



Examining the hardness of the high density polyethylene with method of the cone

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ABSTRACT

Purpose: The purpose of this article is to present results of examining the hardness of the high density polyethylene with method of the cone.

Design/methodology/approach: In the article a method of the cone was used for examining the hardness of the polythene of high density.

Findings: The method of the cone it is possible to examine small samples and he allows for more exact measurements than different methods of examining the hardness.

Research limitations/implications: The methods presented in this paper differ in the size and the shape of the indenter. The choice of the method of the measurement of the hardness in case of crystalline polymers is difficult since none of known methods has the right measuring resolution. The method of the cone is solving in the case of examining polymers. The method of the cone isn't limited only to polymer materials

Practical implications: Presented method can be applied for other materials in the future.

Originality/value: The expressed method can be applied in the future for developing the research on the hardness of polymers.

Keywords: Engineering polymers; Mechanical properties; Hardness; Method of the cone

MATERIALS

1. Introduction

Hardness is an unusual physical property in that it is the result of a defined measurement procedure and not an intrinsic materials property susceptible to precise definitions in terms of fundamental units of mass, length, and time. The term can apply to deformation from indentation, scratching, cutting or bending. The advantage of this test is that it involves only limited area for measurement so the specimen is relatively unaffected by the test [1, 7].

Hardness has been well established in characterizing metallic material and ceramics for many years, but only recently has it been widely employed for characterizing polymers. In metals, ceramics and most polymers, the deformation considered is plastic deformation of the surface. For elastomers and some polymers, hardness is defined as the resistance to elastic

deformation of the surface. The lack of a fundamental definition indicates that hardness is not a basic property of a material, but rather a composite one with contributions from the yield strength, work hardening, true tensile strength, modulus, and others factors. In practice, hardness is measured in terms of the size of an impression made on a specimen by an indenter of a specified shape when a specified force is applied for a specified time; the indent being measured after the force has been removed [7]. There are three principal standard testing methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell [8-10]. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry [11]. Shore, Rockwell and pressed bullet methods are applied for examining the hardness of polymers. There is an interdependence between the hardness and resistance

to stretching. For plastics which have modulus of elasticity over than 2500 MPa resistance on stretching amounts to 35% ($\pm 10\%$ hardness acc to. Brinell) [19].

The process of crystallization of polymers has the influence on their hardness. Crystallization is accompanied by release of the latent heat fusion. Hence, the initial temperature distribution changes inside a material undergoing solidification. In metal and other low-molecular substances, an interphase, at which the transformation occurs, follows an isotherm of the melting point [12]. The process of transformation is then controlled by heat dissipation. Polymer crystallization usually proceeds at large supercoolings, well below the melting point, because it is controlled by primary and secondary nucleation rather than by the dissipation of latent of fusion. Competition of the rate of secondary nucleation with that of buildup of the crystal face layer allows to distinguish three crystallization regimes. In Regimes I and II macromolecules are primarily reeled out of the melt and crystal layers are built up in a chain folded manner. High-pressure crystallization allows to have the chains disentangled and extended. Spherulite growth rates are faster in Regimes I and II in polymer melt with disentangled chains. In Regime III, crystallization produces a polymer with strongly bonded neighbouring crystals and one endowed with a high mechanical strength. After the primary nucleation, a crystalline aggregate (a spherulite) grows until impingement with neighbouring spherulites takes place [2, 3, 14]. The temperature near the crystallization front might be increased by the liberation of the latent heat of fusion but may still be well below the melting temperature of the crystals [18, 15]. Polymers are poor heat conductors, hence, except for thin films, the temperature increases during the crystallization in bulk [4, 5, 6]. Experimental measurements show that in polymer the temperature increases due to crystallization either during cooling or because of isothermal ambient conditions [17]. The cooling of thick wall products during industrial processes results in significant temperature gradients that are enhanced by the liberation of the heat of crystallization. The crystallization inside a material occurs at an elevated temperature, which is unfavorable for the strength and toughness of polymer. Therefore, it is important to have the ability to predict both the course of crystallization and temperature inside thick-walled products during cooling from a molten state in industrial processing conditions [13, 16, 20].

Table 1.
Methods of hardness measurement [8-10]

The method of hardness measurement	The diameter of indenter [mm]	Distance from the edge of the sample [mm]	Distance of the measurement from the measurement [mm]
Rockwell	12.7	10	10
Method of pressing the bullet (Brinell)	5	10	10
Shore	0.79	13	5

The choice of the method of the measurement of the hardness in case of crystalline polymers is difficult since none of known

methods has the right measuring resolution. Conditions of carrying out measurements were put in Table 1.

