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Poster #TUPCAV003

1.3 GHz Seamless Copper Cavities via Cnc Spinning Technique

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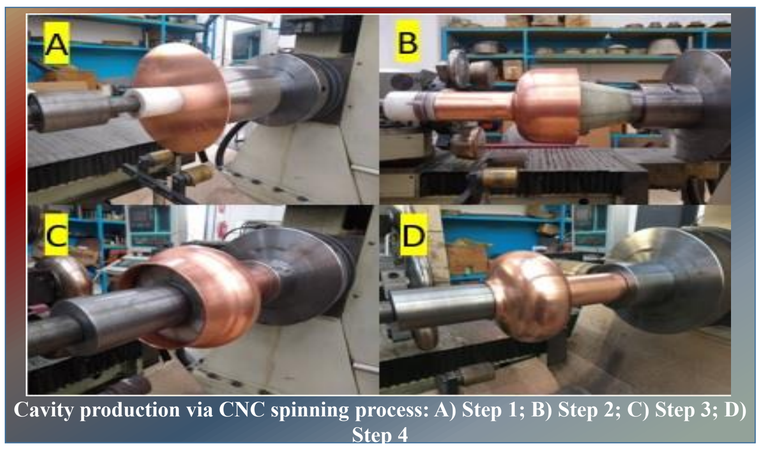
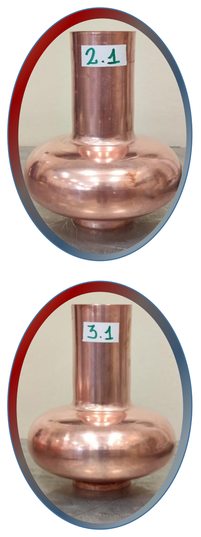
ABSTRACT

The spinning process is an established technology for the production of seamless resonant cavities. The main drawback is that, so far, a manual process is adopted, so the quality of the product is subject to the worker's skills. The Compute Numerical Controlled (CNC) applied to the spinning process can be used to limit this problem and increase the reproducibility and geometrical accuracy of the cavities obtained. This work reports the first 1.3 GHz SRF seamless copper cavities produced by CNC spinning at the Laboratori Nazionali di Legnaro of INFN. For this purpose, metrological analysis was conducted to verify the geometrical accuracy of the cavities after different steps of forming and thermal treatments; axial profile and wall thickness measurements were carried out, investigating different zones of the cavity profile. The cavities were also characterized through mechanical and microstructural analysis, to identify the effect of the automatic forming process applied to the production process of the 1.3 GHz SRF seamless copper cavities.



Cavity production via CNC spinning process: A) Step 1; B) Step 2; C) Step 3; D) Step 4



1. *Initial annealing of the plate*
2. *Intermediate annealing*
3. *No final annealing*

