CALIBRATION OF THE LIGHT MICROSCOPE

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ABSTRACT
Metallic materials thanks to the excellent combination of data on material properties are obtained by standardized and agreed testing of samples made from semi-finished or finished products. Metallic materials can be tested by different testing techniques. One of them is metallographic testing, for which a light microscope is used as a basic device. In order for the test workability and strength are very important construction materials. The most complete and most accessible group of results to the light microscope were reliable it is necessary to calibrate the microscope according to certain standards and guidelines, and by the national metrology standards.
This paper describes the procedure for calibration of the light microscope at the Metallographic Laboratory at the Institute "Kemal Kapetanović" in Zenica, University of Zenica.

1. INTRODUCTION

Metallic materials, thanks to the excellent combination of workability and strength, are a very important construction material. The most complete and accessible set of data on material properties was obtained by standardized and agreed tests of samples made of semi-finished or finished products [1].

2. MICROSCOPE

The metallographer's most important tool is the metallurgical microscope.
Each metallographic laboratory has at least one metallurgical microscope for observing microstructures.
The term "microscope" is derived from the greek words mikros (small) and skopein (see). Giovanni Faber, a roman scientist, combined the words and gave them the latin form in 1625. In the mid 1600s, Anthony Van Leewenhoek, Dutch scientist amateur, was the first who observed microscopic life in a little water and is called the father of the microscope [2].
Although the microscope was used for more than 300 years, only in the last part of the 19th century microscope was first used for the observation of metal.
Henry Clifton Sorby, the father of metallography, used a microscope to observe a polished and etched sample.

Figure 1 shows the main parts of the microscope:

1. Switch
2. Halogen bulb
3. Light intensity control knob
4. Stand
5. Coarse and fine adjustment screws
6. Revolver with lenses
7. 35 mm camera
8. Polaroid camera
9. Control unit

Figure 1. Optical microscope

The optical system mainly consists of a lens (a set of lenses near an object or a sample) and an eyepiece (a set of lenses near the eye). They are called a set of lenses, because each lens and eyepiece contain more than one element of the lens, ie. these are complex lenses.

2.1 Lens

The lens, figure 2, is the most important component of the optical system, because it defines the quality of the magnified image. The lens of objectives controls six important properties of the optical system of a microscope. They are: magnification, numerical aperture, power of resolution, depth of field, working distance and ability to capture light [2].


Figure 2. Lenses

The final magnification of a microscope is usually the magnification of the objective times the magnification of the eyepiece. For example, a 100 x magnification of the objective times a 10x magnification of the eyepiece gives a total magnification of 1000x.

For convenience, most of a metallurgical microscope in the rotating lens is mounted with three or more objectives (different magnification).

2.2 Eyepieces
Metallurgical microscope eyepieces are not as complex as objectives. The figure of the eyepiece is given in figure 3. The function of the eyepiece is to increase the image obtained by the objective. Eyepieces are also made with different magnifications, which are imprinted on the top ring of the eyepiece.

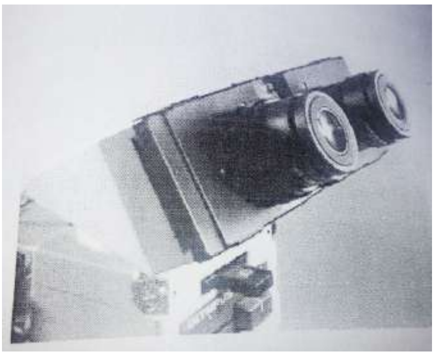


Figure 3. Eyepieces

Measuring eyepieces. Some eyepieces contain special measuring scales called reticles (or graticule). When viewed through an eyepiece, these scales are imprinted on the sample image. The body of the eyepiece will rotate to the scale set in the same focus and field of view. An eyepiece with a graduated linear scale is usually used. The reticle scale is important when measuring the length or diameter of grain size. These scales must be calibrated with a stand micrometer [2]. The figure of eyepiece micrometer scale is given in figure 4.

