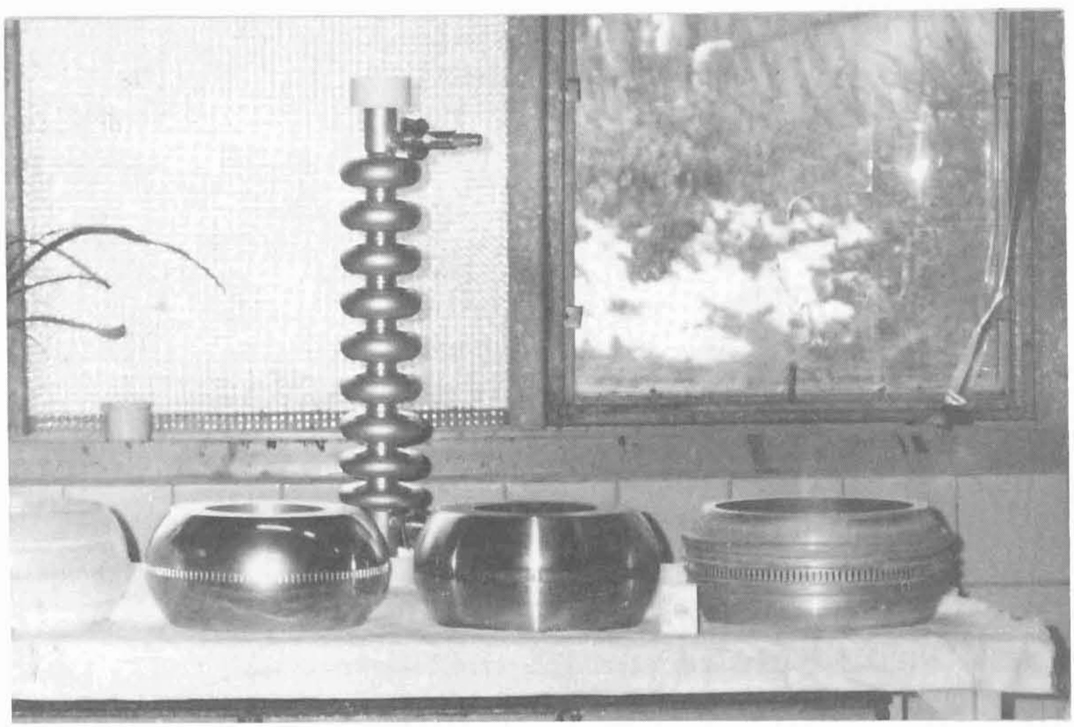

Fig. 2. The sequence of techological operations during manufacturing cavities:
1 - organic glass mandrel, 2 - organic glass mandrel with very thin copper coating applied by the magnetron sputtering technique, 3 - organic glass mandrel with combined copper coating (copper is applied on the previous larger by the galvanoplastic technique), 4 - cavity with water-cooling channels.

Figure 3 shows the technological feasibilities of the galvanoplastic shaping technique. Here one can see a "whispering gallery" cavity for multiplying microwave power that was manufactured according to the technology developed at our laboratory. In this cavity, the electromagnetic energy of the modes with a large number of azimuthal variations is concentrated close to the cavity surface.