It appears from the table that it is possible to make only a few measurements on one sample, which does not portray the full of the image of the hardness of the checked diameter.

Therefore, in order to expand the measurement possibilities the method of the cone was developed (Fig.1).

2. Experimental section

Device used in the method of the cone consists of:

- sliding table with the handle for the assembly of the sample,
- clock for 0.001mm accuracies,
- cone-shaped indenter (Fig.2).

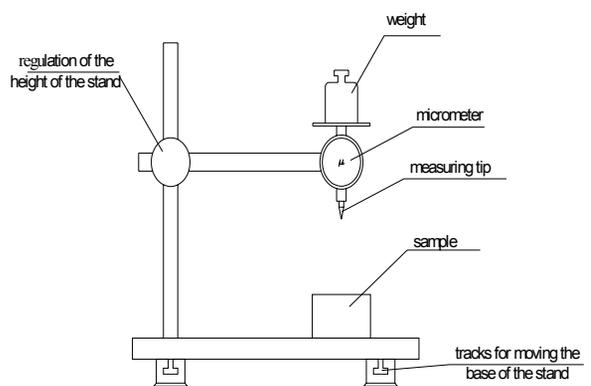


Fig. 1. Device used in the method of the cone



Fig. 2. The measuring cone-shaped end

The method adopted for averaging the measurement consists in lowering the remainder of the micrometer to the surface of the cross section of the wall of the pipe. A preliminary burden is inflicted in order to establish the initial state. After establishing the zero state, a main burden is inflicted and after 30 seconds a measurement of the hollow is read out of the indenter.

2.1. Material for examinations

Samples used for examinations were taken from pipes and of plates. The kind of the sample resulted from the technology of

producing the element but exactly, of process of the exchange of the ambient temperature while solidifying.

In case of the pipe, the receipt of the warmth is radial, and in the surface - double-sided. One should also expect differences in the disintegration on the surface of contents of the crystalline phase. All samples were made around PE-HD.

3. Results

Pictures 3, 4 and 8, 9 are showing the hardness for pipes about different thicknesses. However pictures 5, 6, 7 are showing the hardness for plates about different thicknesses.

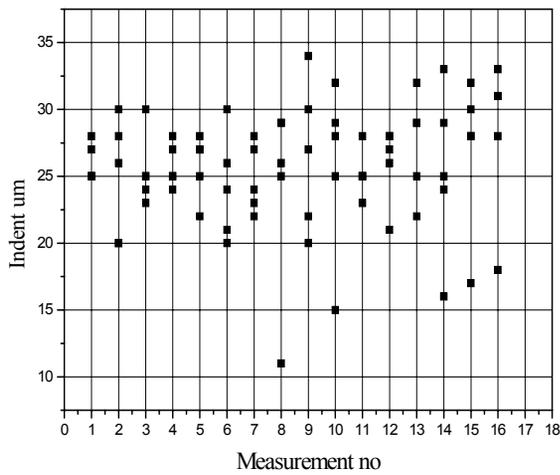


Fig. 3. Pipe thickness 30 mm: 0 - inside partition wall 16 - outside partition wall, burden: 100g, time 30 s

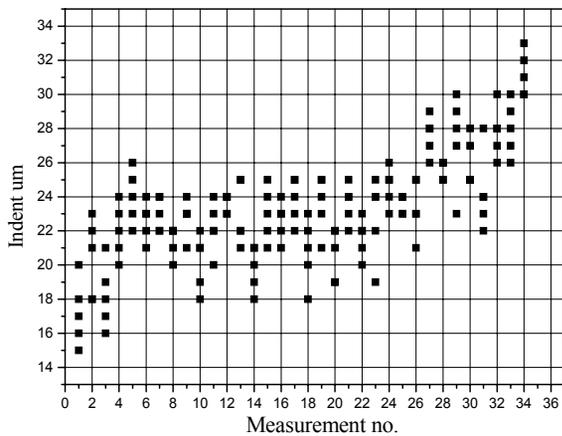


Fig. 4. Pipe thickness 60 mm: 0 - inside partition wall 34 - outside partition wall, burden: 100g, time 30 s