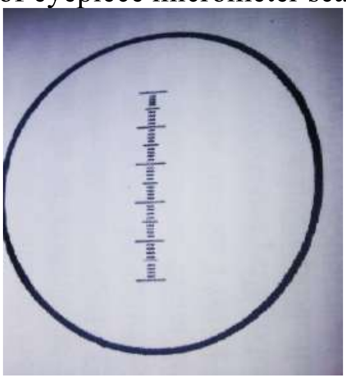
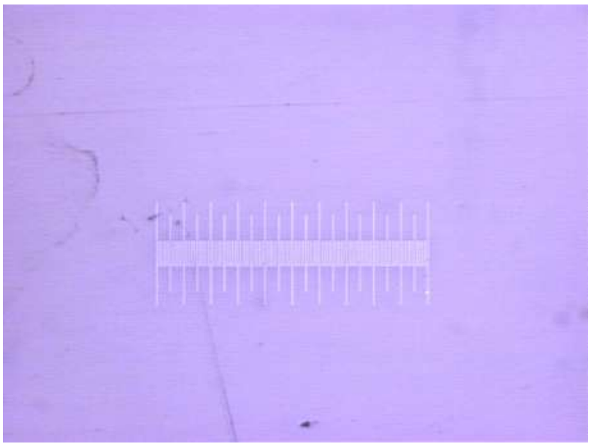
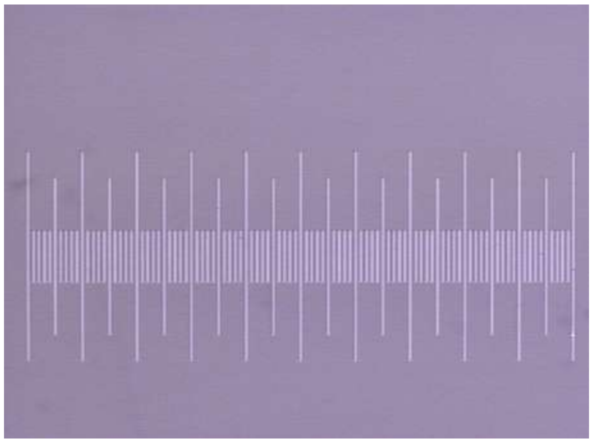


Figure 4. Eyepiece scale

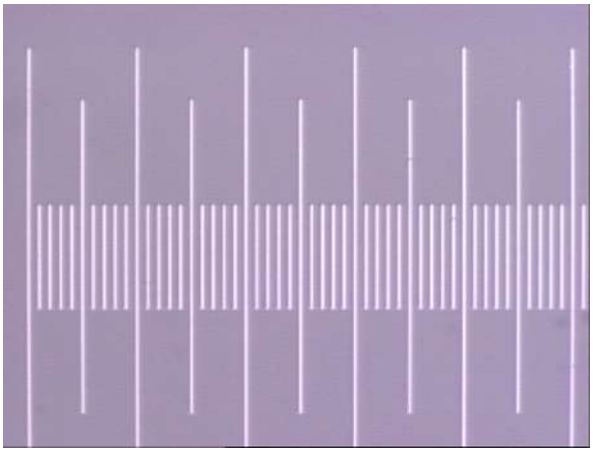
2.3 Micrometer Stand
The micrometer stand is a glass or metal plate on which the calibration scale is precisely engraved. An example of the appearance of a micrometer stand is shown in figure 5 a plate is placed on the microscope stand and used to calibrate the magnification of the microscope through the lens and eyepiece of the microscope.



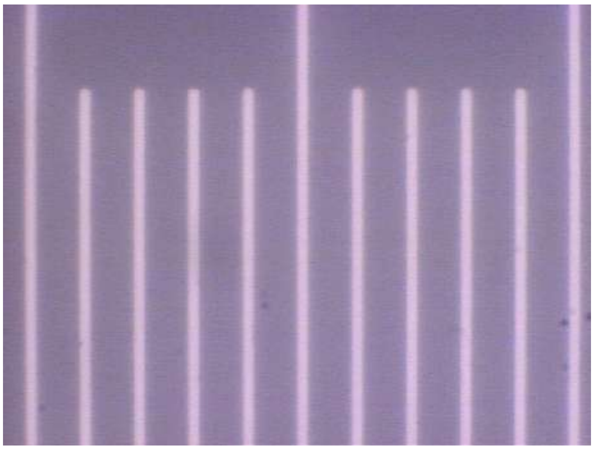
Objective x2.5 - magnification in the figure x 37.5