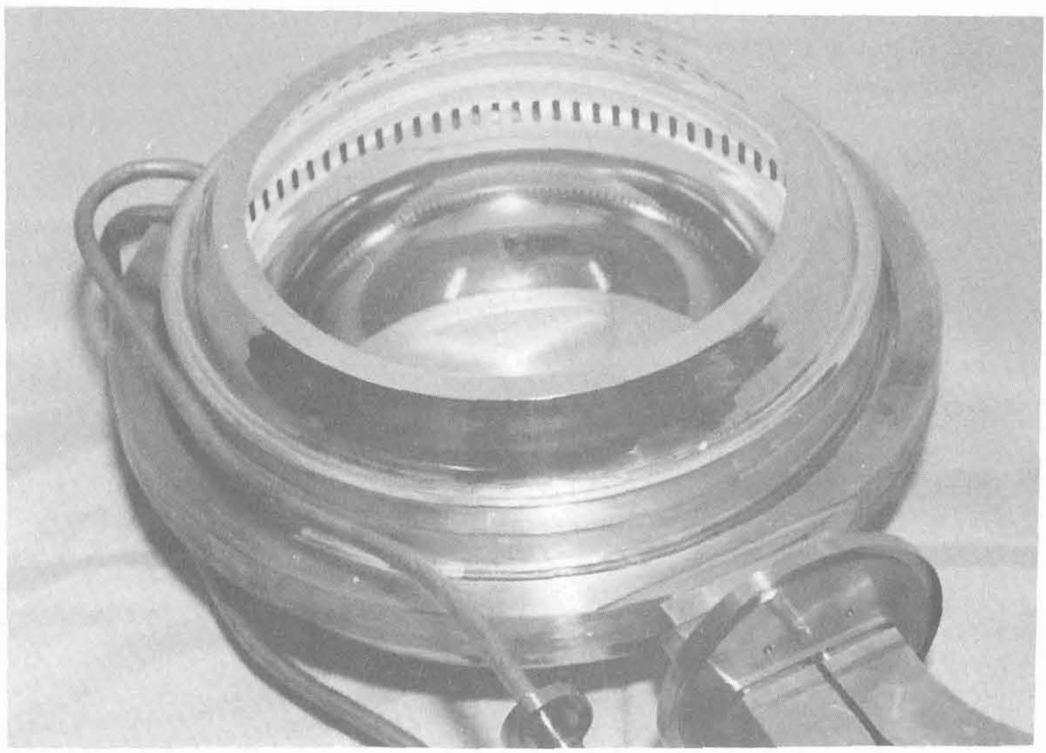

Fig. 3. "Whispering gallery" cavity manufactured in the beginning of 1992.

The photo shows well the RF windows for microwave power transfer between the cavity and waveguide and the cooling channels. This RF power multiplier has recently been sent to KEK for joint tests.

The Q-value of the copper cavity, measured by phase method, was Q = 10(5). It should be noted that the experimental results obtained with this cavity are close to the theoretical ones.

3.2. The development of the technology of copper shells of SC cavities.

Figure 4 shows the copper shell of a SC microwave structure of a complicated shape and having 9 cells. The structure was manufactured with the help of galvanoplastic technique and has no welds. If required, it is possible to make He cooling channels in the body of this geometry.

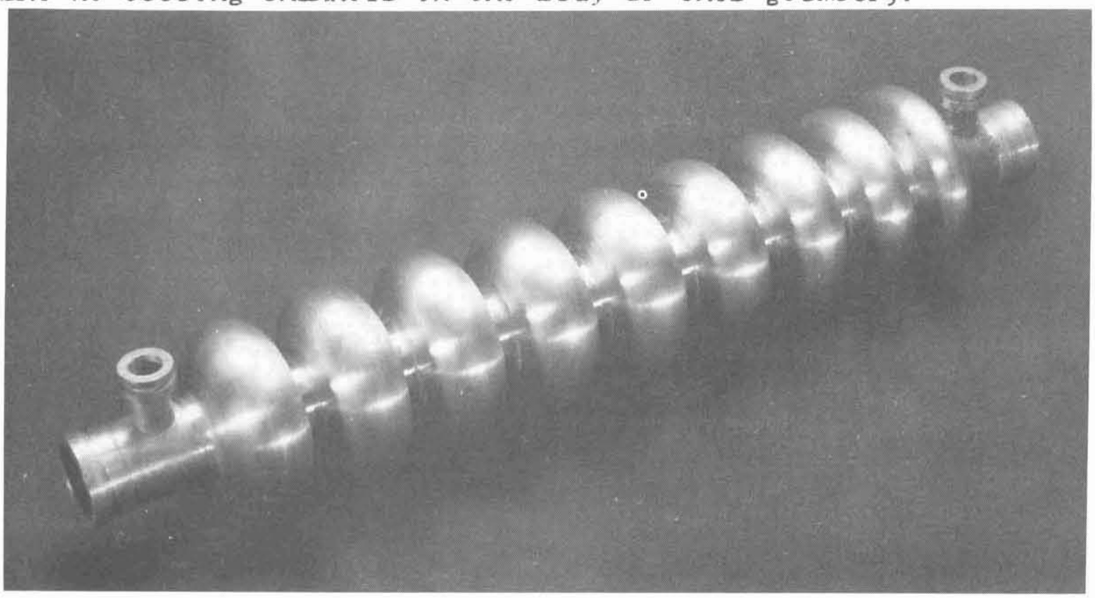

Fig. 4. 3 GHz SC mircowave strucrture manufactured by galvanoplastic shaping technique. The Nb SC coating was applied by magnetron sputtering technique.

This structure was manufactured specially for the 5 MeV electron linear accelerator under construction at JINR (Dubna, Moscow region). At present this structure undergoes cryogenic tests at a resonance frequency of 2,972.315 MHz.

The distribution of electric field on the accelerating structure axis is presented in the Table 1.

Table 1

Cell number	1	2	3	4	5	6	7	8	9
Field ratio	0.873	0.891	0.893	0.893	0.891	0.827	0.965	0.964	1.000

It should be noted that the results were obtained without preliminary tuning and point to a good accuracy of the reproducibility of geometric dimensions.

4. C o c l u s i o n s

The first experiments with copper cavities designed for operating as a RF power multiplier in the linear collider VLEPP as well as those with shells of SC microwave structures of complicated shapes demonstrated the promising features of the technology are developed at our Laboratory.

To conclude, the authors would like to express their sincere gratitude to V. Belygin, I. Sytchenko and I. Zvonarev for their kind assistance in making RF measurements of the SC cavity shells.

R e f e r e n c e s

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