Evaluation of the Quality of the Photographic Process at the Components Dimensions Measurement

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Abstract: *The trend of recent developments is photographic technology gained considerable momentum. This is also caused by constant progress of new technologies for still image recording, in which we often lose the overview. The work was aimed to characterize these technologies and create a general overview of photographic technology and sensitive elements. Consequently use the photographic technology Canon EOS 5D mark II with lens Canon 100 mm USM f 2.8 Macro to measurement parameters of components. We chose to measure the outer and inner diameter of bearing. In the last parts of the thesis, we evaluated competencies to use this process in comparing with commercial process of measurement parameters of components. We found, that the measuring with photography technology is a suitable method with process automation for measuring of technical components.*

Keywords: *camera, CCD, CMOS, diameter, measurement, sensor*

INTRODUCTION

The exploitation of photographic technology has recently still gets into new areas. Innovative solutions enable photographic technology used with special accessories in the field of engineering and manufacturing industry itself.

A camera is an optical instrument that records images that can be stored directly, transmitted to another location, or both. These images may be still photographs or moving images such as videos or movies. The term camera comes from the word camera obscura (Latin for "dark chamber"), an early mechanism for projecting images. The modern camera evolved from the camera obscura. The functioning of the camera is very similar to the functioning of the human eye [4, 10, 12].

This thesis aims to elucidate the possible use of photographic technology to measure the dimensions of the selected technological components, the bearing. Photography technology was used as a means of measuring the dimensions of components. The information from these measurements was processed and evaluated using computer software Google SketchUp. Subsequent comparison of measurement methods with conventional methods it was possible to propose the use of this process in technical industry.

MATERIAL AND METHODS

The experiment was used Canon EOS 5D Mark II. The camera has a wide engagement CMOS sensor the size (36x24 mm). Camera EOS 5D Mark II offers ISO sensitivity range up to ISO 6400 for handheld shooting in low light. The EOS 5D Mark II offers continuous shooting speeds up to 3.9 frames per second. We used also professional lens Canon 100mm f/ 2.8 Macro USM. This lens is suitable for the manufacture of close-up shots, so macro images with magnification 1: 1 [4, 10, 11].

Basic technical characteristics of the device:

- Effective Pixels: approximately 21.1 [Million Pixels]
- Shutter Speed: 30-1/8000 [s]
- Coverage: Approximately 98 [%]
- Dimensions (W x H x D): 152 x 113.5 x 75 [mm]
- Weight: 810 [g]
- Minimum aperture: 32
- The minimum focusing distance: 0.3 [m] [1, 2]

We decided to measure the selected dimensions (inner and outer diameter) of roller bearing 32024X. The bearing consists of inner ring, rolling elements (cones), cage and outer ring (usually is inserted into the gear housing) [3, 5].

The basic characteristics of the bearing:

- Outer diameter D = 180.00 [mm]
- Inner diameter d = 120.00 [mm]
- The overall width of the bearing T = 38 [mm] [5, 12]

The principle of measurement was shoot the image with the selected photographic technology and subsequent prepare shots to computer software Google SketchUp. For differentiation measurements, we selected two basic criterias: change shutter speed (exposure time) and aperture. Shutter speed, aperture and ISO sensitivity form together exposure triangle, which manipulates with light on the camera's sensor and the resulting picture. We chose exposure time of 1/30s-1/250s and aperture values (minimal number was f2.8) of f4.0-f11.0 (aperture numbers).

The main magnitude that have been observed during the photographic process:

1. Focal Length - 100 [cm]
2. The distance from the camera to the component - 60 [cm]
3. ISO sensitivity – 800 [6]

We shot 10 shots (pictures) in one selected photographic characteristics. The following figure (Fig. 1) shows the workplace layout, where we measured the dimensions of selected components.

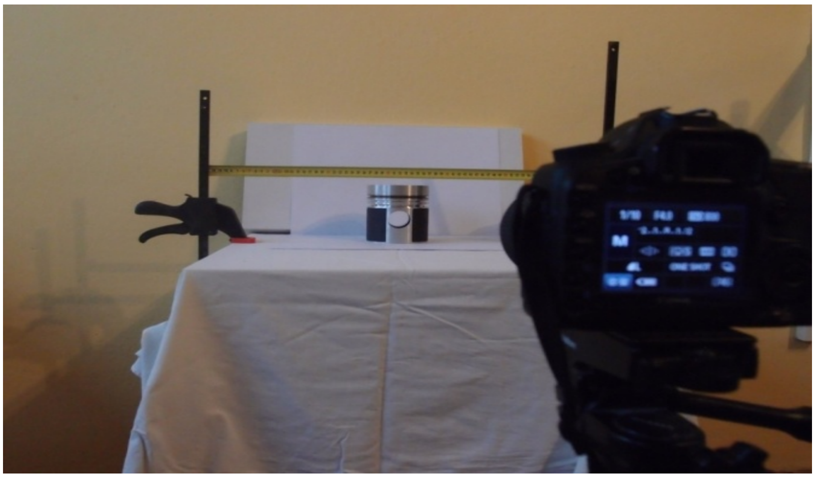

Fig. 1 Workplace Layout

We used software Google SketchUp for photo processing. The following figure (Fig. 2) shows the environment of Google SketchUp.