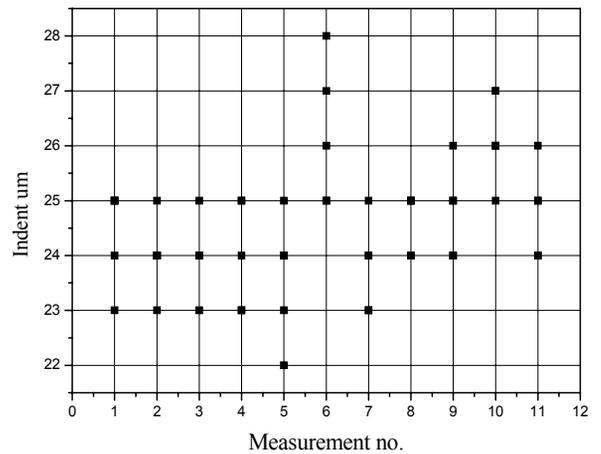


Fig. 5. Plate thickness 20 mm: burden: 100g, time 30 s

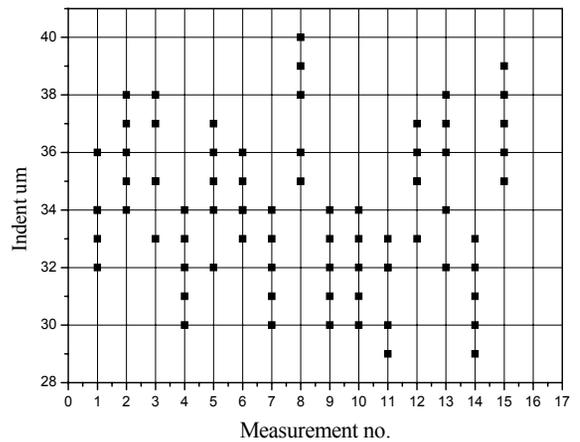


Fig. 6. Plate thickness 15 mm: burden: 100g, time 30 s

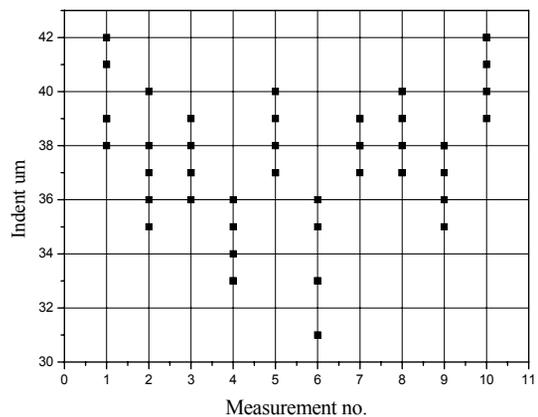


Fig. 7. Plate thickness 10 mm: burden: 100g, time 30 s

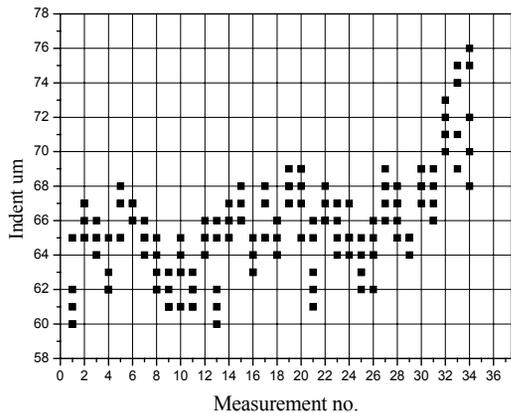


Fig. 8. Pipe thickness 60 mm: 0 - inside partition wall 34 - outside partition wall, burden: 200g, time 30 s

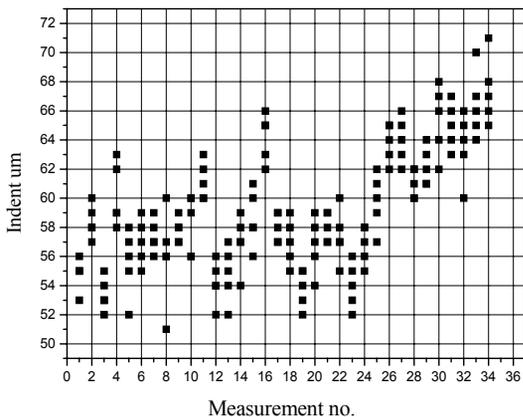


Fig. 9. Pipe thickness 60 mm: 0 - inside partition wall 34 - outside partition wall, burden: 200g, time 60 s

4. Conclusions

After carrying out examinations it is possible to conclude that the differences in the hardness on the diameter are caused by all sorts of contents of the crystalline phase; differences in contents of the crystalline phase are portraying the presence of inner stresses.

On the basis of results it is possible to draw a conclusion about the temperature of the tool in case the plate is missing plunging differences, which justifies the statement that the temperature of the tool amounts to several dozen degrees of Celsius. As for pipe we have the diversified schedule of the hardness on the diameter, which allows us to state that the temperature of the tool is low and there is an intense heat transfer during the process.

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