RF MEASUREMENTS ON VARIATIONS OF THE ALBA DAMPY CAVITY

M. Langlois, M. Cornelis, F. Perez and D. Einfeld
CELLS, ALBA Synchrotron, Carretera BP-1413, Km 3,3, Cerdanyola, Spain

Abstract

ALBA storage ring will use six ambient temperature nose cone HOM damped cavities tuned at 500 MHz, DAMPY, designed by a EU collaboration under the leadership of Ernst Weihreter (BESSY), also known as the EU cavity. The pre-series cavity leaked when RF power was applied, due to a localized overheating in the vicinity of the dampers gaskets. Three modifications were implemented and tested. All of them had a positive effect. Combining two of these modifications, the cavity can now sustain 80 kW (or more) of dissipated power.

INTRODUCTION

Six DAMPY cavities, operating at 500 MHz and up to 160 kW (60kW dissipated in the walls and 100 kW to the beam), will be used in the ALBA storage ring.

They are pill-boxes with nose cones working at ambient temperature, designed by a EU collaboration under the leadership of Ernst Weihreter (BESSY) [1]. Three dampers are attached to the body. Each damper has a circular ridged waveguide terminated with ferrite tiles brazed on copper. The fundamental mode does not penetrate in the dampers, because of the cut-off frequency of the ridged waveguide, and has an impedance of about 3.3 MΩ (transit time corrected). The high order modes do propagate and dissipate in the ferrite tiles, thus giving low impedances for these modes.

The pre-series cavity has shown two problems. First, the HOM damping is very efficient but for one mode. The longitudinal impedance of the E011 mode was found to be around 11 kΩ, close to the ALBA stability threshold [2]. Second, over heating close to the dampers flanges induced vacuum leaks. Three main alterations to overcome these problems were designed, manufactured and tested.

OVER HEATING SPOTS

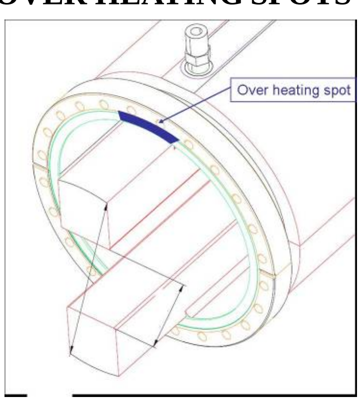

Figure 1: Over heating spot.

When RF power is fed into the cavity, the indicated places in Figure 1 and 2 overheat.

As there are vacuum gaskets in the vicinity, the localized thermal expansion causes vacuum leaks. The over heating can be conveniently monitored with temperature sensors on the dampers flanges.

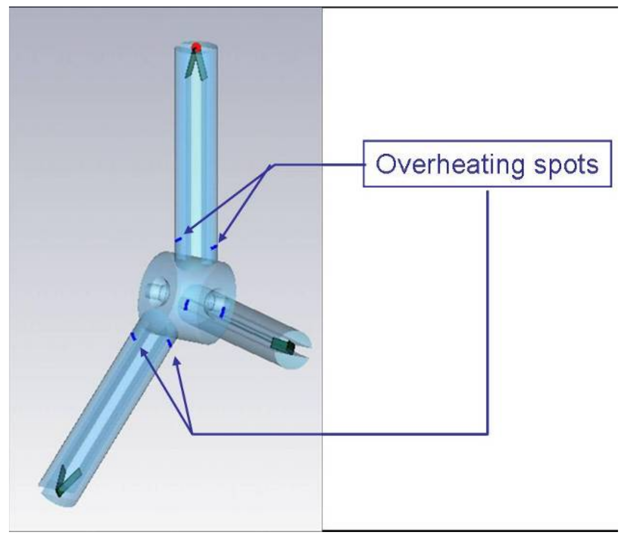

Figure 2: Over heating spots.

MODIFICATIONS

RF Gaskets

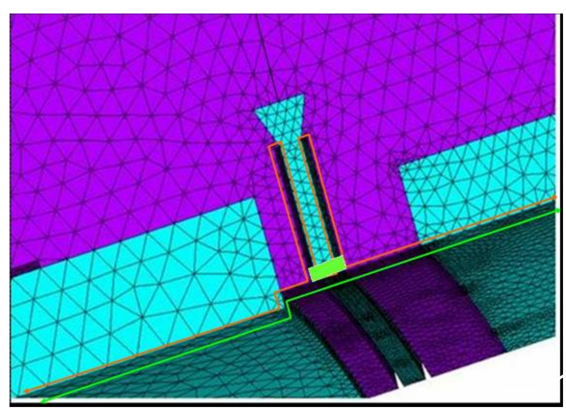

Figure 3: RF gaskets.

With conventional CF gaskets, the current path is shown in orange in Figure 3.