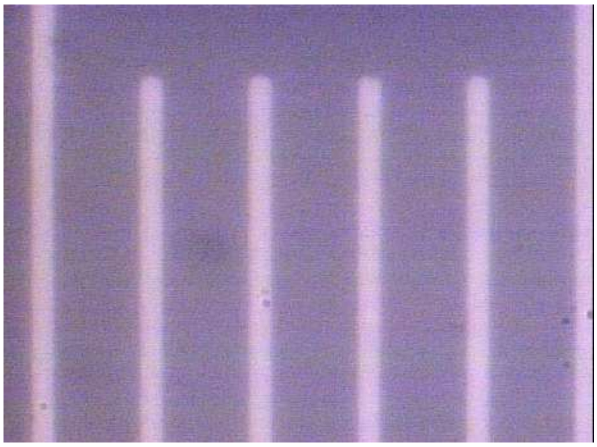
Objective x 5 - magnification in the figure x 75



Objective x 10 - magnification in the figure x 150



Objective x 50 - magnification in the figure x 750



Objective x 100 - magnification in the figure x 1500

Figure 5. Micrometer scale at various magnifications, on paper

3. CALIBRATION

Calibration: A set of activities that in certain conditions establish the relationship between the values shown by the measuring instrument or measuring system and the corresponding values realized by the etalons [1].

Etalon: A material measure, measuring instrument, reference material or measuring system intended to define, realize, store or reproduce a unit or one or more values of one quantity, to transfer it to another measuring instrument by comparison.

International etalon: A etalon recognized by an international agreement for international application as a basis for determining the value of all other standards of appropriate size.

3.1 Eyepiece reticle scale calibration procedure

Many times a metallographer will need to make measurements of microstructural elements using a reticular eyepiece with a linear scale. Before such a measurement, the scale must be precisely calibrated. This is done using a calibrated stand micrometer in combination with an eyepiece reticle. The procedure is as follows [2]:

Step 1: Place the micrometer on the microscope stand. The micrometer consists of a graduated scale with small divisions incised on the plate. To ensure accuracy, the stand micrometer must be calibrated to a national (international) etalon.

Step 2: Place the eyepiece with the reticle in one of the binocular openings. The eyepiece micrometer has a reticle with a linear scale, similar to the scale on the stand micrometer shown in figure 5.

Step 3: Focus on the micrometer of the stand using the lowest magnification objective. Rotate higher magnification objective if necessary.

Step 4: Set a micrometer image of the stand to match the eyepiece reticle. Figure 6 shows an example of a micrometer image (scale to the left) and reticle (scale in the middle of the field of view). Align two scales until they are parallel, as shown in Figure 6 and align the "0" both micrometer scale as shown. On this micrometer stand, the small division is 0.1 mm.

Step 5: As shown in the figure, count the divisions on the micrometer scale of the stand so that they correspond to 100 divisions on the scale of the eyepiece reticle. In this example, 100 divisions of the eyepiece scale are equal to 122 divisions on the micrometer scale of the stand.

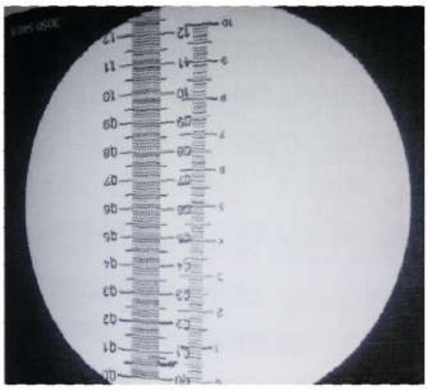


Figure 6. Eyepiece scale relative to the micrometer scale

Step 6: Repeat steps 3 and 4 for each objective

Step 7: Prepare the eyepiece scale calibration table (Table 1)

4. CALIBRATION OF OLYMPUS PMG3 MICROSCOPE IN METALOGRAPHIC LABORATORY OF THE INSTITUTE

Calibration of the Olympus PMG3 microscope is performed using a calibrated object micrometer OB-M 1/100 (Olympus PMG3) and an eyepiece (x 7.5) with a calibrated scale [3].

Regular calibration of the microscope is performed once a year, and obligatorily after the return of the scale from the calibration in an accredited laboratory.

Extraordinary calibration of the microscope can be done, if necessary, especially at any magnification.

