# Unification of microscope objectives in view of the assembly

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**Abstract**

The aspects and results of the unification of microscope objectives, which allowed a rational core design and a model number of the most popular lens microscope objectives, as well as improve the efficiency of their manufacturing, assembly and control. In the unified design is the possibility of automating assembly processes in the production of microscope objectives.

## Introduction

The first after agreeing terms of reference is the optical calculation, which performs the required overall and aberration characteristics of the lens, determines the location of its optical power components, modeled the passage of rays through the system and the process of constructing an image with the desired overall performance and image quality. Optical calculation is the result of the composition of the lens is positioned relative to each other in the microscope objective [1] and determines the initial requirements for the implementation of structural and technological features of the lens when the engineering design of opto-mechanical design, development, production technology of optical and mechanical components, the assembly of individual opto-mechanical assemblies and the microscope objective as a whole.

A comprehensive unification of lens design, which is the unification of their optical and opto-mechanical structures is a prerequisite for the possibility of developing the elements of an automated assembly and certification of microscope objectives.

## Unification of the technical characteristics of objectives

Specifications of all newly developed microscope objectives must be standardized in accordance with the technical regulations that are consistent world producers of this type of technology. In modern microscopes are used microobjectives calculated for an infinite length of the optical tube (with an additional focusing system), and the choice of a number of focal length microscope objectives determines the size of a microscope. Are standardized dimensions and connecting dimensions of lenses for microscopes, especially those on the housing and exterior signs, informational character. The optimal solution would be to ensure interoperability of national objectives with foreign counterparts. This would allow complete domestic lens microscopes of different manufacturers.

## Unification of optical construction of microscope objective

Optical construction of microscope objectives, which represent the results of optical calculations for microscope objectives are usually quite complex, involve several elements - the individual in the form of the meniscus, and two trehskleennyh components. To unify the characteristics of the optical structures may include such parameters as the principal optical scheme, the degree of aberration correction, the optical materials used in optical coatings, adhesives, etc. In addition, the design of any microscope objective can be constructed as a combination, the composition of some basic optical components with known marker and aberration properties. These components can include single meniscus, positive single and dvuskleennye lenses used in the "middle" part of the microscope objectives, and others.

As an example, we give a unified description of the optical design shown in Figure 1, a lens with optical achromatic correction [3]. It is used as the base in several microscope objectives with a different linear increase in manufactured in the present industry. The current dependence of the number n of single positive lens on the input numerical aperture of the $n = 2{,}5A_{ob}$ rounded to the nearest whole number makes it possible to calculate achromatic microscope objectives with different numerical aperture in object space. Thus, for input apertures $A < 0{,}1$ is chosen $n = 0$, i.e. enough to have the adjustable parameters only cemented lens component. To provide input apertures of $0{,}25 < A < 0{,}40$ choose $n = 1$. To provide input apertures $A > 0{,}60 - 0{,}65$ is chosen $n = 2$. To provide input apertures $A > 1{,}25$ chosen $n = 3$. Select the number of lenses of the first component, n = 4 is possible, however, has no practical meaning, since it becomes difficult to calculate the lens with a numerical aperture greater than 1.6.

Universal optical microscope objective design contains two components along the optical axis. The first component 1 is a combination of n positive single lens, and the second component 2 - achromatic lens with one surface of the bonding, the surface bonding of the second component 2 may be facing concavity as a space of objects and the space images. In addition, the variable distance from the second component is the material the diaphragm 3.

## Unification of opto-mechanical structures

Unification of structures and mechanical parts microscope objectives aimed at reducing the range of parts, specialized equipment and tooling, the widespread use of well-established model of technological processes of manufacturing parts and assemble them into a single optical-mechanical design of the lens.

We have developed the basic model of optical-mechanical design of a micro it possible to realize the possibility of a very large number of different lens options, using a limited number of mechanical parts in accordance with the selected parametric series of their size. This, in turn, allowed for the unification of parts of the configuration, size and shape, as well as providing the ability to automate their assembly and alignment.

Figure 2 presents a model of a micro base, which used a complex unification of lens design. On the links given standardized basic mechanical parts.

