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STUDY REGARDING THE WAYS FOR PRACTICAL EXECUTION OF SOME ENCLOSURES FOR HEATING THE SPECIMENS AND THEIR ADJUSTMENT FOR THE TESTING MACHINES IN ORDER TO PERFORM HIGH TEMPERATURE MECHANICAL TESTS

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Abstract: *This work presents a critical study on the possibilities of practical execution of some rooms, resp. furnaces, with relatively small sizes, in view of their future adjustment for the tensile testing machine, Brinell hardness tester, Charpy friction pendulum, existing in the Material Resistance Lab inside the Engineering Faculty of Hunedoara.*

By executing these rooms it is desired to carry on some strength and toughness mechanical tests for the steels that operate at high temperature, in order to increase the lifetime of the components made of such steels.

Keywords: *the tensile test, high temperature, hardness test, shock bending test*

1. INTRODUCTION

The ordinary test performed at high temperatures within the industrial labs is the tensile test, but at beneficiary's request, there can be also performed the hardness and the shock bending test.

The temperature at which the tests on materials are generally performed and at which tests on metallic materials are specially performed, is stipulated by the standards corresponding to the type of the test performed and/or to the product standards, respectively to the specification agreed between the parties (the material producer and the beneficiary).

2.ENCLOSURES FOR HEATING THE SPECIMENS FOR PERFORMING THE HIGH TEMPERATURE TENSILE TEST

In principle, the tensile test under high temperature conditions is performed in the same way as at the ambient temperature. The difference consists in the fact that the specimen is previously heated at the desired temperature and it is held at this temperature, in certain prescribed limits, during the test.

In order to perform the mechanical tensile tests at high temperatures, the possibility to adjust a furnace-enclosure, which is to be connected to a temperature measuring system, was studied for the universal machine for tensile testing. Figure 1 shows the constructive elements.

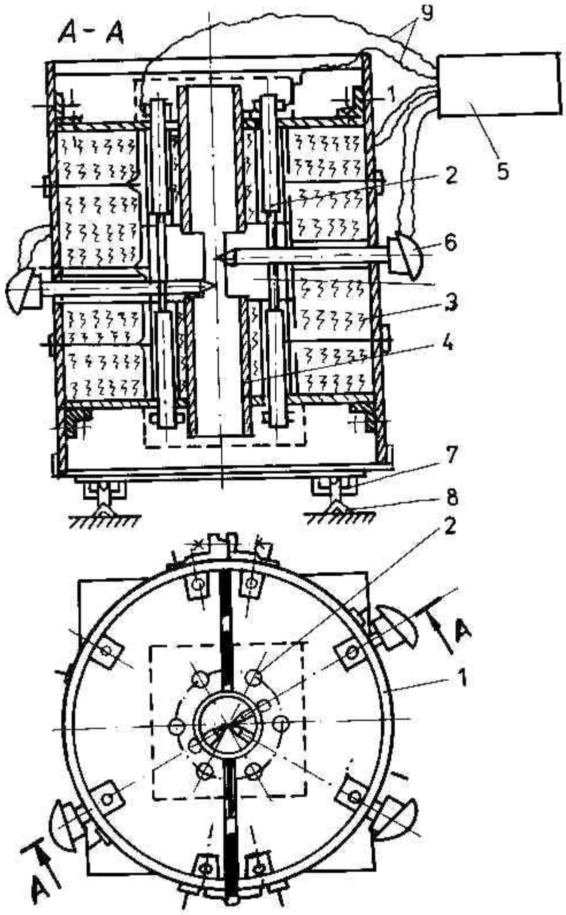

Fig.1. *Furnace-enclosure for heating the specimens: 1-cylindrical wall; 2-resistors; 3-thermal insulating;4-refractory steel tube; 5-electrical installation; 6-PtRh-Pt thermocouples;7-mobile carrier; 8-guidings*

The constructive version of a furnace enclosure presented in Figure 1 consists of a cylindrical vertical electric furnace, having the following main parts: the resistors (2) made of silicon carbide bars (6 pieces), the thermal insulating (3) made of ceramic fiber, the central tube (4) made of refractory steel for protecting the bars (2) and the semi-covers 5 (upper and lower) between which the other components of the furnace are located (2, 3, 4).

The electrical installation for switching and controlling the heating (9), the thermocouples (6) Pt-RhPt 10% (3 pieces) and the carrier (7) for supporting the furnace are elements that are attached to the furnace in order to operate it during the lab tests.

For an easier maintenance of the lower part of the furnace, this is made of two semi-cylindrical half (with a vertical separation plane that passes through the cylinder shaft) that are connected by hinges and screw tightening elements. Between the ceramic fiber insulating (that resists up to 1250°C) and the outer metallic walls, a 6 mm thick asbestos layer was mounted. The thermocouples (6) are guided towards the specimen through tubes made of refractory metallic pipes that are fastened with distance pieces on the semi-covers (5).

