CAD - based indirect dimensional measurement method

Mircea Teodor Pop[1] and Gabriela Georgeta Nichita[2]

[1, 2] University of Oradea, Faculty of Management and Technological Engineering,
1 Universității Street, Oradea, Romania
popmt@uoradea.ro[1] , gnichita@uoradea.ro[2]

Abstract. Quality control is an important step in the validation of the production process. An important role of the process is determining the dimensions for the various components of the part. The universal measuring tools are not always suitable. In case we do not have any specialized measuring tools, a potential solution would be to find an indirect method of measurement that can involve, for example, the use of a CAD program, which enables the user to import "objects" or images in different file formats and to process the images with the purpose of measuring dimensions. The solution presented in the paper consists in acquiring the image of a part in the position required by the size to be measured and inserting the file for processing in the Autodesk Inventor program with an educational license, in order to measure the dimensions with the "Measure" tool.

1. Introduction

The structure of the products involves the existence and assembly of the various component parts, some standardized, others made using basic manufacturing processes in such way that for a proper assembly and to fulfill their functional role, these components must comply with the requirements of the execution documentation.

Their validation is ensured by quality control, which thus plays an important role, as these components provide measurements that validate the parts in terms of dimension (matching the dimensions within the permissible limits established by the designers), shape and position deviations, surface quality and other conditions expected to be met.

2. Methods and tools for measuring dimensions

Dimensions can be determined by measuring with universal instruments (as shown in figure 1), such as calipers, micrometers or with specialized instruments such as various types of gauges, calipers, etc.

This is the direct measurement method. Sometimes it is useful to determine size by checking certain dimensions of the parts such as: thread pitch, diameters of shafts and holes. In such situations, there are used means of verification such as threaded plug gauge, gauges for checking shafts, gauges for checking holes - gauge buffer.

Figure 1. Universal tools for measuring dimensions.[3]

There are some dimensions which cannot be measured by means of universal measuring instruments, such as:

- **thread pitches**, shown as an example for the piece in figure 2.

Figure 2. Example of a part with an external thread.

- **very small holes**, shown as an example for the piece in figure 3.

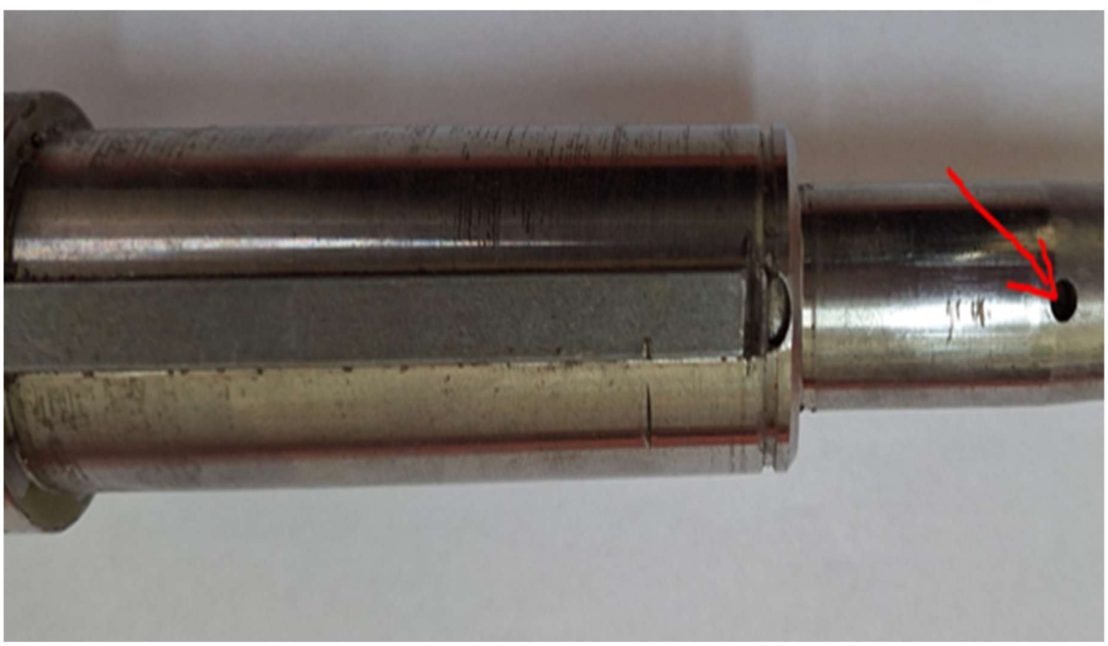

Figure 3. Example of a part with a very small hole.

- **different inclinations of cylindrical surfaces.**

An example of a part with an inclination on the cylindrical surface is illustrated in figure 4.

Figure 4. Sample of a part with an inclination on the cylindrical surface.

In case we do not have any specialized measuring tools, a solution would be to find a CAD-based indirect measurement method, which enables the user to import "objects" (computer files of various picture formats) and to process the images with the purpose of measuring dimensions with the "Measure" tool.

One of the CAD programs which facilitate the import of images in different file formats is Autodesk Inventor Professional. The window for creating an Inventor file is illustrated in the figure 5.

