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RESEARCH ON THE INFLUENCE OF HIGH TEMPERATURES ON THE TENACITY OF 12MoCr90 STEEL

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ABSTRACT
The paper introduces the shock bending test for steel grade 12MoCr90 carried out on Mesnager-type test rods (the groove depth h = 2 mm) under high temperatures. The test rods were longitudinal, respectively cross-sectional samples of semi-finished ingots. We introduced the results of the experiments and the analysis of the influence that the type of test rod sampled longitudinally or cross-sectionally with respect to the rolling direction, has upon the values of resilience.
During the experiments, the heating of the test rods meant for bend shock under high temperatures was being done in an oven built by the author on this particular purpose.
Keywords: dynamic shock, high temperature, resilience.

1. GENERAL CONSIDERATIONS
The dynamic shock trials are being used in order to study material behavior under high charging rates, in order to point out their deforming capacity under high deformation rates, and the dependency on the strain state and trial temperature. On principle, these dynamic trials can be carried out for all simple strains: traction, compression, bending and torsion. Out of these, it is only shock bending that is norm-regulated [10].
In order to carry out the shock bending test under high temperatures, the following elements are needed: test rods, having well-determined shapes and dimensions; an oven for heating up the test rods to the desired temperature and a scale pendulum hammer (Charpy hammer).
Test rod heating up to high temperatures can be done in ovens that, on principle, consist in a thermally insulated room, in which the set of test rods can be placed on a stand, so as to ensure their contact on all surfaces with the heating means. The ovens are either delivered as annexes of the trial equipment, or are built in the industrial labs mean for mechanical trials. After the rod reaches the desired temperature, it is being kept for a time at this temperature and removed from the heating oven and placed on the trial device of machine, in view of performing the trial.
The time elapsed while handling the test rod between the oven and the trial device must be short enough in order to basically keep the trial temperature of the test rod.
Once the *trial temperature has increased* the character of the break is influenced by a series of factors such as: the content in alloy elements, the content in impurifying elements (sulphur, phosphorus, oxygen, hydrogen, etc,); the strain focusers, and also the surface flaws; microstructure; hardness.

2. THE TEST RODS USED IN SHOCK BENDING TRIALS
The shock bending trial under high temperatures shall be carried out similarly to the one done at room temperature and the length and cross section of the test rods used in the shock bending trials must be chosen according to the capacity of the pendulum-hammer.
Norm [10] points out that "in case of trials carried out under temperatures other than room temperature, the test rod should be introduced into a heating means for a sufficient time span, so as the entire test rod reach the respective temperature (for example 10 minutes into a liquid or at least 30

minutes into a gaseous medium). The test rod must be broken within 5 seconds from the moment it has been removed from the heating device.
The principle of shock bending trial consist in breaking at a single blow, by means of a pendulum hammer, under determined conditions, a test rod having a U or V-groove in the middle, seated on two supports. The determined characteristic is called **absorbed energy** [J] and it is specific for the shock resistance of materials (also called “resilience”).
The sampling procedure, the type of test rod used, the number of test rods, the thermal treatment applied (as the case may be) and their orientation are mentioned in the product standards.

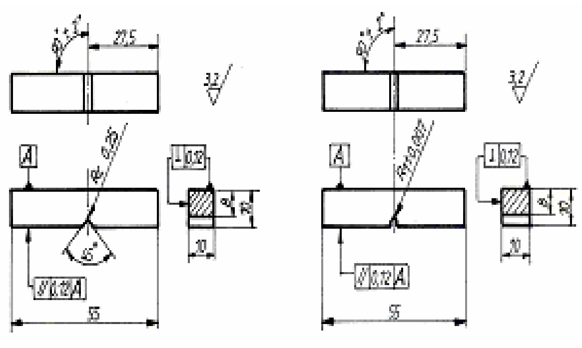

Figure 1. The shape and dimensions of the test rods used in the trials

The cropping and working of the test rods shall be done only by cutting procedures. The **U** groove shall be obtained by drilling, making use of an adequate device, and the **V** groove shall be done by means of a properly shaped milling machine.
The shape and dimensions of the test rods to be used in the experiments are given in figure 1.
For steels with special destination, working under high temperatures, we used U-grooved test rods.
The U shape of the groove brings into relief the capacity of a steel to resist initial cracking and the V shape points out to the capacity of a steel to resist the propagation of an existing crack.

During the experiments, the heating of the test rods meant for bend shock under high temperatures was being done in an oven built by the author on this particular purpose. We also had in view the estimation of the shock bending characteristic of cross-sectionally sampled test rods with respect to that determined for longitudinally sampled ones, for a certain trial temperature.