So called RF gaskets feature a lip on the inside diameter. This lip is provided with slots to prevent the formation of a virtual leak. With RF gaskets, the current path is the green line in Figure 3. The RF losses in the vicinity of the knife edge of the gasket are reduced, and so is the over heating.

The difficulty is to ensure simultaneously a suitable deformation of the gaskets by the knife edges and a decent RF contact.

Bridges Between Ridges and Cavity Body

Models computed with CST Microwave studio provided evidence that the gap between the ridges and the cavity body was responsible for this over heating as well as for the high value of E011 impedance.

We installed short circuits in the pre-series cavity DAMPY 0. They were made of copper, bridging the ridges of the dampers waveguides to the cavity body, see figure 4 and 5. They decrease significantly the RF currents at the junctions between the ridges and the waveguides, where the over heating takes place.

The cavity body has many cooling channels and the drilling to attach the bridges has to be very accurate.

The bridges are provided with RF lips and attached by bolts to the ridges on one side and the cavity body on the other. The bolts are screwed in stainless steel inserts. They have a hole to preclude any virtual leak.

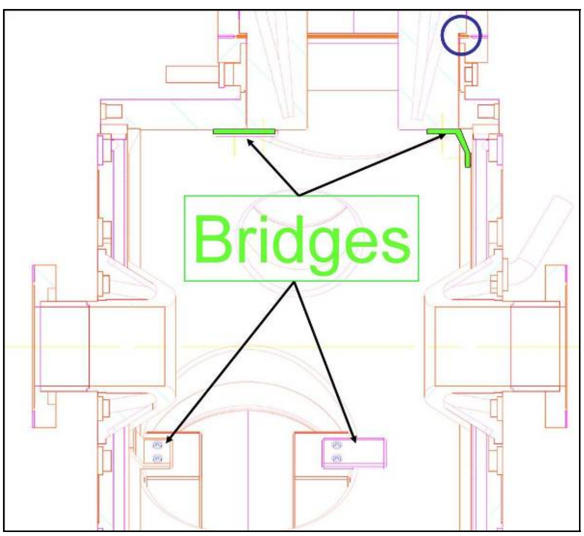

Figure 4: Bridges.

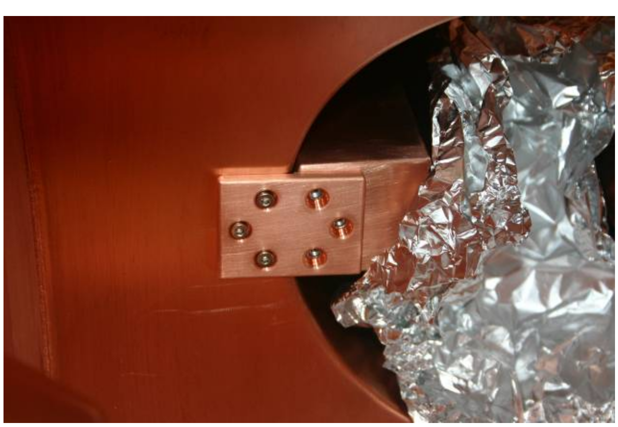

Figure 5: Implementation of a short circuit.

Heat Transfer Enhancement

The blue circle of figure 4, which is one of the over heating spots, is enlarged in figure 6. The left side of the picture shows shapes and materials used in the pre-series cavity.

As stainless steel conducts heat very poorly, it has been replaced whenever possible with copper in the over heating locations, as seen on the right side of picture.

Moreover, the gasket thickness was increased from 2 to 2.5 mm and it was provided with a lip to shorten the current path (RF gaskets).

The gaskets were annealed in a vacuum oven at 600°C to ensure that the gasket copper is softer than the cavity copper.

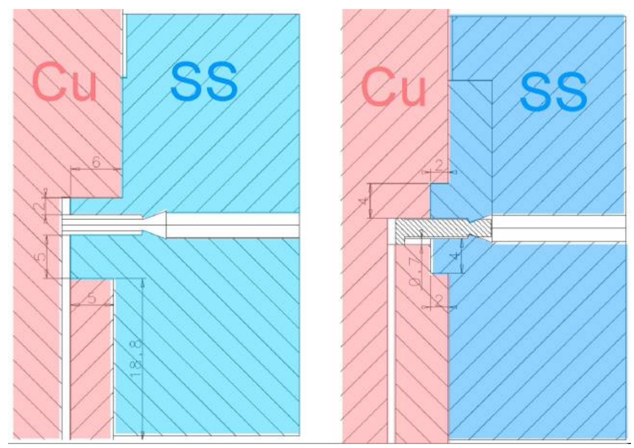

Figure 6: Copper enhances heat transfer.

This latter modification was not possible to implement in the pre-series cavity DAMPY 0 since it was already produced.