The ceramic fiber is fastened on the inner walls of the furnace by means of some refractory anchors with 5mm diameter. The silicon carbide bars (2) are inserted in tubes made of fire clay, that are cut-out only against the chamber for heating the specimen.

The central tube (4) made of refractory steel is cutout on two opposite sides on the length of the chamber for heating the specimen. This length is equal with the gauged length.

The mobile carrier (7) moves on the guides (8) together with the furnace (1), on which it is fastened by screws (M6) after each breaking of a specimen, in order to replace it with another one, for a new test.

The three thermocouples Pt-RhPt are connected (after their pairing) as follows: the first one for regulating the electric supplying installation at the temperature required for measurement, the second one is connected to a installation for digital measurement of the specimen temperature and the third one is mounted on a device for recording the temperature during the practical measurements.

3.ENCLOSURES FOR PERFORMING HARDNESS TESTS AT HIGH TEMPERATURES

The hardness tests performed at high temperatures have gained more and more importance, as the resistance elements of the vessels, of the gas and steam turbines, of the reactors, etc. work long time at high temperatures, being stressed by high mechanical loads. As comparing to the tensile tests, the high temperature hardness test has the advantage that it is performed very quickly and with much more simple devices.

The corresponding testing methods are the Brinell and Vickers procedures. In order to perform these, there can be used normal construction devices, at which a heating furnace is adjusted.

The specimen that is to be tested is brought into the furnace heated at the required temperature and it is held there until the furnace temperature is reached. The temperature is automatically adjusted within ±3°C. There is to be made vacuum (0,01 mm Hg) inside the furnace in order to avoid the oxidizing of the specimen surface.

When the temperature of the specimen has reached the prescribed temperature, the penetration tester is pressed with a corresponding force, just like when determining the hardness at ordinary temperatures. The measuring of the print dimension is performed after the specimen is taken out of the furnace and its temperature has reached the ambient temperature. The time during which the penetration tester is kept in contact with the specimen has a decisive influence on the measurement result. This time can vary from a few minutes up to a few hours and is to be chosen depending on the nature of the material.

The penetration testers used when performing these tests have to be temperature resistant. For temperatures under 300°C, there are to be used alloyed steel balls, for temperatures between 300-600°C there are to be used diamond penetration testers and at temperatures over 600°C, there are to be used synthetic carborundum penetration testers.

In order to avoid a too intense heating of the penetration tester, it is very advantageous to use the dynamic methods, at which the contact between the penetration tester and the heated specimen is kept only during the shock.

Two possibilities for execution the enclosures that are used for performing the high temperature hardness tests are presented. At the lower end of the rod 1 (Figure 2) the holder 4 is mounted with the hole under the penetration tester 2. The upper end of the rod is to be brought into the hole made at the end of the device and it is fastened into it by means of a tightening screw 7. A rod having a penetrating tester with a 120° acute-angled tip can replace the rod on which the detachable penetration testers 2 are mounted. On the working table of the device, the holder (console) 3 made of high temperature resistant steel that is used as a holder for the studied specimen, is to be simple fastened or screwed on.

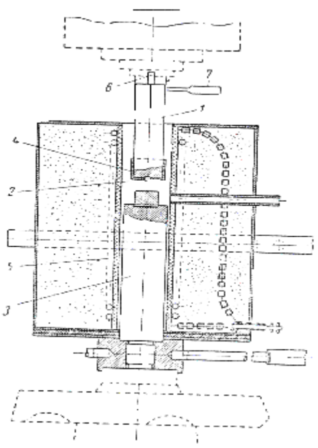

Fig.2. *Constructive version of an enclosure that can be adjusted to the Brinell hardness device*

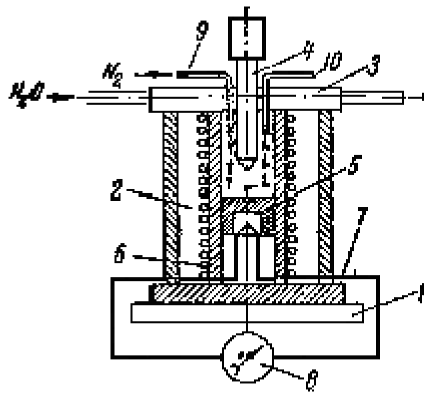

Fig. 3. *Constructive version of an enclosure used for heating the specimens that are to be subjected to the high temperature hardness test*

The main request for a proper performing of the high temperature hardness test is the equality between the temperature of the tested specimen and that of the penetration tester. The shape of the enclosures used when performing the hot hardness tests do not cause difficulties in what concerns the heating of the specimen and of the penetration tester at the required testing temperature, as long as the furnace is isolated from the device working table by asbestos packing or by any other material which is not heat conductive.