On the basis of this unified structure is implemented range from six modified parametric series of mechanical parts lenses stigmachromats (FSS), which allows for a typical assembly process more than 350 options for different microscope objectives. The level of the Unification is characterized by the coefficient of applicability of mechanical parts, ranging from 65 to 100%.

## "Virtual quality" of microobjective

The idea of "virtual quality" [5], its natural element "virtual assembly" can be regarded as an effective tool in the appointment and to optimize the values of tolerance in the scheme of the lens to determine in the opto-mechanical design of the value of the adjustable air-gap (in the complex lenses, there may be two), as well abandon the "rolling" perpendicular to the optical axis of the component [6]. Furthermore, the use of "virtual quality" made it possible to study the complex effects of deviations from the calculated structural parameters of nodes, components of a micro together and each of them separately - on the resulting image quality.

In a "virtual assembly" should be measured practically all of the real value of parts and components intended for further assembly of the whole lot microscope objectives, identify their errors and creating a database for further calculations in the "virtual money" them ready parts and assemblies.

## Automation of assembly processes

Automation and assembly processes to ensure quality targets microscope objectives (image quality, height, and "centering") is based on adaptive selection of components and assembly processes based on a "virtual" assembly model. Specific features of this automation is the difficulty caused by strict accuracy parameters of lenses and mechanical parts, their combination with the arrangement in a single design.

The problem of automating the assembly microscope objectives is complex, as a result of it you want to achieve in the real manufacturer lens "diffraction-limited" image quality, which is estimated shares of the operating wavelength. It is assumed that not only the automation of assembly microscope objectives, but also the automation of quality assessment, and if the realizable "in theory", in practice not possible.

Practical implementation of integrated automation assembly microscope objectives have not yet been reached. But a theoretical and applied research, develop options for the solution [7].

Using the technique of adaptive-selective assembly (ACC), which became the next step in finding a rational methodology, consistent with the concept of group lens assembly has been adapted to all stages of production of microscope objectives from the design of optical systems to certification of finished products. At the stage of the optical calculation, for example, the use of the ACC is not possible to eliminate the full compliance of the optical calculation of the real location of the knots of the assembled microscope objective.

Lens objective must meet a number of requirements for technical parameters, reliability, minimize size and others, but key indicators of the quality of the collected micro-objective is aberration produced by the image quality, ensuring the height and alignment (centrality) of its optical and mechanical axes.

## Structures of microscope objectives with the elements of build automation

Creating designs to automate part or all of the assembly process and control microscope objectives, is a very complex engineering problems, are currently under investigation to determine the effectiveness of several engineering solutions.

The idea of unification of frontal components microscope objectives (on the basis of performance in these conditions fix neizoplanatizma) at the time of the optical method of calculation and automation of control [8] may be useful for implementing elements of the automation production of "simple" achromatic lenses for large-scale production.

Success in achieving the automation of assembly and quality control also depends on the level of the elemental base of systems engineering and microelectronics products, which currently does not fully meet the criteria defined by the complex optical systems.

The basic principle of the elements of the automated systems is the projection of images chosen as a reference, the test object to the receiver of the optical image for further research. According to the survey (using specialized algorithms), information on the performance of alignment operations in collected microscope objective as a whole or its individual node is transmitted elements used in automated robotic systems.

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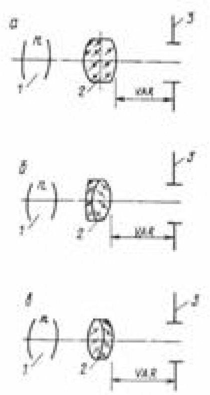

Figure 1. Unified description of the optical design

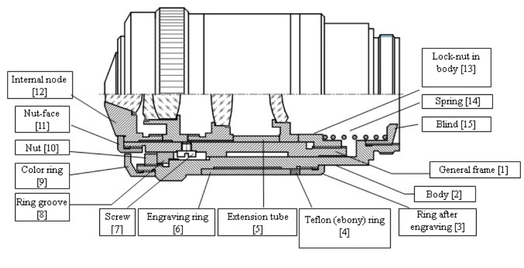


Figure 2. Model with complex unification of lens design