Comparative Analysis of Geometrical Characteristics of a Test Specimen for Testing the Tensile Strength Before and After Punch Sharpening

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Abstract: *In the present article, a comparative analysis of the widths and thicknesses of a test specimen prepared by punching a hydraulic press before and after sharpening the guillotine blades is made. The types of characteristics of the punch are considered. The comparative analysis was performed by a non-destructive method using a 3D computed tomography.*
Keywords*: WIDTH, THICKNESS, TEST SPECIMEN, PUNCH, 3D TOMOGRAPHY*

1. Introduction

During the tensile test, test specimens are tested, the shape of which must ensure a homogeneous uniaxial tensile condition of tension in its working part during the test.

The design of the technology for cutting a metal test specimen necessary for the tensile strength test provides for determining the shape and dimensions of the test specimen, determining the number, type, and sequence of intermediate operations (if any) and determining the required force for the implementation of technological operations. The standard by which the test specimen is prepared is BDS EN ISO 6892-1 [1].

The present work aims to make a comparative analysis of a test specimen for tensile strength testing. The specimen was prepared on a hydraulic press and the specimen was taken before and after sharpening the guillotine blades. The analysis was performed by using a 3D industrial computed tomography.

2. Experimental Setting

2.1. Specimen for research

Normally, the tested metal tensile strength specimens shall have widenings at both ends of the parallel length, which engage the jaws of the test machine. The other reason for these widenings is to avoid the rupture of the test specimen at the jaw grip of the test machine (Figure 1),

where:

a_0- thickness of the test specimen, mm;

b_0- width of the original thickness of a flat test specimen, mm;

S_0- section of the test specimen, mm;

L_c- parallel length, mm;

L_0- original overall length, mm;

L_t- total length of the test specimen, mm2.2. Basic equipment used

The dimensions of the test specimen are determined according to the standard BDS EN ISO 6892-1 with a width and tolerance of 20 ± 1 mm.

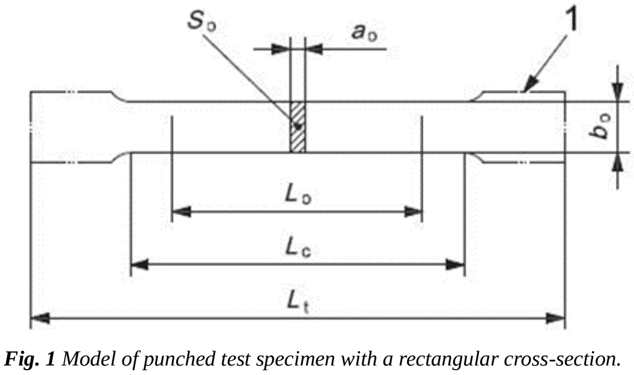


Fig. 1 *Model of punched test specimen with a rectangular cross-section.*

2.2. Technological preparation - punching

Punching makes it possible to quickly produce a product from the starting material with high precision and a perfect desired shape, which can immediately move on to the next stage of production or even be put into operation. During the punching process, the material does not lose its original properties such as strength and corrosion resistance.

The force of pressure, which is performed by mechanical or hydraulic punching presses, carries out the processing of sheet materials by plastic molding. The molding process begins with the creation of a specific matrix according to which the element will be made. After completing the die to be used in the manufacturing process, the sheet or strip is placed on the die, and pressure is applied to the metal by force. Thanks to the good interaction between the press and the die, the sheet material is formed into a final product without any defects and without the need for additional processing [2, 3].

Cutting is done with mechanical scissors with parallel or inclined blades or with disc scissors. In mechanical scissors with inclined blades, also called guillotines, the upper blade is inclined to the lower at a certain angle in the range 2-6 °. Therefore, only a certain part of the cross-section of the sheet is cut with them at any one time, and therefore the cutting force is less. A disadvantage of guillotine shears is that the cut strip bends in the direction of movement of the upper blade and it has to be straightened. A pair of disc blades that rotate in opposite directions does cutting with disc scissors. Under the action of friction forces, the sheet material is entrained between the discs and is gradually cut similar to cutting with guillotine shears.

In the specific case, the press used is hydraulic with a single cutting punch with a simple action with a test specimen. The punch for the press is manufactured in the tool department of the company according to the requirements that must be met for the production of the desired sample for a test specimen. The hole of the punch for placing the test specimen has dimensions HxW-300x40 mm.

