CUSTOM TRANSLATION GDA

REGARDING THE INFLUENCE OF SURFACE-ACTIVE SUBSTANCES ON MEASUREMENTS OF HARDNESS AND MICROHARDNESS (BASED ON INDENTOR IMPRESSIONS) AND TENSILE STRENGTH

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Recently P. A. Rehbinder and his school have published many papers indicating an apparent influence of surface-active substances on the mechanical properties of solids, and in particular on their hardness. From our point of view, the existence of such a phenomenon cannot be given any theoretical basis, nor, according to our own experiments, is it confirmed in practice.

We have already mentioned /1-3/ the errors committed by Rehbinder and his colleagues in the pendulum method and the fact that they have systematically ignored the papers of D. I. Mendeleev, a pioneer in the art of measuring hardness by the pendulum method (and indeed the creator of this method) and also the papers of M. I. Koifman /4-8/ and B. V. Il'in /9-11/.

As a second stage in our research, we set ourselves the problem of finding whether "surface-active" substances had any influence on the results of measurements of hardness and microhardness made

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Fig. 1. Photograph of a pile of copper plates subjected to the impression of the steel sphere ~~of~~ in a Brinell press. It is clear that the thickness of the upper plate in the center of the hole has been slightly reduced and that all-round (hydrostatic) compression does not therefore take place here.

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by the impression method, and also on the results of tensile tests (giving the tensile strength σ_B). We feel that such tests may be of great practical interest, since the views of Rehbinder have received widespread attention.

In order to check the possible effects of surface-active substances on hardness we made a number of comparative measurements of ~~the~~ "impression" hardness and microhardness on various materials both in the dry state and after wetting with various surface-active media.

If, as stated by Rehbinder and his colleagues, there were really any effect of surface-active materials on the mechanical properties, then the "impression" hardness (being a function of such properties) would certainly have a different value when measured in a surface-active medium, and this effect would be especially noticeable when measuring under small loads (i.e., when measuring microhardnesses).

It is sometimes said that the results of measurements of "impression" hardness cannot be sensitive to the influence of surface-active substances, since in such mechanical tests there is a state of all-round (hydrostatic) compression in the test material under the indentor tip. This, however, is not so. It is well known that we are not dealing with a state of hydrostatic compression in hardness tests. Such an assertion is devoid of all physical basis. Almost all research workers are of one mind in saying that hydrostatic compression does not take place under the impression of the sphere in the Brinell test.

In order to examine this point we made the following experiment. Cementing several copper plates together, we pressed the sphere of a Brinell press into the whole block. Then, after removing the load, we separated the block along the diametral plane of the hole and polished the surface of the cut. The resultant polished section showed clearly that the thinning of the plates under the impression was not uniform (see Fig. 1). Analogous results are given by another experiment. We take a thin plate of red copper about 1 mm thick, lay it on the polished surface of a steel sample, and impress a Brinell sphere into this system under a load of 3000 kg. After removing the load we cut the copper plate along the diametral plane of the hole. It is immediately obvious on studying the section that at the bottom of the hole the plate is severely thinned (to a thickness of about 0.1 to 0.2 mm). This is because under the influence of the nonuniform compression the material of the plate flows from the center of the depression to the periphery. On all these grounds, we consider that there is no foundation in asserting that hydrostatic-compression conditions exist in static methods of hardness measurement.

The hardness test is a form of mechanical testing which depends on the mechanical properties of the material in a very complex and often unknown fashion, varying with different methods of hardness measurement. The hardness is associated with many mechanical properties of the material, and if these properties change so does the hardness. The principle properties of the material include the ductility, elasticity, tensile strength, impact strength, and so on. The hardness depends in a complicated way on the elastic modulus, elongation, and so forth. If these constants change, so must the hardness; if they remain constant, the hardness must follow suit. Thus a measurement of hardness enables us very simply to judge whether the mechanical properties of a body have changed under the influence of surface-active substances or not.

Hardness Measurements

In order to find whether surface-active substances had any effect or not, we measured the Brinell and Rockwell hardnesses of various metals in the dry state and with their surfaces wetted in various surface-active liquids. The test samples were made in the form of rectangular blocks .....mm in size. The samples were finished on a planing machine, ground on a plane grinder, and polished with "GOI" paste to a surface finish of..... . The measurements were made in complete agreement with the All-Union Standards for Brinell ~~hardness tests~~ (All-Union Standard 10241-40) and Rockwell (All-Union Standard 10242-40) hardness tests.

Table 1*

Hardness as a Function of the Medium in Which the Tests Were Conducted

Key

1) Material

2) Steel

3) Dural

4) Medium

5) Dry

6) Pure alcohol

7) 50% diluted alcohol

8) Emulsion

9) ~~Petroleum~~ Gasoline

10) Water

11) Rockwell hardness **, scale B

12) Holes, mm

13) Brinell hardness

14) * Brinell and Rockwell hardnesses determined as the arithmetic mean of three measurements for each medium.

15) ** Accuracy of the apparatus ±1 scale unit.

Our tests revealed no affect whatsoever of the surface-active substances on the results of the measurements. This is demonstrated by the Brinell and Rockwell hardness measurements listed in Table 1 for Dural and various types of steel.