Calibration of the magnification on the microscope

Calibration is performed according to ASTM E 1951, point 5.4. According to ASTM E 1951, clause 5.1.2, the total magnification in Mt is given by the equation:

$$Mt = MoxMexMi$$

M_o – objective magnification
M_e – eyepiece magnification
M_i – zoom on microscope

Calibration of total magnification X100

Calibrated object micrometer OB M 1/100 placed on a stand microscope. Set the ~~lens~~ objective with a magnification x10 and eyepiece with a calibrated measuring scale. Sharpen the micrometer image in the eyepiece. Set the ZOOM to 1.33 and align the lines in the eyepiece and on the scale of the micrometer object on the length of the first ten divisions.

In this way it was confirmed that the magnification in the eyepiece:

$$Mt = 1{,}33x7{,}5x10 \approx 100$$

Calibration of total magnification x75

Calibrated object micrometer OB M 1/100 placed on a stand microscope. Set the lens with a magnification x10 and eyepiece with a calibrated measuring scale. Sharpen the micrometer image in the eyepiece. Set the ZOOM to 1 and align the lines in the eyepiece and on the scale of the micrometer object on the length of the first ten divisions.

In this way it was confirmed that the magnification in the eyepiece:

$$Mt = 1x7{,}5x10 = 75$$

Calibration of other magnifications

Repeat the procedure for each objevtive x2.5, x5, x10, x50 and x100 and each magnification of the zoom system x1, x1.33, x1.6 and x2.

The record of the regular calibration of the microscope is entered in table 1.

Table 1. Eyepiece calibration table using a micrometer

Lens	Zoom	Calibration	Length of division on the eyepiece scale
x 2,5	1	(1mm/19)(1000μm/1mm)	52,6 μm/podjeli (division)
	1,33	(1mm/25)(1000μm/1mm)	40,0 μm/podjeli (division)
	1,6	(1mm/31)(1000μm/1mm)	32,3 μm/podjeli (division)
	2	(1mm/37)(1000μm/1mm)	27,0 μm/podjeli (division)
x 5	1	(1mm/38)(1000μm/1mm)	26,3 μm/podjeli (division)
	1,33	(1mm/55)(1000μm/1mm)	18,2 μm/podjeli (division)
	1,6	(1mm/63)(1000μm/1mm)	15,8 μm/podjeli (division)
	2	(1mm/75)(1000μm/1mm)	13,3 μm/podjeli (division)
x 10	1	(1mm/75)(1000μm/1mm)	13,3 μm/podjeli (division)
	1,33	(0,98mm/100)(1000μm/1mm)	9,8 μm/podjeli (division)
	1,6	(0,80mm/87)(1000μm/1mm)	9,2 μm/podjeli (division)
	2	(0,60mm/90)(1000μm/1mm)	6,7 μm/podjeli (division)
x 50	1	(0,19mm/72)(1000μm/1mm)	2,6 μm/podjeli (division)
	1,33	(0,15mm/72)(1000μm/1mm)	2,1 μm/podjeli (division)
	1,6	(0,15mm/84)(1000μm/1mm)	1,8 μm/podjeli (division)
	2	(0,10mm/75)(1000μm/1mm)	1,3 μm/podjeli (division)
x 100	1	(0,1mm/75)(1000μm/1mm)	1,3 μm/podjeli (division)
	1,33	(0,05mm/52)(1000μm/1mm)	0,9 μm/podjeli (division)
	1,6	(0,05mm/62)(1000μm/1mm)	0,8 μm/podjeli (division)
	2	(0,05mm/75)(1000μm/1mm)	0,6 μm/podjeli (division)

Calibration of the eyepiece with a measuring scale, obtained as: **(Length on calibrated micrometer (mm) / number of divisions on eyepiece)(1000μm/1mm)**

5. CONCLUSION

Confidence in the measurement result can only be achieved by achieving traceability to the primary etalon. Therefore, the calibration and testing of measuring equipment should be in accordance with national metrological standards. In all steps, a standard calibration is carried out, whose quality metrology calibration etalons are already fixed at higher level metrology [1].

Ensuring traceability is achieved by calibrating measuring equipment and calibration equipment in laboratories that can prove their traceability and competence. Such laboratories must have a defined system for the calibration of complete equipment to be calibrated and implement an equipment calibration plan to ensure traceability of measurements to the international etalon.

So, all equipment used for testing and / or calibration as well as accessories for extra measurements which has a significant impact on the accuracy of the test results and calibration should be calibrated before use.

6. REFERENCE

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