Figure 2 shows a test specimen with the presence of edges in the cutting area before punch sharpening (marked with elliptical shapes in the figure). The detail was taken from the last batch before stopping the machine for sharpening the guillotine blades of the punch in the company's workshop.

Fig. 2 *Test specimen with edges (before punch sharpening).*

2.3. Used equipment

The Nikon XT H 225 3D industrial computed tomography was used for the analysis of the linear values of width and thickness (Fig. 3) [4, 5].

Computed tomography (CT) is a non-destructive method that provides high accuracy and can examine the internal and external dimensions of the provided test specimen. It also provides an additional view through the density of the material and its microstructure.

Fig. 3 *3D industrial computed tomography Nikon XT H 225.*

3. Experimental Results

The obtained data from the experimental results are presented in tabular form. Table 1 shows the values of a test specimen measured with a 3D computed tomography by using a non-destructive method before punch sharpening of the press, and Table 2 after punch sharpening the press. One specimen was analyzed before punch sharpening of the press, and measurements of the width were made at three points and three planes, shown in fig. 5, 6, and 7. After sharpening the blades, an analysis of 1 specimen was also performed at three points in one plane.

Table 1: *Test specimen values measured with a 3D computed tomography before punch sharpening of the press.*

Measurement	**Number of measurement**	**Beginning**	**Middle**	**End**
Width, mm	1	19,93	20,04	19,81
	2	19,95	20,04	19,69
	3	19,94	20,05	19,63
Thickness, mm	1	0,92	1,04	0,88

Table 2: *Test specimen values measured with a 3D computed tomography after punch sharpening of the press.*

Measurement	**Number of measurement**	**Beginning**	**Middle**	**End**
Width, mm	1	19,98	19,96	19,9 6
Thickness, mm	1	1,01	0,97	1,01

After the 3D computed analysis of the test specimen, prepared before sharpening the guillotine blades of the press, a defect on its surface is visualized. Due to the wear of the blades, the metal is crushed and deformed. The size of the defect is 0.12 mm, as is shown in Fig. 4.

From the analysis of the two types of specimens, it is clear that in the examined specimen produced before sharpening the blades, the deformation is visible. The positions of the measurements are at three planes, presented in the beginning, middle, and end (Fig. 5).