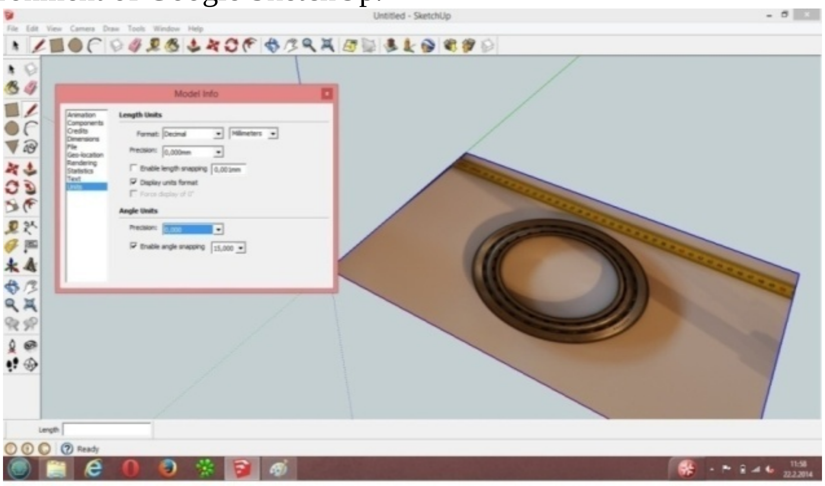

Fig. 2 Software environment

RESULTS AND DISCUSSION

The result of processing 40 pieces of photos was information about the comparison of accuracy, quality and the ability to accurately record the dimensions of selected components. We have achieved the opportunity to evaluate the measurement results. The following figures (Fig. 3 - Fig. 4) show, the variation in the quality and intensity of light reaching the camera sensor.

Fig. 3-4 Effect of aperture value to photo quality

We construct tables to clear the processing of the measured values and the interpretation of measurement results (Table 1- Table 4). For a benchmark measurement accuracy, we selected the length of average value measurements (10 measurements) from the tabulated value measurement. Consequently, was possible to compare the accuracy of the measurement with photography technology to measurement using classical calipers as representative measurement methods in a conventional manner.

Table 1 The measured inner diameter of bearing

Number of measurements	Aperture	Exposure time [s]	Canon 5D mkII + 100mm	Caliper	Tabular value
1	4,0	0,10	120,08	119,20	120,00
2	4,5	0,10	120,12	120,00	120,00
3	5,0	0,10	120,09	119,60	120,00
4	5,6	0,10	119,96	119,40	120,00
5	6,3	0,10	120,14	119,60	120,00
6	7,1	0,10	120,19	120,20	120,00
7	8,0	0,10	120,22	120,00	120,00
8	9,0	0,10	120,13	119,80	120,00
9	10,0	0,10	120,15	119,60	120,00
10	11,0	0,10	120,26	120,10	120,00
$\bar{x}$			120,134	119,750	120,00

From the measured results (Table 1) show, that the Canon EOS 5D Mark II has reached the difference between the table value and the measured value of 0.110%. The accuracy of measurement (aperture numbers of f 4.0-11) was varied minimal during the entire spectrum measurements. We found out that with increasing of aperture number is increasing the depth of field.

Table 2 The measured external diameter of bearing

Number of measurements	**Aperture**	**Exposure time [s]**	**Canon 5D mkII + 100mm**	**Caliper**	**Tabular value**
1	4.0	0.10	180.09	180.02	180.00
2	4.5	0.10	180.06	180.04	180.00
3	5.0	0.10	180.06	179.96	180.00
4	5.6	0.10	180.12	180.02	180.00
5	6.3	0.10	180.13	180.06	180.00
6	7.1	0.10	180.16	179.64	180.00
7	8.0	0.10	180.19	180.04	180.00
8	9.0	0.10	180.21	180.04	180.00
9	10.0	0.10	180.18	179.94	180.00
10	11.0	0.10	180.21	180.02	180.00
$\overline{x}$			180.141	179.918	180.00

When we measured the outer diameter, the conditions for spreading the aperture were identical. Subsequent treatment, we found that the difference between the table value and the measured value is 0.070%.

On the next course, we did not affect the measurement results by changing the aperture numbers, but we changed the exposure time (shutter speed) as another important factor that affects photos exposure (Table 3 - Table 4).