3. THE TRIALS

In order to demonstrate the tough character of the steel under study at high temperatures we carried out chock bending tests on test rods longitudinally, respectively cross-sectionally sampled with respect to the rolling direction.
We used test rods having the width b = 10 mm, with the **U** groove of depth h = 2mm, as mentioned in the product norms given for steel 12MoCr90, at room temperature.
The shock bending trial was done on lot of three test rods, for each temperature level between + 20^{0}C and +500^{0}C.

Table 1. Chemical composition of steel 12MoCr90

Material	C	Mn	Si	S	P	Cr	Ni	Al	Mo
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
12MoCr90	0,15	0,58	0,55	0,015	0,011	9,42	0,17	0,09	0,95
STAS 8185-77	0,08… 0,15	0,30… 0,60	0,25… 1,00	max. 0,035	max. 0,035	8,00… 10,00	-	0,015- 0,045	0,90… 1,10

The test rods used in the experiment were sampled from a 12MoCr90 steel charge, elaborated in an electric arc oven, having a chemical composition that complies with the product standard. The surface working of the test rods was made by cutting and the groove by drilling by means of a proper machine.

4.EXPERIMENTAL RESULTS

The experimental values obtained as a result of the trials are given in table 2.
The test rods were heated up in an oven and kept at the respective temperature for about 10 minutes, so as temperature deviations in the last 5 minutes ranged within the accepted limit deviations [10].
The temperature of the test rods was measured by means of a Cr-Al thermo-coupling.

Test rod handling was done by means of some pliers of special construction, whose active part was heated up to the same temperature and that allowed setting and centering the test rod on the stand of the pendulum-hammer, which was ready for the trial. The test rods were broken within 5 seconds from the moment they were removed from the oven.

Table 2. The resilience values – for the 12MoCr90 steel test rods longitudinally and cross-sectionally sampled

Temp.	KCU2 resilience for the longitudinally sampled test rods [J/cm^2]			Mean	Temp.	KCU resilience for the cross-sectionally sampled test rods [J/cm^2]			Mean
+20^{0}C	132	142	140	**138,00**	+20^{0}C	40	51	43	**44,66**
+100^{0}C	146	149	148	**147,66**	+100^{0}C	52	60	61	**57,66**
+200^{0}C	174	192	180	**182,00**	+200^{0}C	54	62	54	**56,66**
+300^{0}C	175	156	170	**167,00**	+300^{0}C	62	68	52	**60,66**
+400^{0}C	172	172	172	**172,00**	+400^{0}C	86	70	72	**76,00**
+500^{0}C	169	166	168	**167,66**	+500^{0}C	66	67	64	**65,66**

As a result of the trials, we could determine the KCU2 resiliencies for the test rods that were longitudinally, respectively cross-sectionally sampled as to the rolling direction.
Picture 1 shows a lots of test rods after their trial under high temperatures.
The resilience variation with temperature is given in figure 3 and figure 4.

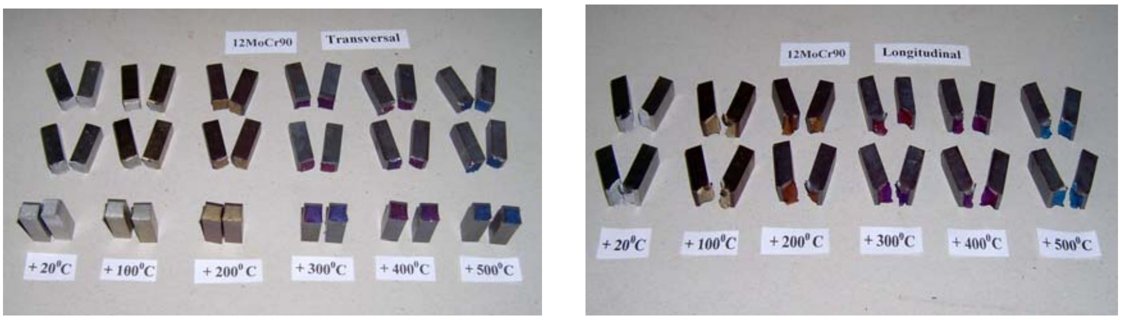

Figure 2. Lots of test rods tried under high temperatures

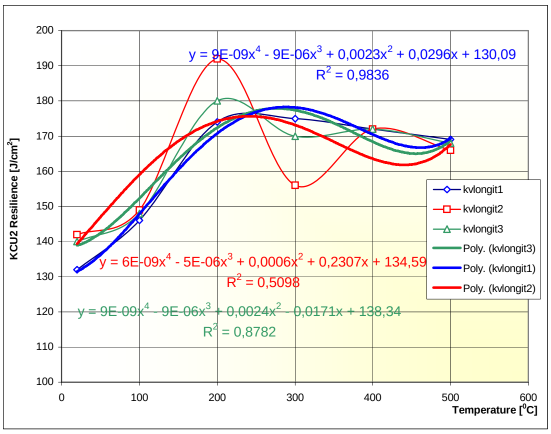

Figure 3. The KCU2 resilience variation with respect to trial temperature, for test rods longitudinally sampled as to the rolling direction

