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## EXPERIMENTAL STUDY OF FRACTURE OF THE CAST IRON SPECIMEN DURING COMPRESSION

**Abstract:** The results of experimental compression testing of the cast iron round specimens were presented in the article. The compression diagram of brittle material was obtained based on the applied load and the compression value of the specimen. The analysis of the deformation degree of the cast iron specimen after realization of compression testing was made.

**Key words:** the specimen, compression, fracture, deformation, the load, material.

**Language:** English

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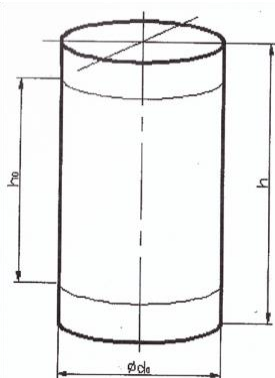
### Introduction

Compression testing is widely used for determining mechanical characteristics of low-plastic materials (cast irons, tool steels, ceramics, etc.). Sequence of realization of compression testing is provided in the relevant official document [1].

During compression testing, the specimen of the standard shape is placed in the special device installed on the testing machine and subjected to continuous smooth deformation to the specified strain value or to fracture. In this case, the dependence between the

compressive force and shortening the calculated height of the specimen is recorded in the form of the compression diagram. The compression diagram allows to evaluate behavior of the specimen in the elastic and elastic-plastic stages of deformation and determine characteristics of the mechanical properties of material.

The short specimens with the height to diameter ratio of 1:3 are used for compression testing. The round specimen for compression testing is presented in the Fig. 1.



**Figure 1 – The round specimen for compression.  $d_o$  – the outer diameter of the specimen, mm;  $h$  – the specimen height, mm;  $h_0$  – the calculated height of the specimen, mm.**

Studies in this direction has been carried out by various scientists in the works [2-9]. These works present the results of the laboratory and computer experiments on compression of cast irons of various grades in the cold and heated to the certain temperature states. The compression diagrams were obtained for various metallic and non-metallic brittle materials. The special device was proposed for compression testing of the long flat specimens with the thickness of less than 1 mm.

The purpose of this work is the analysis of deformation intensity and subsequent fracture of the

cast iron round specimens in the cold state based on the obtained compression diagram.

### Materials and methods

Compression testing of the metallic round specimens was performed three times for obtaining the average values of the studied parameters. The metallic specimens with the outer diameter of 4 mm and the length of 4.5 mm were subjected to compression. The round specimens were made of gray cast iron. The cast iron specimens for realization of compression testing are presented in the Fig. 2.



**Figure 2 – The cast iron specimens for realization of compression testing.**

Compression testing was carried out on the "TM-20" special testing machine [10]. The machine is equipped with the displacement sensor for determining the load applied to the specimen. In the process of loading the specimen with the compressive forces, its height decreases and its diameter increases unevenly along the specimen height. This leads to significant changing the shape – the specimen

becomes barrel-shaped. The barrel shape during compression occurs due to friction between the contact surfaces of the compressible specimen and the device. Friction prevents transverse deformation of the specimen. The scheme of deformation of the cast iron round specimen during compression is presented in the Fig. 3.

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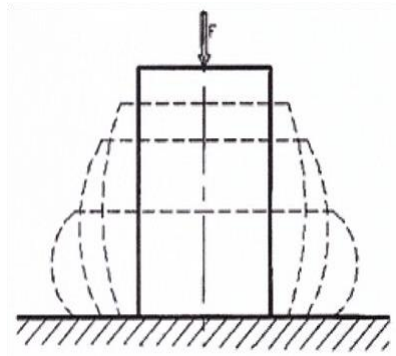


Figure 3 – Deformation of the round specimen during compression.

The specimen was subjected to compression to partial fracture.

### Results and discussion

The stages of compression testing of the specimens are presented in the Fig. 4. After eliminating the backlash in the machine mechanism, the upper movable punch moved vertically down. The

specimen was mounted on the lower fixed device. The specimen was subjected to elastic deformation (pre-loading), residual deformation (changing the shape and the dimensions), and subsequent partial or complete fracture during compression testing. The load on the end surface of the round specimen was removed at cracks formation in material.

