A MACHINE FOR DETERMINATION OF THE CHARACTERISTICS OF CRACK RESISTANCE IN THE CRACK ARREST STAGE AT NORMAL AND LOW TEMPERATURES

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The method recommendations on determination of the characteristics of fracture toughness (crack resistance) in the crack arrest stage establish certain requirements for test machines and above all else for their rigidity [1]. It is desirable that the rigidity of the machine be an order of magnitude greater than the rigidity of the specimen. The capacity of the test machine to fix the specified external displacement regardless of what load is required for this is also important [2]. Based on this it is possible to conclude that mechanical machines are preferable to hydraulic.

From Fig. 1, which gives the rigidities of various test machines according to the data presented in [3], it follows that the rigidity of the majority of the machines is insufficient even for 20-mm-thick double cantilever beam type specimens, which are the most commonly used in crack arrest tests.

Double cantilever beam specimens are loaded by various methods including through pins (off-center tension) [1], by a wedge parallel or transverse to the specimen (compression [4, 5], or by a thrust screw (torsion) [1]. Since each of these methods possesses both advantages and disadvantages it is desirable that the machine permit use of all of these forms of loading.

In the Institute of Strength Problems of the Academy of Sciences of the Ukrainian SSR using a KM-50 test machine as a base, a machine with increased rigidity has been built making it possible to conduct crack resistance tests of double cantilever beam specimens up to 20 mm thick. On it it is possible to load in tension, compression, and torsion. Figure 2 shows the general plan of the machine, which uses the base 1 of the KM-50 machine with the drive mechanism mounted on it and also the fastened steel columns 2. The remaining assemblies and parts were specially developed for the machine built.

The columns 2 are fastened to each other by the upper crosspiece 5. The feed screw 14 is rotated through a reducer by an electric motor or manually. The feed nut 13 is rigidly connected to the feed screw and rotation of it causes movement of the lower load rod 12. This rod is located in the guide sleeve 11, which is fastened to the lower crosspiece 3. The tensile or compressive force is transmitted through the rod to the lower clamp 10 and then to the specimen 9. The upper clamp 8 is connected through the rod 7 with the spherical bearing 6 to the upper crosspiece. The upper and lower crosspieces are fastened to each other by the short thrust columns 4.

The specimen is centered by the double cylindrical hinge formed by the joints of the clamp with the specimens and the clamp with the rod. This method of loading makes it possible to provide off-center tension of double cantilever beam specimens.

On the machine it is possible to test double cantilever beam specimens with loading of them with a wedge. In this case the wedge 2 (Fig. 3) is placed in the upper crosspiece 1 in place of the upper load rod. The test specimen 3 rests on its end on the lower load rod 5 through the ball 4.

The machine also makes it possible to load the specimen with the use of a thrust screw. For this the crossbeam and the upper 1 and lower 4 clamps of the KM-50 test machine are used. Into the clamps are inserted the thrust screws 3 holding the specimen 2 (Fig. 4).

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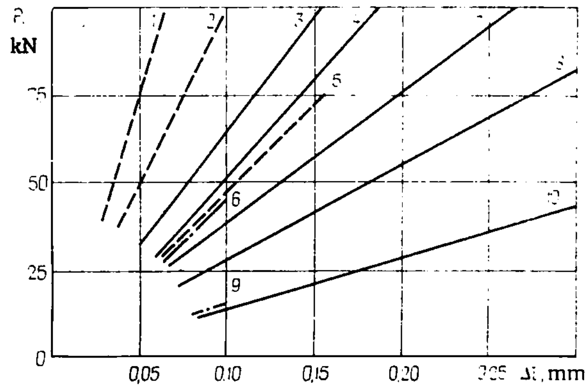

Fig. 1. The rigidity of test machines and double cantilever beam specimens: 1) the load frame of a machine for crack resistance testing; 2) the same with added rods; 3) TsD-40 test machine; 4) TsD-10 test machine; 5) load frame of a machine for crack resistance testing with added rods and studs; 6) 20-mm-thick double cantilever beam specimen; 7) TsD-4 test machine; 8) TsDMI-30 test machine; 9) 10-mm-thick double cantilever beam specimen; 10) Instron TTK-25 test machine.

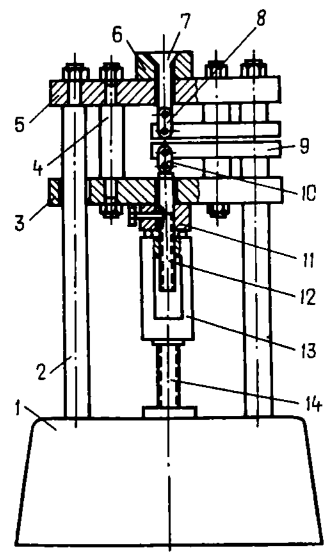

Fig. 2. General plan of the machine for determination of the crack resistance characteristics in the crack arrest stage.