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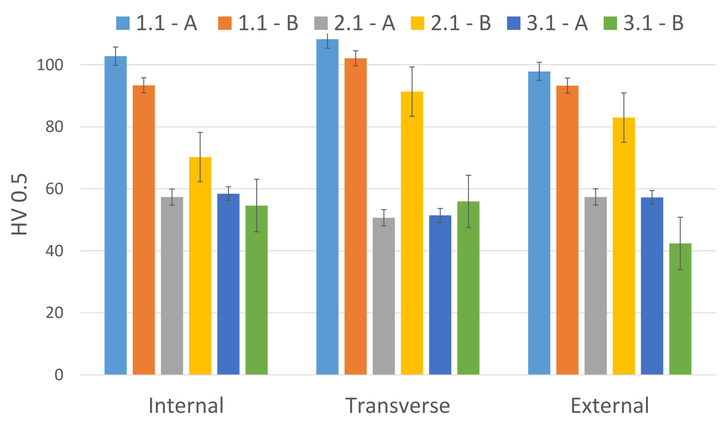
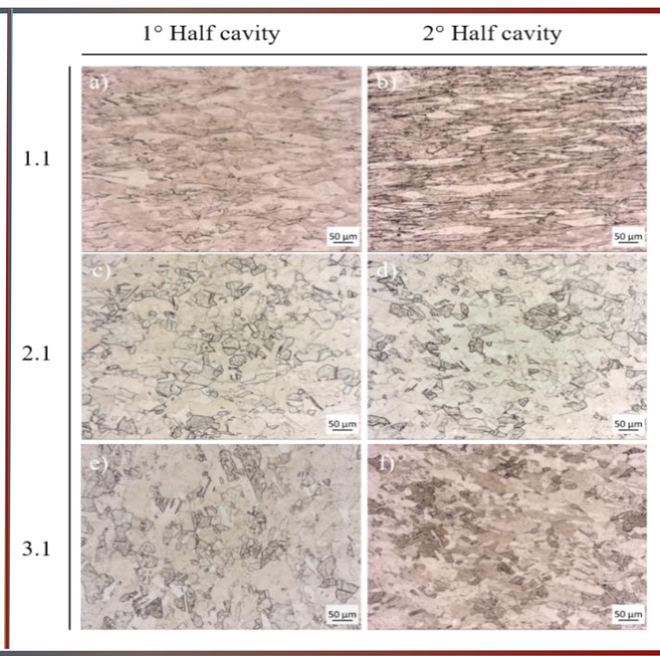


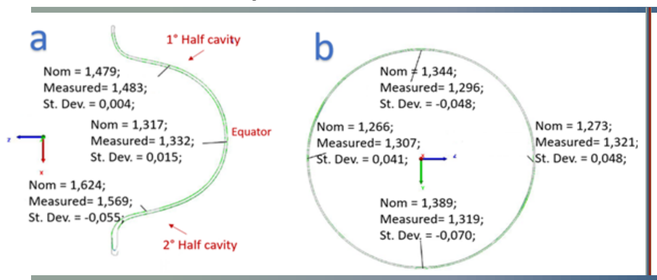
Micro-Hardness plot: Cavity 1.1, for both sampling A and B, shows a comparable values of hardness. The intermediate annealing of cavity 2.1 lower the hardness for sampling A, due to the recrystallization of the microstructure, while shows higher values of sampling B due to the cold work. Cavity 3.1 shows the lowest value of hardness duo to the final annealing.



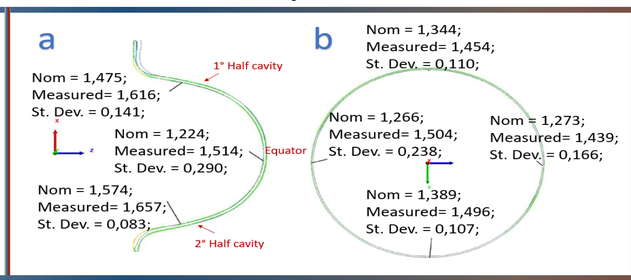
Metallographic analysis: The cavity 1.1 does not undergo any heat treatment during the process or at its end. In Figure 8 the microstructure shows a strong elongation of the grains along the spinning direction, and it has also the higher hardness in both the half cells (Fig. 17) The intermediated annealing treatment of the cavity 2.1 recrystallised the microstructure releasing the stress and dislocation accumulate during deformation and permit restore the ductility of the material, in figure 8 c, d in fact it is possible to observe equiassic grains characterized by recrystallization twins. The second half cell of the cavity 2.1 does not show, internally, a strong deformation of the microstructure and the hardness results are similar to the annealed one. Externally, the deformation process between the step 3 to 4, produce a slight work hardening that does not influence greatly the inner surface. The more homogeneous results it is obtain with the 3.1 cavity with a final annealing, also in this case the material is characterized by a fully recrystallized microstructure. Both the half-cell has a reduce hardness typical of annealed copper.

