Abstract

This paper reports design, modelling, simulation and optimization results for the ALBA MIRAS infrared radiation extraction mirror. Finite element analysis (FEA) was used to simulate the thermal mechanical behaviour of the device. With the aim to ensure a good thermal performance, conservative assumptions were applied: all of the incident Bending Magnet (BM) radiation is absorbed at the mirror surface, constant bending magnetic field and low thermal contact between the mirror Al 6061 and the OFHC copper arm. A novel solution has been implemented in order to provide an effective cooling by a natural convection on the in-air part of extraction mirror assembly. This has voided the necessity for a water cooling that often causes problems due to the associated vibrations. The power conditions were calculated by using SynRad+. The main ALBA Storage Ring design parameters are: 3 GeV, 400 mA and 1.42 T. According to these conditions, the mirror absorbs 15 W with a peak power density of 0.51 W/mm². The peak temperature calculated was 63.2 ºC. The real measurements reported during the commissioning stage showed a good thermal performance, in agreement with the results predicted by FEA.

The ALBA Infrared Extraction Mirror

The ALBA infrared mirror is based on the slotted, non-cooled, type. The concept of the slotted mirror not only avoids interaction with the central high energy core of the dipole emissions, but also allows to realize a simple design that functions reliably without additional water cooling that often causes problems due to the associated vibrations.

Air Cooling Optimization

In order to enhance the heat dissipation on the air cooling system, three geometries are studied: A) Stainless steel cylinder, 2 mm wall thickness, B) Copper cylinder, 10 mm wall thickness, and C) Case B with internal fins attached.

Ray Tracing and Power Deposition

Surface power density distribution using the SynRad+ computer code.

FEA Results

<table>
<thead>
<tr>
<th>Type</th>
<th>T_max (ºC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case A</td>
<td>125.6</td>
</tr>
<tr>
<td>Case B</td>
<td>76.6</td>
</tr>
<tr>
<td>Case C</td>
<td>63.2</td>
</tr>
</tbody>
</table>

Effect of fin surface on the temperature. This effect is studied by means of the variable $F_A$ ratio between the total fin surface and the case without fins.

Conclusions

The measurements reported during the commissioning stage showed a good thermal performance of the mirror, and the results are in agreement with the conservative results predicted by FEA.

The case C has been found the most appropriate geometry in terms of maximum heat dissipation. This model has been designed and implemented for ALBA.