In order to prevent the furnace muffle from being rusty, this can be protected inner and outer by an inert gas, for example nitrogen (Figure 3). This protection can be also made in order to reduce the effect of the scale layer, even if very thin, that is generated on the surface of the specimens subjected at high testing temperatures. In case of the constructive version from Figure 3, the gas from the bulb passes through the pipe 9, and the spare gas passes through the pipe 10.

4.WAYS OF HEATING THE SPECIMENS FOR PERFORMING HIGH TEMPERATURE SHOCK BENDING TEST

The equipment used for performing the high temperature shock-bending test is the Charpy friction pendulum that has a simple and robust construction, and which has to fulfil all the conditions imposed by the standard *SR EN 10045-2:1994 Shock-bending test on Charpy specimens, Vol. 2: Checking the testing equipment (friction pendulum).*

The experiments within the high temperature field are more difficult to be performed because, as comparing to other mechanical tests, in case of shock-bending test, the temperature of the specimen could strongly change during the manipulation of the specimen from the furnace to the testing equipment.

For a more thoroughly study of the phenomenon that occur during this dynamic shock test, friction pendulums endowed with special equipment that allow the recording of the strains during the test are used.

The heating of the specimens up to the testing temperature can be performed inside different types of enclosures that differ depending on their position inside the testing machine.

An analyzed constructive version is that in which the detachable electric furnace is mounted on a supporting pole near the ram fastened in the upper position. The furnace shell is to be made of two parts, connected by hinges. For lining, the fire clay is used. On the front and on the back walls of the furnace, there are holes for bringing the specimens inside the furnace-working chamber.

After the required temperature is reached, the specimen is kept 10-15 minutes inside the furnace, and then, by switching on the test, the furnace opens and the ram falls together with the specimen.

The high precision can be reached by the rapidity of opening the furnace and of performing the test (a few seconds).

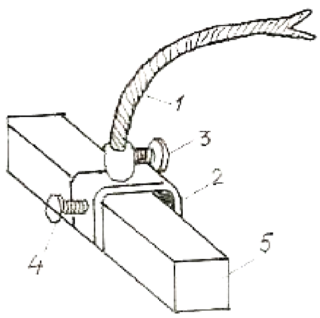

Fig.4. *Way of fastening the thermocouple on the specimen for performing the shock bending test*

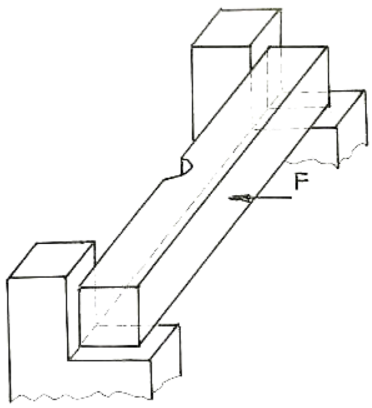

Fig. 5*. Performing the test on the heated specimen*

A special issue during this test is that of measuring the specimen temperature until it breaks. This can be performed as follows: on the opposite side of the specimen notch, at 10 mm from the front side or even on the front side, a 1,2 mm diameter and 5 mm depth hole is to be executed. In this hole the high spot of the thermocouple is brought and it is fastened by means of a thin Ni-Cr wire. Between the thermocouple and the Ni-Cr wire, an asbestos plate for electrical insulating is placed.

Some of the advantages of this method could be the fact that the high spot of the thermocouple is located on the side opposite the specimen notch, at 10 mm distance from the front side or even on the front side. The conditions for cooling the middle part of the specimen and its front part are different. That is why their temperature must not be the same. The asbestos packing that protects the specimen not to be strongly cooled in case it comes into contact with the walls of the impact machine attenuates a little the shock.

The thermocouple is fastened as follows: the thermocouple 1, insulated with an asbestos string is fixed on the specimen O by means of some special clamps, so that the high spot is to be found on the notch. The screw 3 fastens the thermocouple in clamps, and the screws 4 are to be strongly tightened in order to hold the specimen properly. When a certain desired temperature is reached, the thermocouple together with the clamps is taken out from the specimen and then the test is performed. In this way, the temperature control can be performed until the specimen breaks.

5.CONCLUSIONS

When performing the high temperature tensile test it is not recommended to heat individually each sample because of the very high time wastes and that is why more productive methods are to be developed. They have to be oriented on the reducing of the heating period, excluding the influence generated by the heating acceleration on the test results.

The main request for a proper performing the high temperature hardness test is the equality between the temperature of the tested sample and that of the penetration tester. The shape of the enclosures that are used when performing the warm hardness tests does not generate difficulties concerning the heating of the sample and of the penetration tester at the prescribed testing temperature, as long as the furnace is isolated from the table of the device by asbestos packing or by any other material that is not heat conductive.

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