Profile comparison and thickness variation

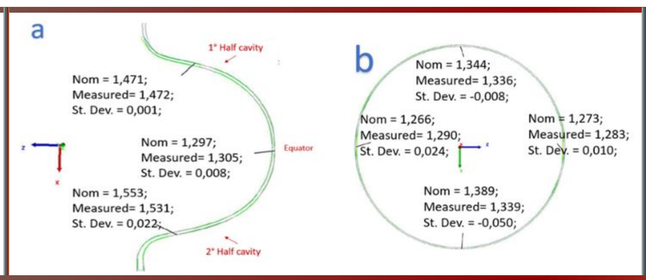
Cavity 1.1 vs 2.1



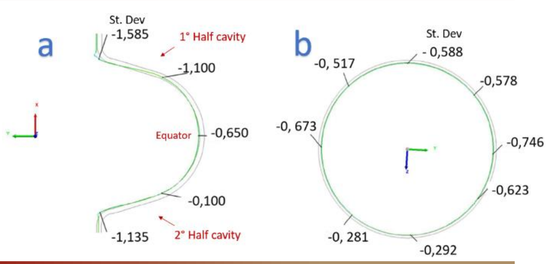
Cavity 1.1 vs 2.1



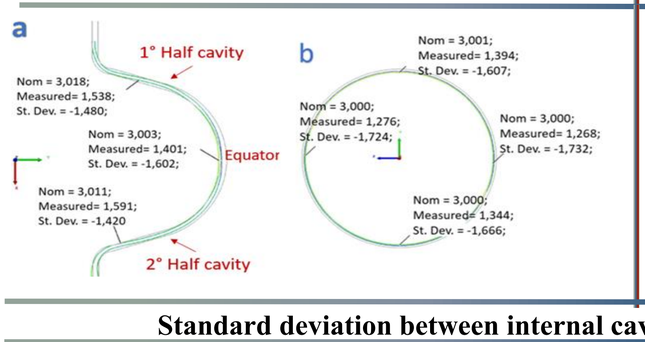
Cavity 1.1 vs 3.1



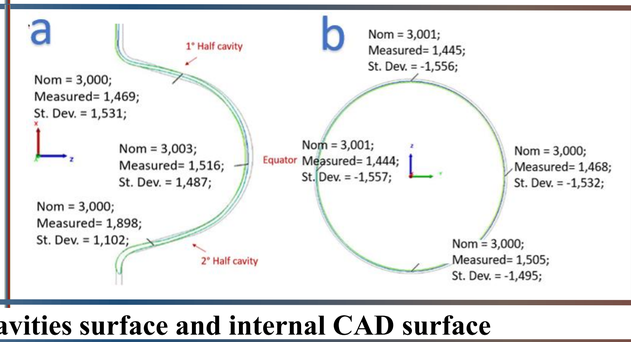
Die vs CAD



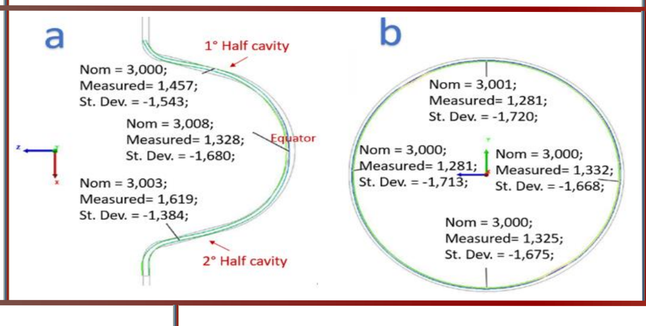
Cavity 1.1 vs CAD



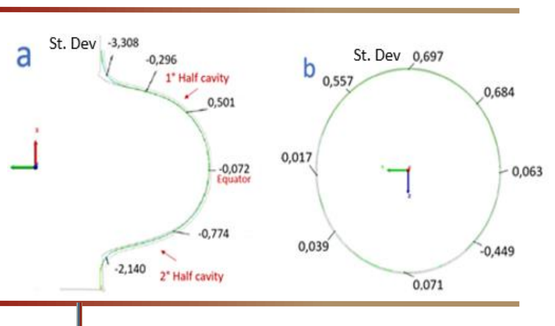
Cavity 2.1 vs CAD



Cavity 3.1 vs CAD

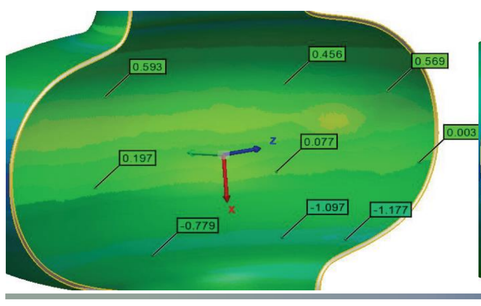


Cavity Die vs cavity 1.1

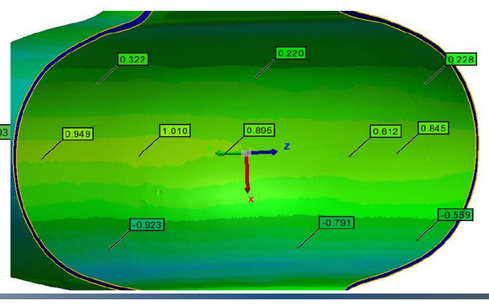


Standard deviation between internal cavities surface and internal CAD surface

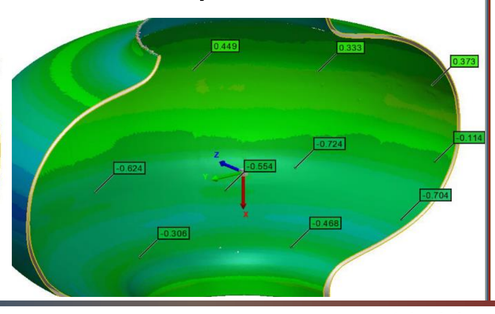
Cavity 1.1 vs CAD



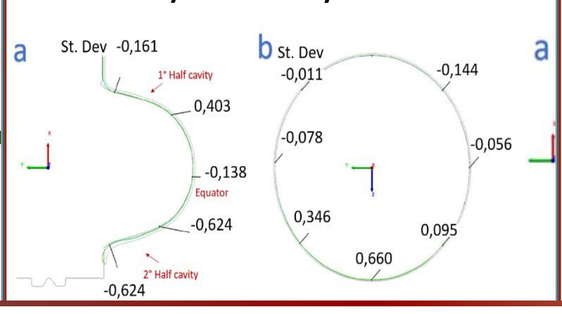
Cavity 2.1 vs CAD



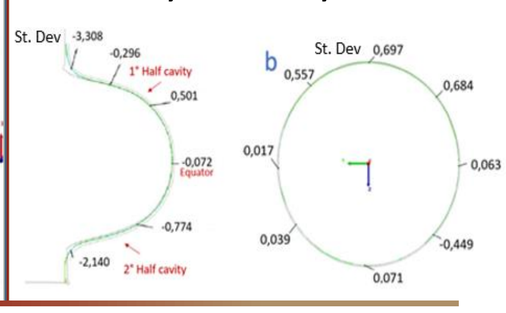
Cavity 3.1 vs CAD



Cavity Die vs cavity 2.1



Cavity Die vs cavity 3.1



Conclusion: The feasibility to produce a 1,3 GHz seamless cavity through CNC spinning process was demonstrated. Metrological analysis carried out have shown a good reproducibility for the cavities having the same thermal history. The initial annealing of the copper plate led to the formation of the cavities without the presence of defects or breaks. Intermediate annealing helped the workability of the spinning process, without bringing advantages in terms of geometric tolerances, while final annealing did not modify the geometrical shape of the cavity. Through these considerations we can assume that an intermediate annealing produce an asymmetry property not contemplable with the fine-tuning process. On the other hand, the final annealing produce a homogeneous state of stress in the whole cavity. Further developments are necessary to improve the geometrical accuracy, acting on the geometry of the Die and modulating the operating conditions of the CNC spinning process, according to the ductility of the material.

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