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Abstract. The primary focus telescope has the advantages of a large field of view and less loss of light energy, and plays an important role in the field of time-domain survey. The 1-meter large field-of-view telescope of Nanjing University uses the primary focus optical system. The 6k × 6k CCD is located at the primary focal point in the optical path. The CCD will have a large amount of heat during the working process, which will affect the telescope's imaging quality. According to the requirements of the imaging quality of the NTU 1-meter telescope optical system, the difference between the temperature of the CCD housing and the ambient temperature needs to be controlled within 1 °C. Therefore, the paper proposes a temperature control scheme for thermal insulation materials, and optimizes the performance of the temperature control scheme. The temperature control accuracy of this solution is within 0.6 °C.

Keywords: Primary focus telescope, CCD camera, Temperature control.

1. Introduction
The primary focus telescope can obtain a larger field of view, and it is the main telescope type for large field surveys. However, because the main focus is in the optical path, the thermal energy generated by the CCD camera installed at the primary focus will cause a large temperature gradient in the optical path environment near the primary focus, which will affect the imaging quality of the telescope. At present, most domestic and foreign schemes cool the camera by circulating cold pipes, but the simple cold pipe temperature control scheme can only control the working temperature of the CCD in a wide range, and it is difficult to achieve the effect of precise control.

2. The temperature control scheme of Insulation material
The thermal insulation performance of a material is determined by the thermal conductivity of the material. The smaller the thermal conductivity, the better the insulation performance. On the premise of ensuring a certain strength and rigidity, the thermal insulation structure also needs to have the characteristics of low thermal conductivity and light weight.
According to the design requirements, the aerogel felt was selected as the material of the thermal insulation device, and the structural diagram of the thermal insulation device was designed using CAD software.

**Figure 1.** The structure of insulation material. 1 CCD, 2 The temperature control scheme of vacuum cavity, 3 Water-cooled block, 4 TEC, 5 Water outlet, 6 Pipe outlet, 7 Water pipe, 8 Line outline.

When a semiconductor refrigerator (TEC) is in operation, one side releases heat and one side absorbs heat. The TEC cold surface is used to cool the system, and the hot surface is cooled by circulating cold pipes. The heating power of the system is 35W, which is cooled by 10 semiconductor refrigerators, each with a power of 3.5W.

3. **Device performance analysis and optimization**

As the working environment temperature of the telescope varies from -30 °C to +30 °C, the greater the temperature deviation, the more difficult it is to control the temperature. Take two extreme temperatures and simulate the temperature control system respectively.

The CAD model of the insulation material structure (10mm material thickness as an example) was meshed in Icepak, and the entire model was divided into 1834288 elements. When the ambient temperature is -30 °C and 30 °C, the heat distribution diagrams at natural convection are as follows.

**Figure 2.** Temperature distribution of Insulation material device at -30 °C.
Figure 3. Temperature distribution of Insulation material device at 30 °C.

The tangential temperature distribution along the outer surface of the device is shown in the figure.

Figure 4. Temperature distribution of structure (10 mm) surface at -30 °C.
Export temperature data. When the ambient temperature is -30 °C, the maximum temperature is -29.0043°C and the minimum temperature is -29.8337°C, so the maximum temperature difference is 0.8957°C. When the ambient temperature is 30°C, the maximum temperature is 31.3767°C and the minimum temperature is 30.1689°C, so the maximum temperature difference is 1.3767°C.

The temperature difference of the outer surface of the device is basically kept within 1 °C. Consider changing the size of the cold source to adjust the temperature distribution. The maximum deviation temperature appears on the right side of the outer surface of the CCD, so increase the TEC power to the right of the CCD to 3.6 W.

The tangential temperature distribution along the outer surface of the device is shown in the figure.

**Figure 5.** Temperature distribution of structure(10mm) surface at -30 °C.
Export temperature data. When the ambient temperature is -30 °C, the maximum temperature is -29.4214 °C and the minimum temperature is -30.1924 °C, so the maximum temperature difference is 0.5796 °C. When the ambient temperature is 30 °C, the maximum temperature is 30.5787 °C and the minimum temperature is 29.8075 °C, so the maximum temperature difference is 0.5787 °C.

4. Summary
In the primary focus optical path, the CCD installed in the primary focus generates heat when it works. The heat will cause a large temperature gradient in the optical path environment near the primary focus,
which affects the imaging quality of the telescope. In order to solve the problem of heating, a thermal insulation device is designed in this article. After optimization of the structure, the temperature difference between the CCD case temperature and the ambient temperature is within 0.6 °C, the Results meet expectations.

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