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Thermal analysis and design of the aerial camera's primary optical system components

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ABSTRACT

To meet the thermal index requirements of an aerial camera with long focal length, three kinds of heat transfer modes including conduction, convection and radiation were analyzed. The measures were designed for the camera's primary optical system components based on this analysis. The design principles and implementing regulations were introduced. The camera's finite element thermal model has been established. The results of model's temperature distribution have been obtained after the calculation according to the boundary conditions. A heat balance test has got done for the camera. The results show that both axial temperature difference and radial temperature difference are less than 5 °C, which meets the camera's thermal control indexes.

1. Introduction

With the higher demand of the resolution and precision, the camera with long focal length which works at high altitude needs a carefully designed thermal control. An aerial camera usually has a more complicated and variable environment and a shorter working period which means needing transient analysis, compared to an aerospace one.

Now, many scholars have described thermal control measures of kinds of aerospace cameras in detail [1–6] and shown the results of the analysis and the heat balance test. Yang used thermal optical analysis and optical wave aberration [7–9] as a high-precision space camera's control index. However, the introduction of thermal analysis and design for an aerial camera is still missing.

In section 1, the structure and composition of the camera are introduced. Section 2 describes the camera's external thermal environment. In section 3, three kinds of heat transfer for the camera are analyzed. In section 4, the camera's thermal design and strategies are introduced. Section 5 shows the results of the typical working conditions. Section 6 introduces the camera's heat balance test.

2. Composition of the aerial camera

The camera is 1.36 m × 0.6 m × 0.6 m, it includes primary optical system components, frame components, camera body components, focusing components, front supporting components, window components, back supporting components, auto focusing components, correction microscope components, focal plane components, electronic control components and thermal control components. Fig. 1

3. Thermal environment of the aerial camera

3.1. The camera's external thermal environment

The upper part of the camera is installed in a pod of an aircraft, the lower part with curved surface contacts with the outside air. Fig. 2

When the camera works, it is in the stratosphere and its typical external environmental condition is relatively stable. The condition is listed as follows:

Aircraft speed: 0.7 Ma; Ambient air's temperature outside the camera: −56 °C; Air's density outside the camera: 0.12 kg/m^3; External air's pressure: 7650 Pa.

3.2. The camera's internal heat sources

The camera has two modes: preparation mode and working mode. Each has a different thermal power. The main heat sources

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