This modification has been introduced in all production cavities (DAMPY 1 to DAMPY 6).

RF TESTS

Impedances

The RF gaskets have no meaningful effect on the impedances of E010 and E011. Neither has the change of material.

The gap between ridges and cavity body was 1 mm wide at first for DAMPY 0. E011 impedance was around 11 kΩ. The dampers were removed and the outside diameter of the ridges machined to widen this gap to 1.5 mm. This increased E011 impedance to 13 kΩ. When short circuits were bolted, another bead-pull test was performed, yielding 7 kΩ.

This effect had been expected from simulation results and previous bead-pull tests [3].

RF Power

The efficiency of the modifications is easily quantified. The temperatures of the flanges are measured with PT100 in the plane containing the ridges as seen on figure 7. There are 6 probes per cavity.

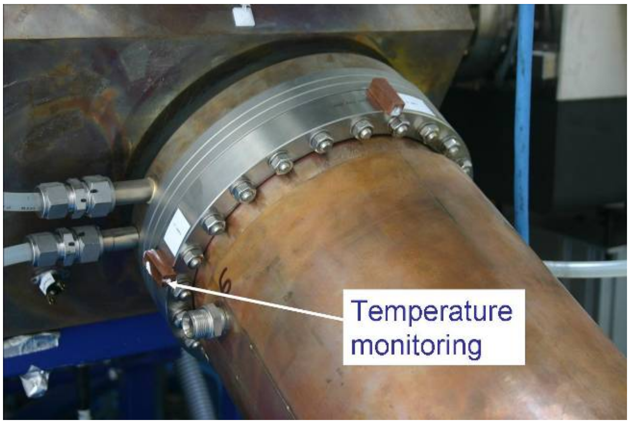

Figure 7: Temperature measurement.

For all of them, temperature increases linearly with the RF power dissipated inside the cavity. The β of the coupler had been trimmed to 1 for all theses tests.

Figure 8 shows the highest flange temperature as a function of the applied RF power.

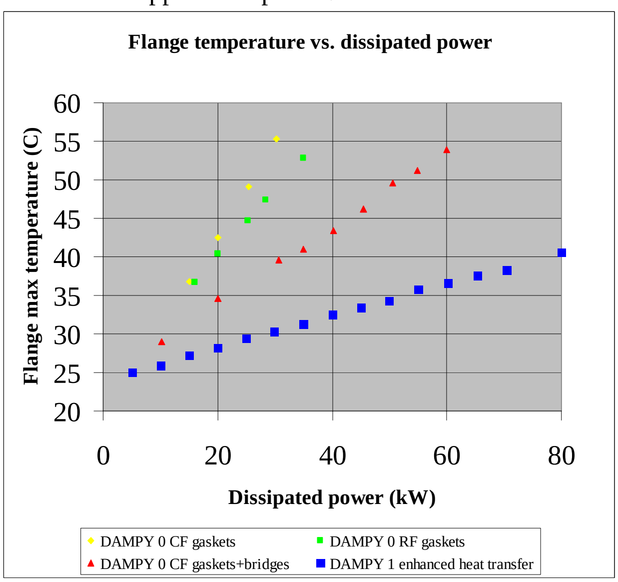

Figure 8: Temperature plot.

The results are summarized in the table 1. The symbol † means that a leak opened at the considered power level and that further tightening of the bolts of the leaky flange did not remove the leak.

The maximum power of our lab RF transmitter is 80 kW, so we could not test over this power.

At ALBA, we shall need to dissipate 56 kW to provide the necessary voltage. This is why we performed cycles at 60 kW when it could be reached. We checked that way immunity to thermal shocks.

Table 1: RF power tests

	max CW power	cycles	slope
DAMPY 0/ CF	30 kW †	-	1,22°C/kW
DAMPY 0/ RF	35 kW †	-	0,84°C/kW
DAMPY 0/ RF+bridges	60 kW	60 kW †	0,49°C/kW
DAMPY 1/ RF+Heat T.	80 kW	60 kW	0,21°C/kW

The heat transfer modification, together with the RF gaskets, solved the over heating problem.

CONCLUSIONS

- Some modifications were implemented and tested on the ALBA cavities at 500 MHz.
- The dissipated power in the cavity reached 80 kW, for an expected operation value of 56 kW.
- The cavity could be cycled up to 60 kW without trouble.

AKNOLEDGEMENT

The authors are grateful to José Ferrer and his mechanical team for their support in the modifications of the cavities.

REFERENCES

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[2] F. Marhauser and E. Weihreter: Impedance Measurements of the HOM-Damped 500 MHz Metrology Light Source Cavity

[3] M. Langlois, P. Sanchez, M. Cornelis, F. Perez: Measurements of the RF cavity for the ALBA storage ring (EPAC 2008)