Table 3 The measured inner diameter of bearing

Number of measurements	**Aperture**	**Exposure time [s]**	**Canon 5D mkII + 100mm**	**Caliper**	**Tabular value**
1	4.0	0.0330	120.06	119.20	120.00
2	4.0	0.0250	120.09	120.00	120.00
3	4.0	0.0200	119.96	119.60	120.00
4	4.0	0.0170	120.14	119.40	120.00
5	4.0	0.0125	120.16	119.60	120.00
6	4.0	0.0100	120.15	120.20	120.00
7	4.0	0.0080	120.19	120.00	120.00
8	4.0	0.0063	120.12	119.80	120.00
9	4.0	0.0050	120.20	119.60	120.00
10	4.0	0.0040	120.21	120.10	120.00
$\overline{x}$			120.128	119.750	120.00

Based on the processing dimensions, we found that the difference between the table value and the measured value is 0.107%. We also found, that the value of the exposure time, although affected the quality of the picture, but not so much, that the accuracy was significantly affected.

Table 4 The measured external diameter of bearing

Number of measurements	**Aperture**	**Exposure time [s]**	**Canon 5D mkII + 100mm**	**Caliper**	**Tabular value**
1	4.0	0.0330	180.02	180.04	180.00
2	4.0	0.0250	180.00	180.06	180.00
3	4.0	0.0200	180.06	179.94	180.00
4	4.0	0.0170	180.11	179.92	180.00
5	4.0	0.0125	180.03	180.06	180.00
6	4.0	0.0100	179.96	180.06	180.00
7	4.0	0.0080	180.04	180.04	180.00
8	4.0	0.0063	180.12	180.06	180.00
9	4.0	0.0050	180.09	180.06	180.00
10	4.0	0.0040	180.23	180.40	180.00
$\bar{x}$			180.066	180,064	180.00

During the measurement, the outside diameter of the bearing, we again came to the fact, that the difference between the table value and the measured value using the Canon 5D Mark II was 0.037%. The following table (Table 5) and graph (Fig. 5) represent the percentage difference the averaged values. This table and graph also show graphically, with how accurate (in %) were measured and evaluated measurement results.

Table 5 - Percentage difference between averaged values and the tabulated values (change a parameter aperture)

Measured dimension	**Canon 5D mkII + 100mm**	**Caliper**	**Tabular value, [mm]**
Inner diameter of the bearing	0.114%	0.625%	120.00
Outer diameter of the bearing	0.081%	0.510%	180.00

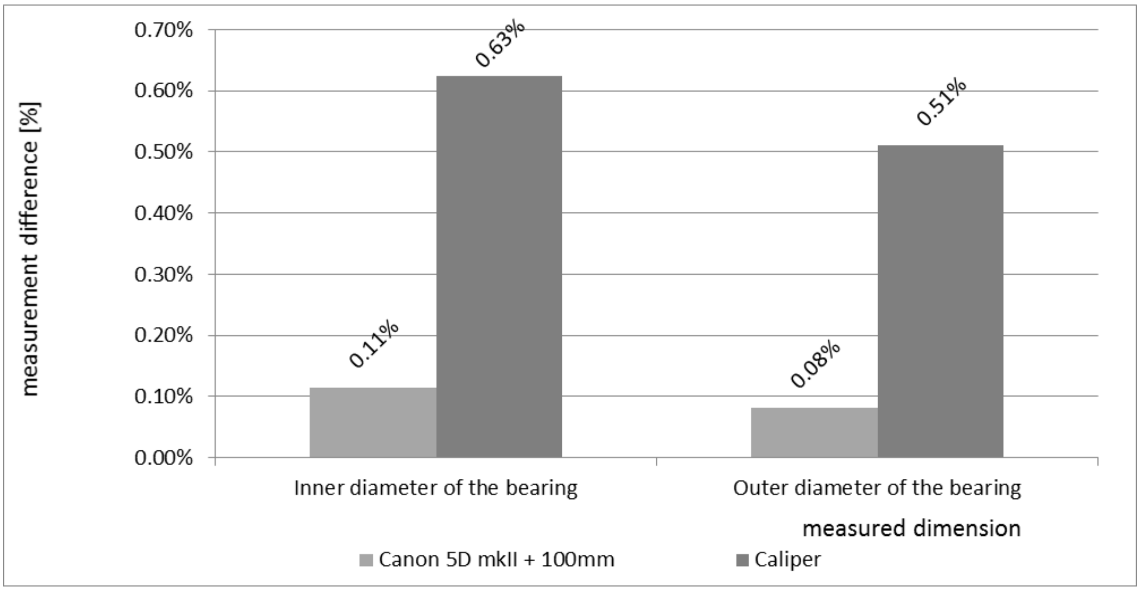

Fig. 5 Percentage difference between averaged values and the tabulated values (change a parameter aperture)

The following table (Table 6) and graph (Fig. 6) clearly represent the percentage difference of measured averages and differences in the accuracy of measurements using calipers to the table values.

