Ghidcop Brazing in Sirius’ Front-End High Heat Load Components

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ABSTRACT
Currently under construction, Sirius is a 3 GeV, fourth generation synchrotron light source. Sirius is designed to have up to 37 beamlines with ultra-low emittance and high brightness, which will allow high-level research and development on a large range of areas as structural biology, materials science and nanoscience. Given its high quality, its components rely on fine requirements on size, safety and cooling capability, having their design on the state of the art. Taking Front-End power absorbers as example: the refrigeration of these components is complex due to their reduced size allied to the high thermal load that is irradiated on them. To solve this problem, engineered materials must be used. The Ghidcop is a good choice due to its good thermal conductivity and preservation of mechanical properties after heating cycles. The difficulty of this project lies on the fact that dissimilar metal components (i.e. Ghidcop and Stainless Steel) must be attached and is needed to isolate both the vacuum and the water chambers. Thus, the joint must be resistant to hold the pressure in the water chamber and must be tight to not allow the transport of small atmosphere molecules to the vacuum chamber. As a trial to manufacture these components, given its specific features, the brazing was chosen as a joining process.

THE COMPONENTS
The photon shutter component (shown on isometric view at the left and on half section view on the right) is one of the power absorbers which will be built by this brazing process. Apart from this one, the fixed mask and the high-power slits will also be manufactured by this chain.

MATERIALS AND METHODS

Microstructure and EDS Analysis of the Brazing Regions

Brazing: Process and Results Description
- The filler metal could fill the whole gap between the surfaces, distributing itself homogeneously in it;
- The coatings covered the whole parts’ surfaces, accompanying its irregularities;
- There was no noticeable difference of applicability between different brazing sections
- In spite of the gap orientation, the capillary action was effective on guaranteeing that the filler metal would occupy the whole empty volume on the mating zone;
- Leak Tests:
  - All the brazing regions were approved with no leak detected up to 10⁻¹⁰ mbar. L/s, full scale and minimum leak rate of the equipment
- Hydrostatic Pressure Tests
  - Operational water pressure = 8 bar
  - Test 1 = 12 bar for 24 hours
  - Test 2 = 34 bar for 5 minutes
  - It supported the test without any problems

RESULTS ANALYSIS
Microstructure analysis of a brazed specimen. On frame a) it is shown a brazing section containing silver diffusion on the Ghidcop Matrix. On frames b) to f) it is presented a EDS (Energy-dispersive X-ray spectroscopy) analysis (the brazing section is illustrated on b), and elemental analysis are shown on c) to f)). Both regions of analysis are longitudinal cuts of the specimen.
- Frame a) presents that the coatings wet efficiently both surfaces (i.e. there are no empty spaces between a coating and the base material and the filler alloy is well bonded to the coatings over the whole surfaces, filling the whole gap).
- Frame b) shows a brazing section on which the EDS analysis was done. The stainless steel is on the upper side and the Ghidcop on the lower. There is a brazing region between them.
- Frame c) shows the elemental analysis for the iron (Fe). It is present only on the stainless steel.
- Frame d) presents the elemental analysis for the nickel (Ni). It is present on the stainless steel 304L alloy in small quantities and more concentrated on its coating. The nickel coating on the Ghidcop suffered diffusion to the base metal matrix during the brazing process.
- Frame e) shows copper (Cu) concentrations, on which are high on the Ghidcop (base material and coating) and on the filler metal.
- Frame f) shows distribution of the silver (Ag) contained on the filler alloy. Also, it is possible to notice some diffusion of silver on the ghidcop matrix.
- It can be notice two distinct phases on the filler metal region: the first rich in copper, containing silver in solid solution; and the second one rich in silver, containing copper in solid solution.

Brazing Process Description

<table>
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<tr>
<th>Stage</th>
<th>Heating Rate [°C/min]</th>
<th>Temperature [°C]</th>
<th>Time [min]</th>
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<tr>
<td>SP1.1</td>
<td>4</td>
<td>25 - 675</td>
<td>-</td>
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<td>675</td>
<td>15</td>
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<tr>
<td>SP3.2</td>
<td>-</td>
<td>795</td>
<td>4</td>
</tr>
</tbody>
</table>

CONCLUSIONS
The objective of the current study was to obtain a brazing process that could be integrated to the manufacture chain of the Sirius’ power absorbers. Also, the joint needed to bond dissimilar metals and result on a leak-tight and mechanical-resistant structure. It is possible to conclude after microscopy analysis, leak tests and hydrostatic pressure tests that the developed process (based on nickel and copper coating and the Cu60 filler alloy) attends the requisites imposed for its application. The Ghidcop and stainless steel components presented satisfactory performance on the tests.

REFERENCES