What A Significant Work Aspherical Lenses Can Do.

Thin lenses match perfectly with the fancy frames to provide style and function for the short sighted. Excellent images with exquisite details are captured instantly with a wide-angle zooming camera or even a cellphone. Vivid and realistic scenes amaze users in virtual environments. All these seemingly magical achievements are made possible by aspherical lenses. Aspherical lenses already have a huge impact at all aspects of our daily life in the above examples and in many other applications including LiDAR, Head Up Displays, Medical Instruments, 5G Communication, IR Instruments and many more.

What are aspherical lenses?

In 1638, Johann Kepler experimented with aspherical surfaces on lenses, which made it possible to obtain spherical aberration free images in both near and far distances. His efforts gradually laid the foundation of aspherical optics.

An aspherical lens is an optical component whose surface is determined by multinomial higher-order equations and has a different radius at each point on the surface. When the incident light enters the aspherical lens the light will focus on one small point. This characteristic eliminates aberrations to obtain high-quality optical image. The multinomial higher-order equation is given as follows:

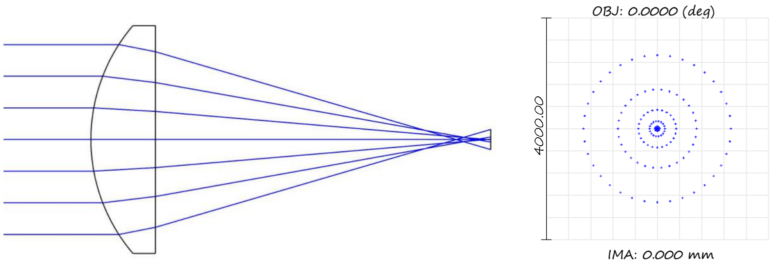
$$Z = \frac{\mathrm{CY}^2}{1 + \sqrt{1 - (1 + \mathrm{k})\mathrm{C}^2\mathrm{Y}^2}} + \mathrm{A}_4\mathrm{Y}^4 + \mathrm{A}_6\mathrm{Y}^6 + \mathrm{A}_8\mathrm{Y}^8 + \mathrm{A}_{10}\mathrm{Y}^{10} + \ldots$$

This equation describes the surface as the deviation from a cone, where:
Z is the verticality of the surface,
Y is the height of the light,
C is the curvature of the surface on the optical axis.
A4, A6, A8... are the 4^{th}, 6^{th}, 8^{th}...aspherical surface coefficient,
k is conic constant.
The relationship between the shape of an aspherical surface and K is as follows:

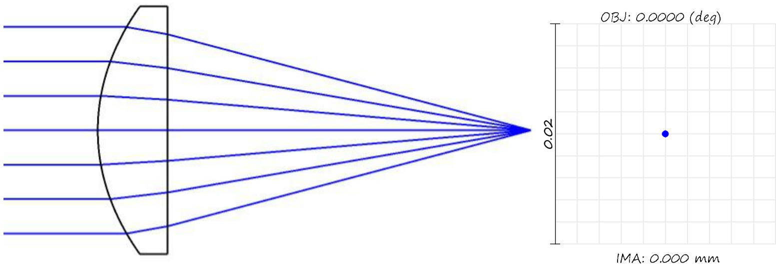
Conic Constant k	Aspherical shape
k=0	spherical surface
k=-1	parabolic surface
k<-1	Hyperbolic surface
-1<k<0	Ellipsoidal surface, the focus is on the optical axis
k>0	Ellipsoidal surface, the focus is on the perpendicular of the optical axis

The difference between aspherical lenses and spherical lenses

Spherical aberration is inherent which cannot be eliminated by a single spherical lens. However, a single aspherical lens can correct spherical aberration, coma, astigmatism, field curvature and other aberrations while reducing the loss of light energy so as to obtain a high-quality image and other outstanding optical properties. Let’s take two comparable lenses with 50mm focal lenth (532nm wavelength) in below figures for example to see the difference in focusing performance between a single spherical lens and aspherical lens.

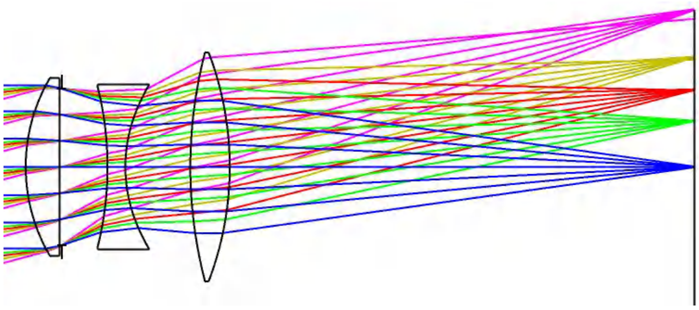


Focusing spot of a spherical lens



Focusing spot of an aspherical lens

From a system design perspective, the aspherical lens has a simpler structure, larger field of view and a higher image quality than the spherical system. Let's look at a Cooke triplet lens design as an example to see the merits of an aspherical lens. As we can see from the image below, the photograph of CASTECH Park, which was also simulated optically in a 30 degree field-of-view designed environment, can be obtained by replacing only the fifth surface of the triplet lens with an aspherical surface, resulting in smaller edge distortion, higher image quality and a more realistic picture.



6 spherical surfaces present blurred image

replacing the 5th surface with aspherical

Aspherical lenses offer great advantages but have been historically difficult to produce. CASTECH has developed precision manufacturing techniques, including CNC Machining and advanced metrology, to produce precision aspherical lenses and acylindrical lenses for many different applications.

CNC machining and measurement technique for aspherical lenses

CASTECH has established an advanced high-precision aspherical CNC (Computer Numerical Control) machining and testing center, with the ability to design, process and test high-precision aspherical lenses and acylindrical lenses applied to laser and other precision optical applications. High precision aspherical lenses and acylindrical lenses are obtained through the repetitive numerical control polishing and non-contact measuring conducted by the program of a CNC machining and testing center. CASTECH offers both standard and customized aspherical products whose diameters range from ф 5 to ф 200mm, surface quality exceeds 20/10 and surface irregularity better than λ /4.

Aspherical lenses

Aspherical CNC machining center

The high-precision measuring equipment is the "eye" of high-precision aspherical lens processing. A Taylor Hobson PGI is used in the fine grinding process, while LUPHOScan 260 non-contact measurement is used in the polishing process. The measurement aperture is up to Φ 260mm, and the accuracy is better than ± 50nm.

PGI optics contact test

LuphoScan 260 non-contact test

Ion Beam Figuring (IBF) for aspherical lenses

CASTECH owns a cutting-edge IBF (Ion Beam Figuring) machining center. With the help of a high-precision non-contact measurement equipment, the aspherical surface irregularity test data is imported into the computer, and the simulation software accurately controls the residence time of the ion beam in a specific area, which can achieve high-performance polishing in a short time. This process can produce an aspherical lens with surface irregularity better than λ / 10.