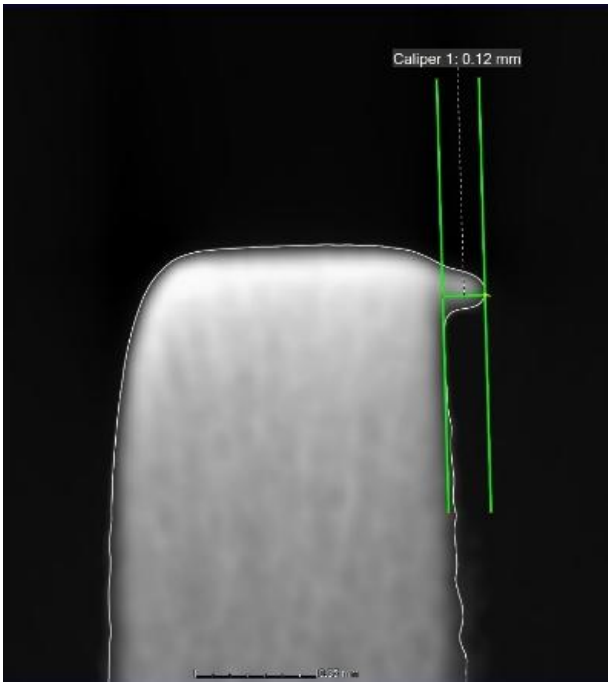


Fig. 4 *Defect of the test specimen after punching.*

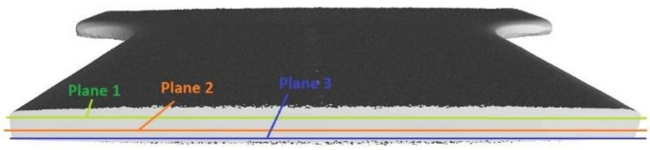
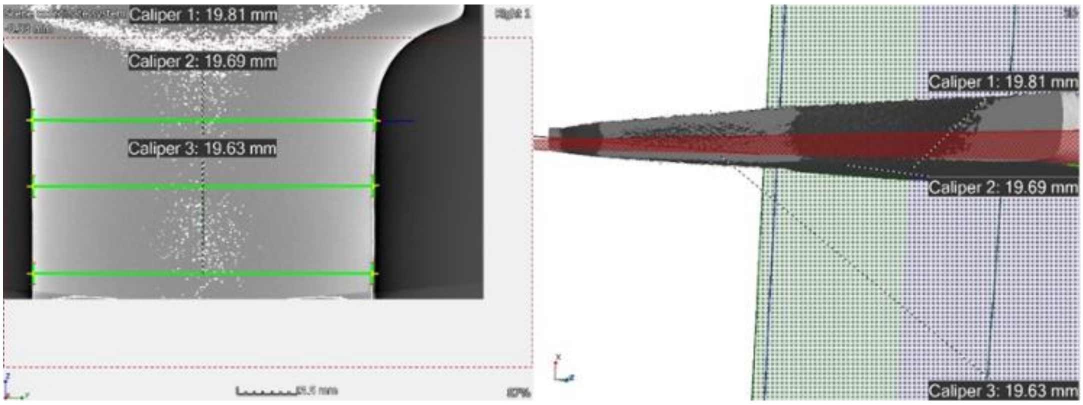


Fig. 5 *Position of the plane.*

In Fig. 6 in the first plane (the upper side from which the blade falls on the metal sheet) are taken 3 sizes of width – 19.81 mm; 19.69 mm; 19.63 mm. On this surface, the metal is crushed and there the width is the narrowest. In the next plane - the middle (Fig. 7) the width is the largest – 20.04 mm; 20.04 mm; 20.05 mm. In the third plane of Fig.8 (the lower point of the metal sheet) there is a deformation, displacement of the metal, the so-called edge with dimensions of width: 19.93 mm; 19.95 mm; 19.94 mm. The defect that occurs is seen in fig. 9 when measuring the thickness of the specimen. Significantly less thickness was measured at the edges of the specimen than the actual thickness in its middle - 0.92 mm; 1.04 mm; 0.88 mm.

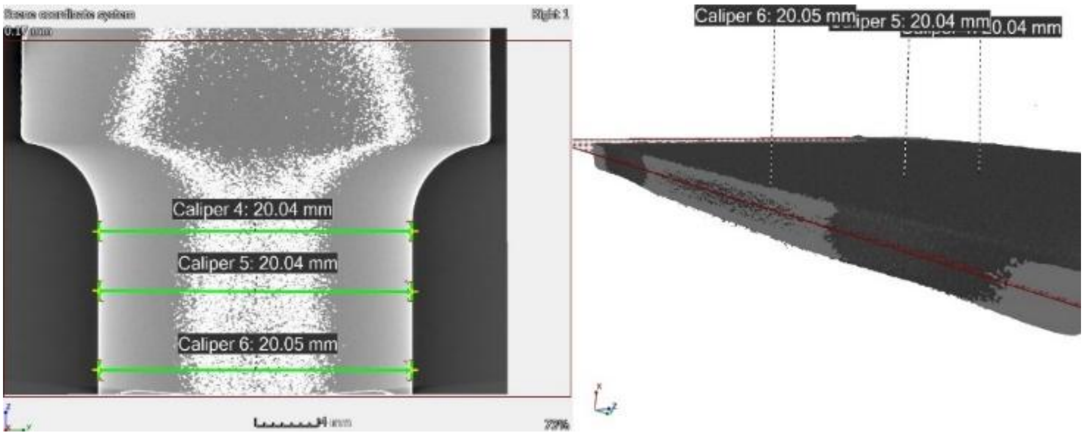
From the analysis of the test specimen prepared after punch sharpening of the press, a uniform width (Fig. 10) and thickness (Fig. 11) is observed. The dimensions of the width are: 19.98 mm; 19.96 mm; 19.96 mm, and those of thickness is 1.01 mm; 1.03 mm, 1.01 mm.

The punch has guillotine blades and after long use, there is an edge on the surface of the test specimen, which must be cleaned or the knives of the die must be sharpened.