Table 6 Percentage difference between averaged values and the tabulated values (change a exposure time)

Measured dimension	Canon 5D mkII + 100mm	Caliper	Tabular value, [mm]
Inner diameter of the bearing	0.107%	0.625%	120.00
Outer diameter of the bearing	0.037%	0.036%	180.00

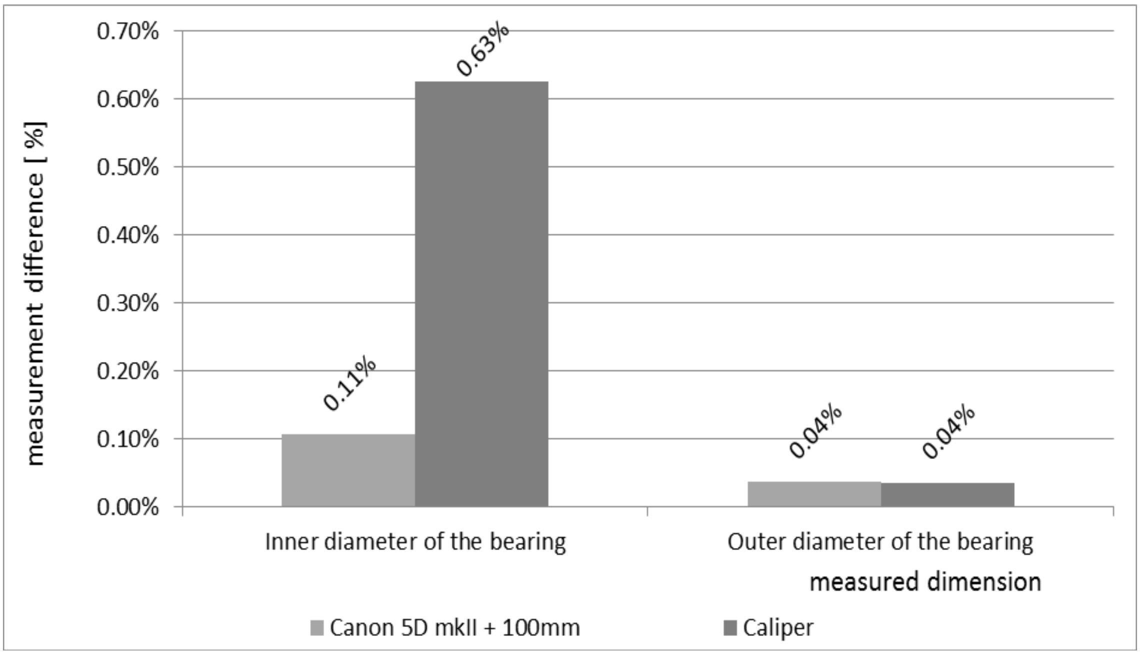

Fig. 6 Percentage difference between averaged values and the tabulated values (change a exposure time)

Caliper achieved consistent results in measurement accuracy. Measuring with a Canon 5D Mark II is comparable with a caliper measurement, in some areas. The results achieved by the camera was more accurately, what is shown on constructed tables and graphs. Based on the results, we can state, that measuring dimensions using photographic technology as a competitive method for the measurement of current methods of measuring for example using calipers. These results can be further clarified by automating the process, then we can use this method in a wide field of measurement of dimensions of components in engineering industry. The results of this thesis can be used as an alternative to the traditional dimensional measurement of different components in the technological area. The thesis provides a theoretical basis for shooting and processing the dimensions for the selected engineering components. The greater use of the method, it is necessary to automate the measurement process.

CONCLUSION

This thesis dealt with the use of photographic technology to measure the dimensions of selected machine components. The main aim of this thesis was to use photographic techniques to measure the dimensions of the selected machine components and then these data prepare to software Google SketchUp. We selected components used in the engineering field, as sample measurements. We decided use the change the aperture number and exposure to achieve the measurement diversity and map out which characteristics affect the measurement accuracy. We subsequently processed shooted photos using computer software Google SketchUp, which provided us useful background to transparent photographic processing and acquirement of the real dimensions of the components. After processing this information, we evaluated the measurement results with respect to the criterias. Then we met another aim of this thesis, compare this method of measuring the dimensions of the conventional measurement method using calipers and graphically visualize conduct of the photographic process. From this, it follows that the method of measurement of dimensions using photographic technology is competitive in terms of accuracy of the method to conventional methods measuring dimensions represented for example. Measurement method using calipers. Other applications of this method of measurement of dimensions can be extended to use in the mass production of machine components with automation this process.

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