Increased rigidity of the machine is provided by the fact that the upper and lower crosspieces (Fig. 2) were produced by welding of thick plates and have a П-shaped cross section. They are connected to each other by short, heavy thrust columns. The crosspieces and the columns form the load frame, the rigidity of which is greater than that shown in Fig. 1 for all of the other test machines. Connection of the load rods to the load frame reduces the rigidity of the whole system insignificantly. The least rigid element is the pins with which the clamps are fastened. To a significant degree the presence of the pins reduces the rigidity of the load system of the machine, which follows from the characteristics presented in Fig. 1.

Figure 5 shows the plan of recording the forces and displacements in off-center tension testing of double cantilever beam testing specimens. The force transmitted to the specimen is recorded with the use of the strain gauges 6 cemented to the upper load rod 5 connected to the clamp 4. After amplification in the strain gauge amplifier 7 the signal from the

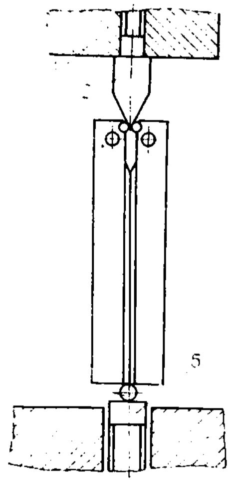

Fig. 3

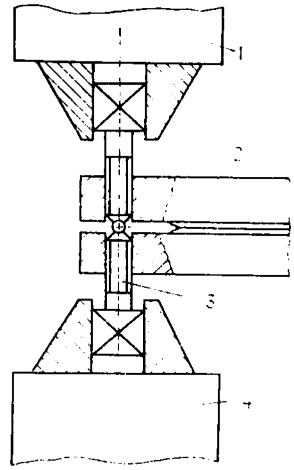

Fig. 4

Fig. 3. Loading of a specimen with the use of a wedge.

Fig. 4. Loading of the specimen with the use of a thrust screw.

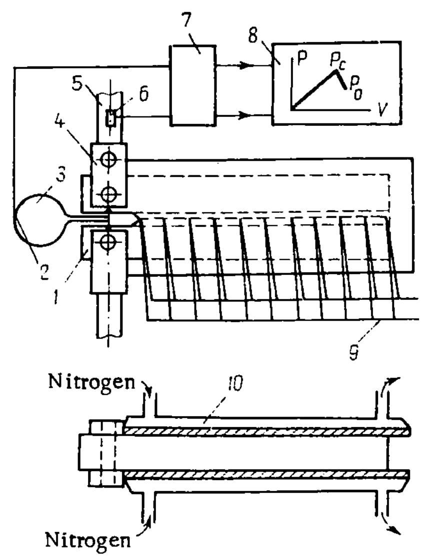

Fig. 5. Plan of measurement of the forces, displacements, and temperature and the device for cooling the specimen.

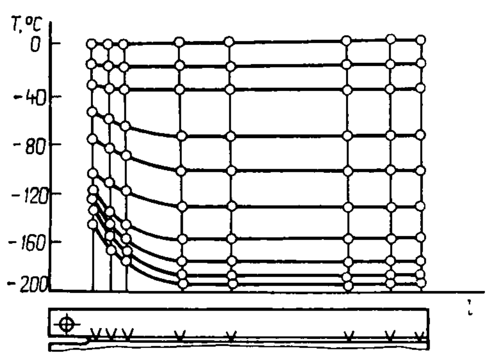

Fig. 6. The temperature distribution along the length of a 20-mm-thick double cantilever beam specimen.

strain gauges is supplied to the two-coordinate recorder 8. The displacements on the line of action of the force are recorded with the use of the bracket 3 on which are cemented the resistance strain gauges 2. After amplification in the strain gauge amplifier 7 the signal from them is also supplied to the two-coordinate recorder 8. The recorder records the load—displacement curve.

The specimen 1 is cooled with two contact coolers 10 to which nitrogen in the gaseous or liquid state is supplied from a Dewar vessel, and the rate of supply is regulated by a special device [6].

The specimen temperature is recorded with the copper—constantan thermocouples 9 and their junctions are welded in the groove along which the crack advances. The surfaces of the specimen not covered with the coolers are thermally insulated with foam plastic.

The temperature distribution along the length of a specimen is shown in Fig. 6. With insignificant cooling (to —40°C) the specimen temperature is practically the same over the whole length while with more thorough cooling the portion of the specimen located near the clamps has a higher temperature. Selection of the proper length of the original crack makes it possible to conduct tests under isothermal conditions.

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