Lens Design

Development and Design of optical imaging systems

Design of mounting and housing elements

Assistance in prototype constructions

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Tasks and applications

Many optical applications can be realized with standard products. But often the demands on an imaging system are so special that no suitable component can be found. In this case, the user must consider custom development.
Development of optical systems is a multi-step process. It typically consists of the following development steps: lens design, also referred to as optics modeling or "optics calculation," design of housing and mounting elements, and manufacture and test of a prototype.
Our clients can decide to what extent they use our services in this area. We will develop the optimum solution for your imaging task.

Lens Design

Lens design involves the detailed design of the optical imaging system. We have significant experience in the field of optics design. We have planned and designed optics for a broad range of uses. We specialize in the development of custom optical systems. Expert specifications, targeted approaches, and skilled analysis by the lens developer are crucial for the final result. We rely on professional software for all calculations. Precise work necessitates a high degree of technical expertise in parameterization.
Lens design includes not just lenses, but all customary optical elements, such as mirrors, prisms, filters, and apertures. We are able to take thermal specifications into consideration in lens design, such as a large temperature range.
The results are documented in an optical data sheet, which typically includes:

1. the precise position and form of the optical elements
2. the optical materials
3. information about surface treatments
4. manufacturing tolerances for all parameters

The data sheet does not include any description of the mounting or housing elements. But any experienced design engineer should be able to implement the information from the data sheet in a professional optical-mechanical design.

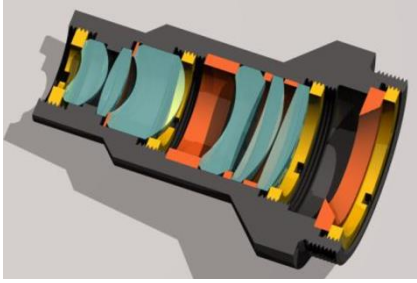

Fig. 2: CAD model of an aplanatic objective for optical data storage

Mount design

If desired, we can assume responsibility for partial or complete mount design and can deliver a shop-ready set of drawings. This includes the drawings of individual parts and their assembly. If desired, we can include installation and adjustment instructions, as well as test procedures. We are also available for consulting should you decide to design the optics yourself.

Prototype construction

We can put you into contact with suitable manufacturers of optical and mechanical components. We prefer to work with companies from the German

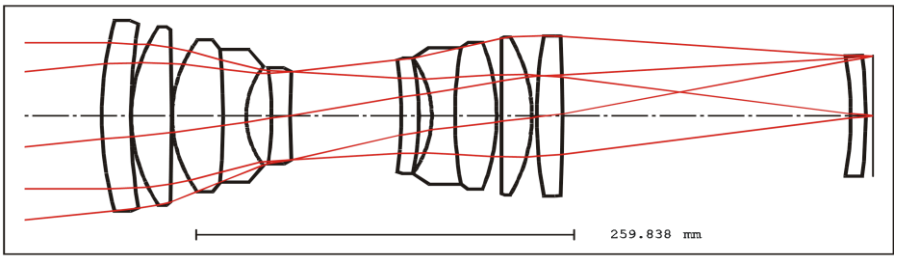

Fig. 1: Longitudinal section and ray path of a high-performance objective for remote sensing of the earth

states of Thuringia and Saxony, where the manufacture of professional optics has a long tradition. We can also coordinate the complete process of prototype manufacture.

Examples

Development of high-performance optics

For a special camera to be used in orbit around the earth, an objective meeting the extreme demands on imaging performance was to be developed. The supplier was to document the physical limits in a study and generate concrete solution recommendations. An optical data sheet resulted that met nearly 100% of the requirements. The longitudinal section of the lens is shown in Fig. 1.
The performance of this lens can be estimated with the help of a variety of diagrams and criteria. A classical criterion is that of transverse ray aberration. Fig. 3 shows the transverse ray aberration for this objective. Depending on the criterion, this objective delivers resolutions of 20,000 – 50,000 pixels across the image diagonal of 100 mm, throughout the entire visual spectrum. The level of distortion is a mere 0.001 %.

