Ultra-precision diamond grinding of large sized infrared aspherical lens

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Abstract

Infrared aspherical lens are widely applied in automobile, civil aviation, and space industries. The normal processing method for infrared aspherical lens is traditional polishing with low efficiency, or diamond cutting with intense wear of tools when processing large sized lens. Therefore, the ultra-precision diamond grinding technology of large sized infrared aspherical lens was researched to improve processing efficiency and surface quality. In this paper, the key technologies of grinding large sized infrared aspherical lens was investigated, including on-machine precision truing of arc-shaped diamond wheels technology, errors analysis and compensation technology for high form accuracy, and grinding parameters optimization technology for homogeneous and well surface morphology. With these technologies, multispectral CVD zinc sulphide for aspherical lens with diameter of 93.5 mm was ground with form error PV≤0.8 μm and roughness Ra <5 nm. This research gives an indication of the strategy to follow to achieve high efficiency and quality ground aspheric surfaces on brittle infrared materials.

Keywords: Ultra-precision diamond grinding, large sized infrared aspherical lens, processing efficiency, surface quality

1. Introduction

Aspheric lens have many advantages in terms of optical system optimization, spherical aberration and optical aberrations reduction of spherical lens in the collimating and refocusing optics system, quantity of optical components decreasing, weight decreasing, size reducing and integration realization[1]. Therefore, aspheric infrared lens have important and extensive application perspectives in aerospace, electrical, building, medicine, automotive, and so on. At present, the main method for mass production of aspheric infrared lens is by means of traditional abrasive polishing with low efficiency and poor product uniformity. While the ultra-precision grinding with high efficiency and technological stabilization, good product uniformity is the novel key technologies for hard and brittle materials[2].

In this paper, the key technologies of grinding large sized infrared aspherical lens was investigated, including on-machine precision truing of arc-shaped diamond wheels technology, errors analysis and compensation technology for high form accuracy, and grinding parameters optimization technology for homogeneous and well surface morphology. Finally, with these technologies, multispectral CVD zinc sulphide for aspherical lens with diameter of 93.5 mm was ground.

2. On-machine precision truing of arc-shaped diamond wheels technology

Arc-shaped diamond wheels with precision profile were usually adopted for ultra-precision grinding of aspherical surfaces[2]. A novel on-machine precision form truing of resin and metal bonded arc-shaped diamond wheels is proposed utilizing rotary green silicon carbon (GC) rod.

Fig.1 shows the ORGCR mutual-wear truing principle of arc-shaped diamond wheel. In ORGCR mutual-wear truing, the GC rod is driven by the workpiece spindle on the machine with the wheel speed n to true diamond wheel with the wheel speed N along the circular interpolation paths circularly with the feed rate v in CNC grinding system as shown in Fig.1 (a). Besides, the motion paths was designed to utilize more cylinder of GC rod to true the arc profile of diamond wheel as shown in Fig.1 (b)

**Fig.1.** ORGCR mutual-wear truing mode of arc-shaped diamond wheel (a)truing mode (b)truing motion paths.

As shown in Table 1, the D3 wheel form error of 2.5μm after truing contrast of 35μm before truing. The similar truing performance also could be presented on the D7 and D15 wheels, and the optimal results of these three wheels in the experiment were displayed in Table 1.

![Fig.2](image-url) shows the LSDM photos of three wheels arc profile topography. Before truing, the arc profile topography transited wavyly, and existed a lot of raised and foveate stripe on the wheel surface, as shown in Fig.2(b), (e) and (h), which certainly reduced the form accuracy of the wheel profile. After truing, the formed arc profile topography was uniform and smooth. Besides, the truing traces could be observed clearly on the metal bonded wheel surface, as shown in Fig.2(c), (f) and (i).

<table>
<thead>
<tr>
<th>Wheel</th>
<th>Expected r</th>
<th>r before truing</th>
<th>r after truing</th>
<th>e, before truing</th>
<th>e, after truing</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3</td>
<td>6 mm</td>
<td>3.093 mm</td>
<td>5.765 mm</td>
<td>35 μm</td>
<td>2.5 μm</td>
</tr>
<tr>
<td>D7</td>
<td>4 mm</td>
<td>3.096 mm</td>
<td>3.867 mm</td>
<td>26 μm</td>
<td>2.8 μm</td>
</tr>
<tr>
<td>D15</td>
<td>4 mm</td>
<td>3.818 mm</td>
<td>4.007 mm</td>
<td>33 μm</td>
<td>3.2 μm</td>
</tr>
</tbody>
</table>
3. Errors analysis and compensation technology

Tool setting error of wheel affect form accuracy seriously, as shown in Fig.3. And tool setting error in X direction can be compensated through grinding workpiece test, on-machine measuring form error profile, calculating error and compensating grinding. Tool setting error in Y direction can be revised through truing of wheel as shown in Fig.1.

Radius error and wear error of wheel may affect form profile as shown in Fig.4, and radius error also can be compensated as tool setting error in X direction, wheel wear error need compensated based on relationship between radius of wheel and grinding ratio in grinding process.

4. Grinding parameters optimization technology

Two classic kinds of grinding points distribution appear on the ground surface because of different parameters, as shown in Fig.5. One kind is remarkable grinding marks with patterned grinding points distribution as shown in Fig.5(a), another kind is the weak grinding marks with homogeneous distribution of grinding points as shown in Fig.5(b).

5. Results

With the errors compensation and optimal grinding parameters, the homogeneous ground surfaces with roughness of Ra<5 nm and high form accuracy of PV≤0.8 μm were finished by the truing wheel, as shown in Fig.6.

6. Conclusion

Through the three key technologies, the ultra-precision large aspheric surfaces can be obtained. This research gives an indication of the strategy to follow to achieve high quality ground aspheric surfaces on brittle materials.

References