The results shown in Table 1 prove that there were no serious variations in hardness number with medium on using static methods to test steels and Dural. The very slight differences shown are no greater than would be expected from the experimental accuracy.

Microhardness Measurements

With the same object in view, we then proceeded to make some microhardness measurements. These were carried out on two different hardness testers, the PMT-2 and the PMT-3, by two different observers in order to remove any possible influence of the personal factor or apparatus error. Tests were carried out on cleavages of natural rock-salt crystals and lead glance, a polished marble surface, and the polished surface of an aluminum single crystal obtained by recrystallization.

Table 2 compares PMT-2 microhardness measurements for the four substances mentioned and also those obtained with plates of cobalt and annealed steel, both in the dry state and in various media, with loads varying from 2 to 200 g.

Table 2

Microhardness of Different Substances in the Dry and Wet States, as Measured on the PMT-2

Key

1) Material
2) Al single crystal
3) Lead glance
4) Marble
5) Rock salt
6) Cobalt
7) Steel
8) Medium
9) Dry
10) Castor oil
11) Oleic acid
12) Distilled water

13) Alcohol

14) Dry, polished

15) Kerosene

16) Dry surface

17) Dry, polished, annealed

18) Microhardness in kg/mm^2, loads given in g

We see that at any rate the hardness numbers of corresponding samples are no higher for a dry sample than for one wetted with a surface-active liquid. The slight differences found are sometimes even in the opposite sense, i.e., in a surface-active medium the microhardness sometimes even appears a little higher than in the case of a dry sample. The differences, however, are very slight, and are mainly limited to the region of small loads (2 to 5 g) ; in general they lie within experimental error.

Analogous measurements were also made with metal samples in the PMT-3 tester, using rather different liquids (Table 3).

Table 3*

Influence of Various Substances on Microhardnesses Measured on the PMT-3

Key

1) Material

2) Steel

3) L-62 (brass)

4) Dural

5) Load in g

6) Conditions of measurement

7) Section dry

8) Length of diagonal

9) Hardness, kg/mm^2

10) Section with pure alcohol

11) Section with distilled water

12) Section with 50% diluted alcohol

13) Section with gasoline

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* The microhardness was defined as the arithmetic mean of the values obtained for four impressions in the cases of 5, ...200-g loads and five impressions in the case of a 2-g load.

In this series of measurements we used sections of metals obtained by mechanically grinding and polishing, i.e., cold hardening in the surface layer was not eliminated, so that the hardness of the samples tested was rather high at the surface. However, as the measurements bore a comparative character, i.e., we were comparing the results of measurements made on dry samples and on the same samples moistened with various liquids, this circumstance should not seriously distort the results.

Here once more the measurements show that there are no appreciable systematic differences in the microhardnesses of these metal samples. Thus the measurements prove that in the case of both macro- and microhardnesses the hardness numbers obtained in the tests are identical for dry surfaces and surfaces wetted with surface-active substances.

Measurements of Tensile Strength..... Carried Out on Dry Samples and Samples Wetted with Surface-Active Substances

In order to discover the effect of surface-active liquids on the tensile strength, we made some comparative tensile tests on steel with H_{R_B} = 58 to 60, using a 35-ton rupture machine constructed by the Central Scientific-Research Institute of Machinery. We tested samples lubricated with "Tavot" grease, commercial vaseline, "Avtol" lubricating oil No. 10, and also dry samples. By way of surface-active substances we deliberately chose lubricants widely used in technology. For all the samples tested we determined the maximum breaking stress (load) P_B and calculated the tensile strength..... . The test method and calculating procedure were in compliance with All-Union State Standard 1497-42. For the tests we used normal circular rupture samples (a proportional sample of circular cross section and a long sample with K = 11.5, type 1, sample 2). The diameter of the sample was measured before the test with a micrometer, in three places along the sample and in two mutually perpendicular positions, to an accuracy of 0.01 mm. In calculating.....we took the smallest diameter. The accuracy of the force measurement on the machine employed corresponded to the requirements of the All-Union State Standard and even exceeded these. In calculating the .....the result was rounded off in accordance with the All-Union State Standard.

Table 4

Results of Measuring the Tensile Strength (of Steel Samples)

Key

1) No. of sample

2) Dimensions, d, mm

3) Medium

4) Dry

5) "Tavot" grease

6) Commercial vaseline

7) "Avtol" lubricating oil No. 10.

8) kg

9) kg/mm^2

We see from the test results presented that the application of the surface-active lubricants caused no fall in tensile strength as compared with that of dry samples.

If certain authors assert (referring to the incorrect view that a state of hydrostatic compression exists when measuring hardness and microhardness by static methods) that hardness cannot change under the influence of surface-active substances, then in any case from their point of view the tensile strength cannot depend on any such influence. As we see, the results of our experiments refute the existence of any effects attributable to surface-active media for the test methods employed and the materials tested.

Conclusions

1. We have shown that the "impression" hardness of the materials studied, as measured by the Brinell and Rockwell methods, is independent of the medium.

2. The microhardness of the materials tested in the PMT-2 and PMT-3 hardness testers is also independent of the surrounding medium.

3. The tensile strength of low-carbon steel undergoes no modification on lubricating the samples with surface-active substances.

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