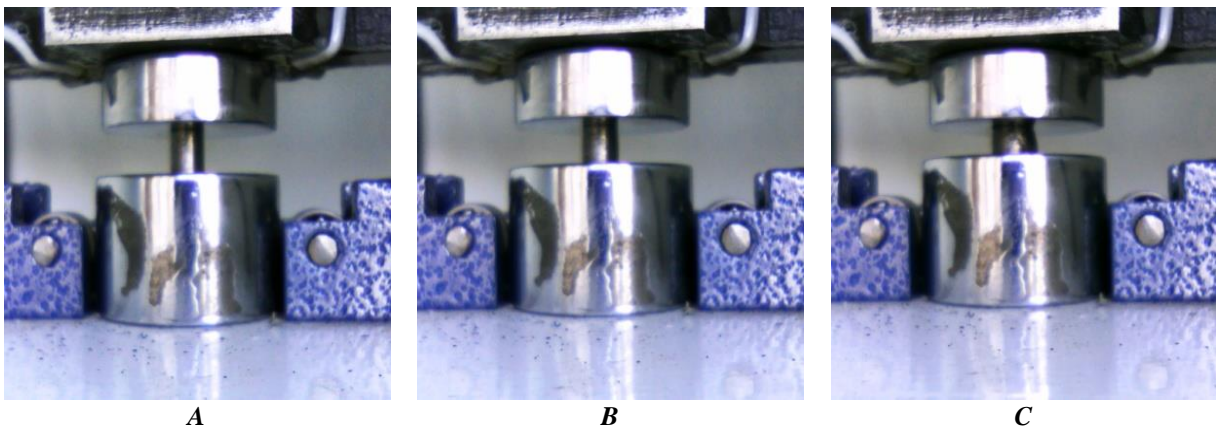


Figure 4 – Performing compression testing: A – pre-loading the specimen; B – residual deformation of the specimen; C – fracture of the specimen (cracks formation).

Deformations in material of the round specimen subject to compression can be described in detail using the compression diagram. The specimen was compressed by 1.61 mm relative to the initial height. In the diagram, the dependence calculated at the distance from 3.16 mm to 3.7 mm and at the load of 3000 N corresponds to elastic deformations in the specimen material. The dependence calculated at the distance from 3.7 mm to 4.2 mm and at the maximum load of 4446 N corresponds to residual deformations in the specimen material. The dependence calculated at the distance from 4.2 mm to 4.77 mm at the decreasing load corresponds to partial fracture of the specimen material. The compression diagram of the cast iron round specimen is presented in the Fig. 5.

Two specimens were completely fractured during compression testing. The third specimen was partially fractured. This specimen was used to analyze the deformation degree of material during compression. The photos of the fractured round specimen after compression are presented in the Fig. 6.

Cracks along the diameter of the cast iron specimen are formed at the angle of approximately 50 degrees on both sides. The fracture area of material is larger (the Fig. 6-B) on one side of the deformed round specimen. This means that the short specimens are fractured unevenly on both sides during compression. This conclusion is also confirmed by deformation of the surface layer of material along the diameter on only one side of the specimen.

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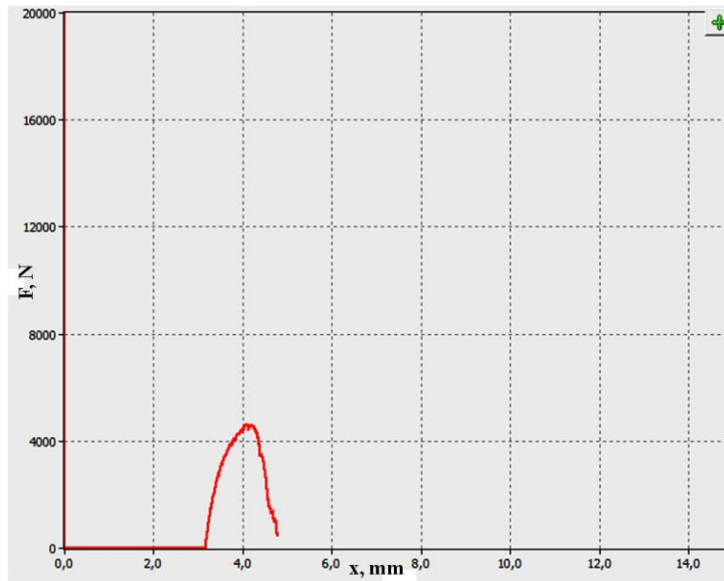


Figure 5 – The compression diagram of the cast iron round specimen.



Figure 6 – The fractured round specimen after compression: A – fracture of material (the view from the end surface); B and C – cracks along the diameter.

### Conclusion

The cast iron specimen with the length of 4.5 mm is partially fractured at 28-30% of compression deformation of material. Cracks formation along the diameter of the round specimen occurs symmetrically,

but deformation intensity of material on each side will be different. The end surface of the specimen does not deform during compression. Cracks along the diameter are shallow and form at the angle of 50 degrees relative to the axial line of the specimen.

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