Individual optics calculation

In order to achieve ideal imaging performance in practice, specified manufacturing tolerances must be complied with, with respect to for instance surface tilt and deviations in radius and refractive index. It is possible to adjust a lens, but the stability of the material parameters is nonetheless limited. In the case of optical glass, differences between smelts cannot be avoided. These tolerances may be unacceptable in high-performance optics, such as the previous example. The only solution is to individually calculate the optical system for each smelt or even for each glass blank. We can assume responsibility for carrying out this task.

Combined imaging and illumination systems

In certain applications, illumination and imaging must be considered as a single unit. In this case, lens design also includes the development, or at least the consideration, of an illumination system. A typical example of the combination of imaging and illumination is the overhead projector. For a Fraunhofer Institute, an overhead projector was retrofitted for long distance operation. Both the condenser (Fresnel lens pair) and the objective had to be newly developed and then exchanged.

For the scanning lens of a data storage medium, we were also responsible for developing an objective adapted to the illumination laser to be used. The resulting aplanatic objective images the surface of the data storage to the camera with high resolution. The objective components of this system are depicted as a 3D model in Fig. 2

Reference applications

Lens development is founded on the long tradition of optics at the Technical University of Ilmenau, especially that of Heinz Haferkorn, a renowned professor and author in the field of engineering optics. Some development services that have been provided to companies so far are:

Fraunhofer Institute for Building Physics, Stuttgart:
Overhead projector for long-distance projection

highRes GmbH Jena:
Switchable measurement objective

Jena-Optronik GmbH:
Investigation and objective for use in outer space

NICS GmbH Berlin:
Optical system for a novel type of data storage

Physikalisch-Technische Bundesanstalt Braunschweig:
Collimator for a spherical interferometer

Technische Glaswerke Ilmenau GmbH:
Free-form surfaces for special lenses

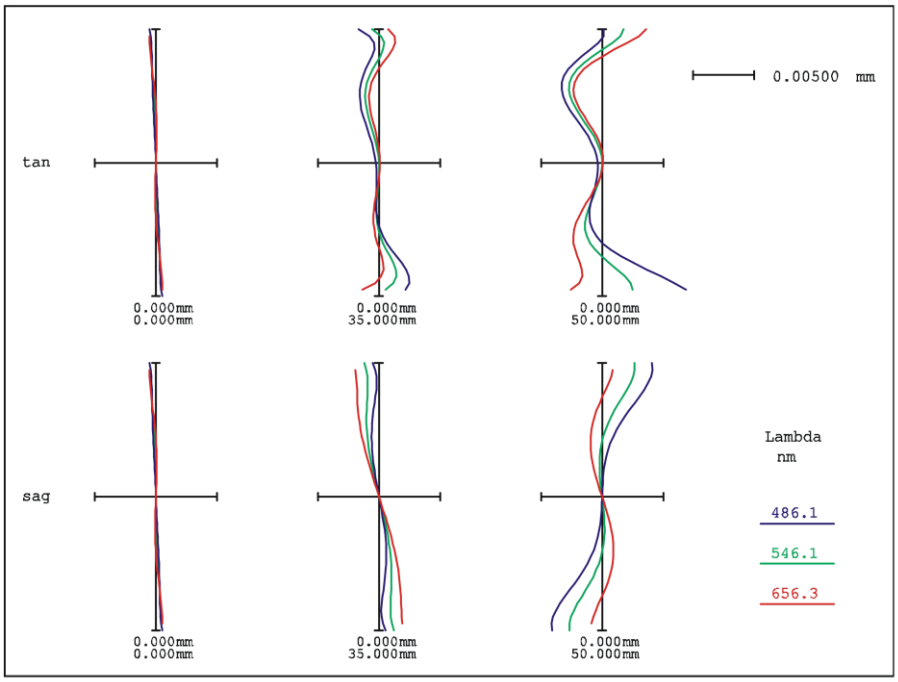

Fig. 3: Diagram of the aberration for the system in Fig. 1