

Mid-IR Borescope— *Thermal imaging of hard-to-access area*

Introduction

Mid-IR borescope is an imaging instrument with customizable requirements for clear inspection of hard-to-access areas, such as boiler tubes, furnace walls, etc. The special environment must be considered in optical and mechanical design, especially the effect of high temperature on the lens. In some cases, customers also require light paths at certain angles in order to view the side wall.

Operation Principle

The overall design concept is shown in Figure 1. It consists of a thermal imaging lens, a Mid-IR camera, and a mechanical jig and apparatus for mounting and alignment. Optional water cooling, air purge unit and protection window can provide an optimum protection of the IR camera under rough environmental conditions.



SCALE 1 : 2.5

Figure 1. Layout of Mid-IR borescope

The key specifications of the Mid-IR borescope are listed below. Compared with similar products in the market, we offer larger field-of-view (FOV) and better pixel resolution.

Material	Single-crystal germanium and silicon
Wavelength	3.5 – 4 μm
Focal Length	12 mm
F#	5
Image Diagonal	20 mm
Circular FOV	79.6°
Detector pixel number	640x480
Pixel size	25 μm

Table 1. Key specifications of Mid-IR borescope

Thermal Mid-IR imaging lens is a type of imaging lens that can withstand a temperature of up to 70° C (high thermal resistance) and over long period of time. The exterior closure is designed to have high corrosion resistance. The layout is shown in Figure 2.



Figure 2. Layout of thermal imaging lens

For example, if the Mid-IR camera was chosen to have a pixel size of 25 μm , it has a calculated resolution of 20lp/mm. The MTF is evaluated based on this resolution when designing. The results are shown in Figure 3.

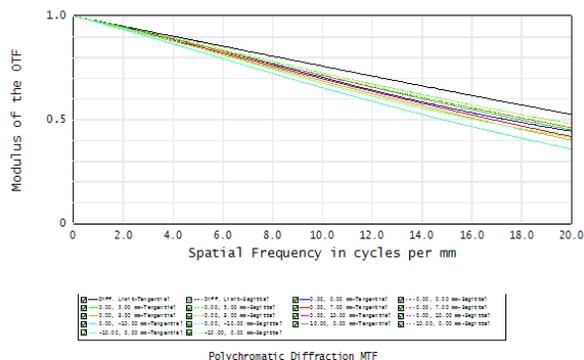


Figure 3. MTF curve with 20lp/mm spatial resolution

Applications

The Mid-IR borescope is suitable for use in hot or harsh environments and is typically placed beside a blast furnace or equipment with high operation temperature for real-time monitoring and control. It is designed to provide excellent monitoring with the image formed by objects at high temperature. Figure 4 below shows the images formed by objects at high temperature.

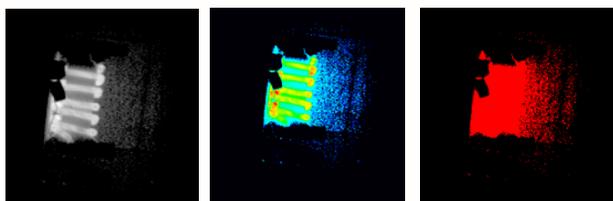


Figure 4. Image result of thermal IR lens

The system could be used in but not limited to the following application scenarios:

- Mobile or semi-permanent through-flame imaging inside power boilers, furnaces and incinerators
- Pinpoint problems before they cause outages
- Inspect build-up of ash/slag on boiler tubes
- Diagnose burner flame conditions
- Measure temperature across entire image
- Record and analyse data to optimize combustion processes

Conclusion

As a global enterprise, leading photonics innovation since 2002, WOE has built up customization engineering capability for thermal imaging, inspection and measurement systems.