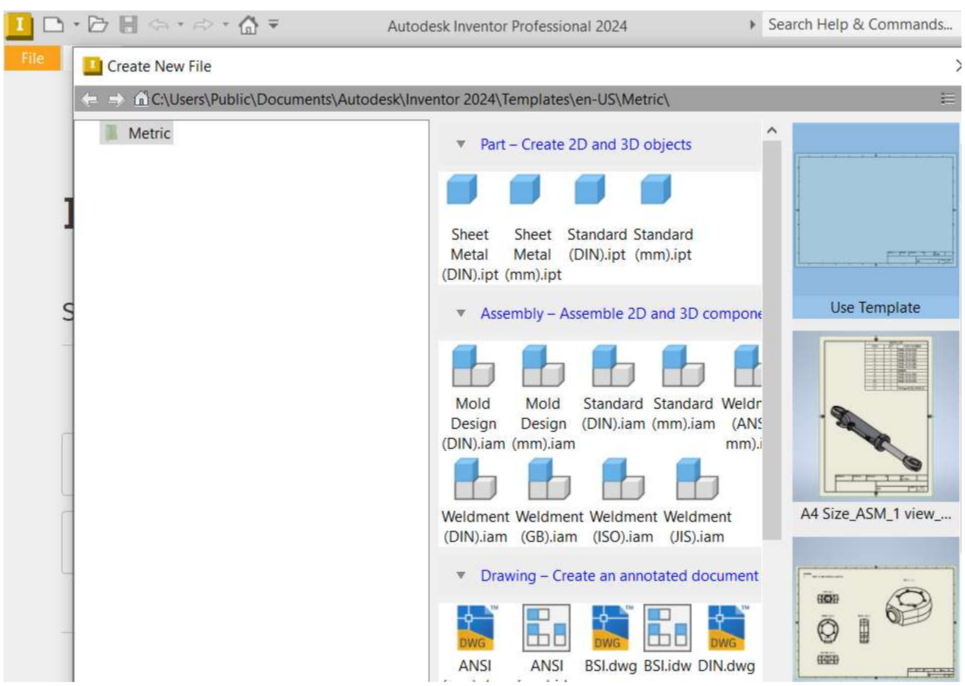

Figure 5. The window for creating an Inventor file.

The steps for indirect measurement using the "Measure" tool as a facility are:

- Acquisition of images of the part, in the position required by the dimension to be measured. Import of the digital file thus obtained into the CAD program.
- Scaling the image according to a measurable dimension, so as to obtain the 1:1 correspondence - physical reality and virtual reality.
- Applying a scale factor to reduce digital measurement errors (Example 100:1; 200:1).
- Using the "Measure" tool to determine the desired value. It is recommended to perform a number n>3 of measurements of the same dimension.
- Calculation of the probable true value with the formula

$$\sum_{i=1}^{n} \frac{\text{Vmi}}{n} \tag{1}$$

- Applying the scale factor to reach the digitally measured value.

3. Experimental part with Inventor 2024 - educational licence.

For the piece presented in figure 6, we have applied these stages in order to determinate the thread pitch.

Figure 6. The part used to determine the thread pitch.

Figure 7 presents the use of the "Measure" tool in Inventor to determine the desired value. In this stage, eight measurements have been made to determine the values.

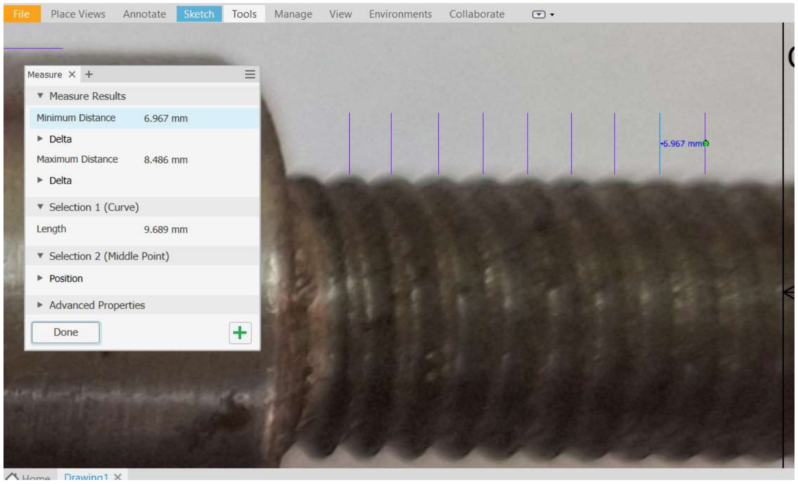

Figure 7. Using the "Measure" tool in Inventor to determine the desired value.

4. Results (M8 x p)

The results for measuring the value of p, with the indirect method proposed by the authors of this paper, are presented and centralized in Table 1.

Table 1. The values determined with the "indirect measuring method".

Crt. No.	Insertion measurement	Calculated scale factor
1	**6.423**	**43.055/8=5.38**
2	**7.2900**	
3	**6.859**	
4	**6.859**	
5	**6.750**	
6	**6.967**	
7	**6.967**	
Indirect measurement value	**6.8735**	
p [mm]	**1.277**	

Thus, the normalized value for p is probably 1.25 [mm].
The deviation obtained in this case is 0,02 %.

5. Conclusion

The precision that the dimension values are determined with using the measurement method presented in the paper can be influenced by factors such as: the precision of the device used to acquire the image, the accuracy of the image and also the scale factor used to insert the taken picture in the CAD program.

6. References

[1] Autodesk education resources, https://www.autodesk.com/education/home, accessed in October 2024

[2] Autodesk Inventor Professional 2024, educational licence contract No 110004344768

[3] https://www.3erp.com/blog/manufacturing/