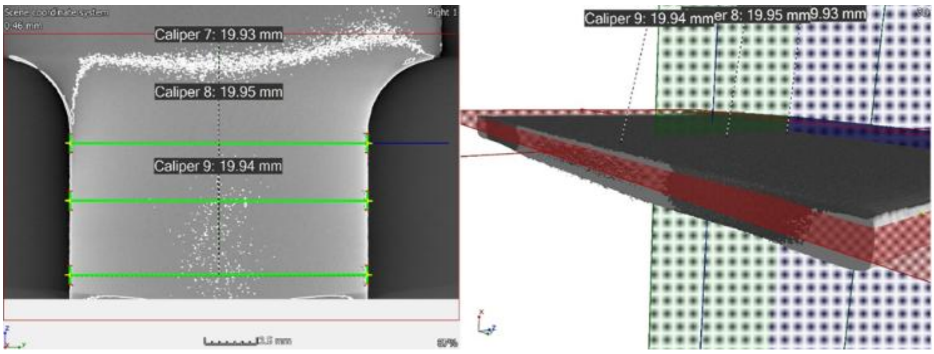
a) Measurement of the width b) Plane – beginning

__Fig. 6__ Measurement of the width of a specimen in the plane – beginning.



a) Measurement of the width b) Plane – middle

__Fig. 7__ Measurement of the width of a specimen in the plane – middle.



a) Measurement of the width b) Plane – end

__Fig. 8__ Measurement of the width of a specimen in the plane – end.

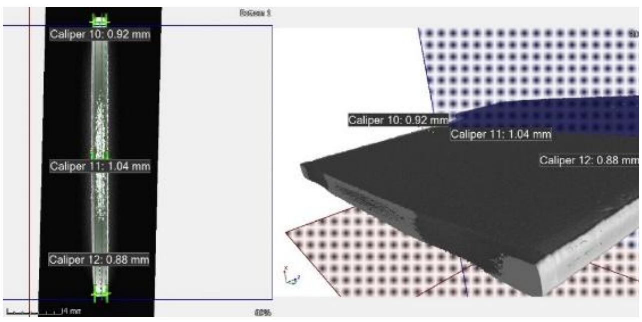
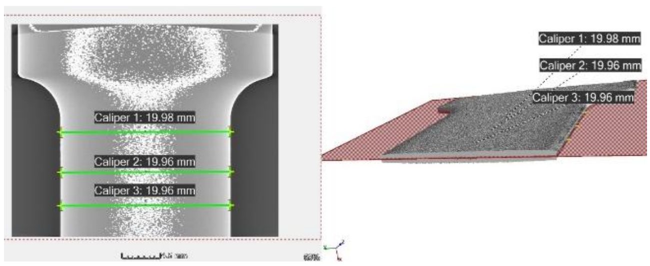


__Fig. 9__ Measurement of specimen thickness before sharpening.



a) Measurement of the width b) Plane

__Fig. 10__ Measurement of specimen thickness after sharpening.

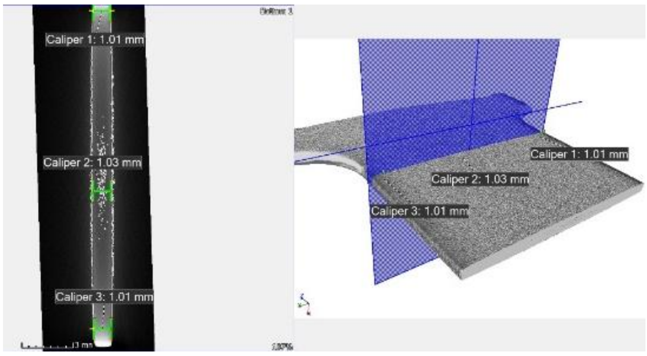


Fig. 11 *Measurement of specimen thickness after sharpening.*

4. Conclusion

From the comparative analysis of the geometrical characteristics of a metal test specimen for tensile strength testing, prepared before and after sharpening of the guillotine blades of the press, significant differences were found. From the measurements made on a 3D computed tomography it was found that when the blades are worn out, large defects occur on the surface of the specimen. During the detailed measurement of the width, there is a crushing of the metal on the upper side of the blade, uniformity in the middle, and a defect in the lower part of the specimen. And the thickness in the final widths is 0.12 mm less, in contrast to the test specimen prepared after sharpening, where the thickness and width are uniforms.

Due to the variety in the hardness and thickness of the test specimen, it is difficult to say after what period of work the guillotine blades of the punch wear out. According to observations for the needs and workload of the current production, it is necessary to sharpen every 2 years on average. Timely sharpening of guillotine blades on the press can lead to a more accurate measurement of tensile strength.

An intermediate inspection of the test specimen for 6 months is recommended, depending on the press load.

Future analysis will be performed to the mechanical parameters when testing the tensile strength of the test specimen before and after sharpening the guillotine blades of the press.

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