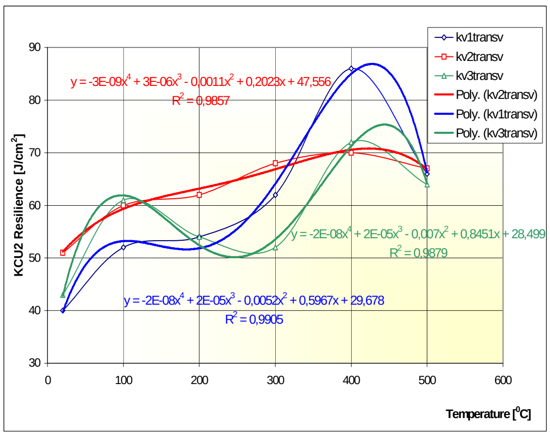

Figure 4. The KCU2 resilience variation with respect to trial temperature, for test rods cross-sectionally sampled as to the rolling direction

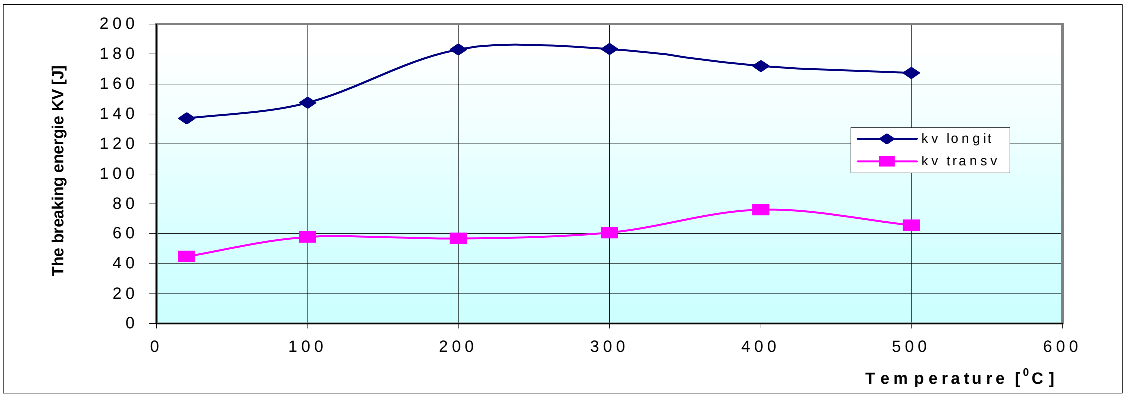

Figure 5. The KCU2 resilience variation with respect to trial temperature, for test rods longitudinally and cross-sectionally sampled made of 12MoCr90 steel

5. CONCLUSIONS

We obtained two types of curves, an experimental one, through points, and another one, by interpolation, by means of the 4th degree polynomial function. Both graphics were obtained with the approximately same form, and their analyses conclude that the breakage energy respects a polynomial variation law of the fourth degree, since the correlation coefficients obtained have values between 0,98…0,99.

Therefore we may say that KV breakage energy simultaneously with the rise of temperature, reaching a maximum value of 100^{0}C, after which it decreases up to 180…250^{0}C. At this point we experience a new tendency to increase, a more obvious one than the one at 100^{0}C (till 450^{0}C) after which it suddenly decreases. The same explanation is to be found at the dynamic stress, when this type of steel shows a tendency to fracture around temperatures of 400…450^{0}C.

Experiments have proved through point marking graphics, that for the type of steel under disenssion, there is a maximum point of breakage energy, around temperatures of 200^{0}C, for longitudinal test specimens, if we analise the experimental curve.

In order the study the tenacity of this steel grade according to the test rot type of sampling (longitudinal or cross-sectional) we drew the graph given in fig. 5, which clearly shows that at high temperatures, the breaking energy for the longitudinally sampled test rods is clearly higher than in the case of transversal test specimens, investigated at different temperatures by analyzing the breakage surface ist is to be noticed that they have a fibrous structure, typical of through materials.

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