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THE INFLUENCE OF LOW TEMPERATURES ON THE MECHANICAL CHARACTERISTICS OF THE 34MoCrNi15X-RS STEEL UNDERGOING SHOCK-BENDING, DEPENDING ON THE SAMPLING POSITION

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Abstract
The paper introduces the tests of shock bending undergone over the 34MoCrNi15X-RS steel, carried out on Mesnager test bars (the groove depth h = 2mm), under low temperatures. The test bars were longitudinal, respectively cross-sectional samples of semi-finished sections of ingot middle. We first described the cooling room we used, then gave the experimental results obtained and analyzed the influence of the main alloy elements on the values of resilience.
Keywords
shock bending, low temperatures, cooling room.

1. GENERAL NOTIONS

The principle of the shock-bending test consists in breaking at a single blow, with a pendulum hammer, under determined conditions, of a test bar having a groove at its middle, **U** or **V** shaped, freely placed on two supports.

The shock-bending test is dealt with in **SR EN 10045-1:1993**, where general considerations are being given with respect to the conditions for low temperature tests. Although this European norm replaces **STAS 6833 -79**, which sets the conditions for shock-bending under low temperatures, the **standard** products are still being processes according to the national standards.

In order to carry out shock-bending tests under low temperatures we need the following elements: test bars of a well-determined shape and size; a cooling-room for cooling the test bars down and a pendulum-hammer provided with a scale, (Charpy hammer). The special character of this test consists in the fact that the test bars are being cooled down in a cooling room, which is out of the work area of the pendulum-hammer. Generally it is necessary to, sub-cool the test bars in the cooling room and to reduce the handling time to 5 seconds at most.

2. THE ROOM FOR COOLING TEST BARS

We used for the tests a cooling room built by the author, which uses as cooling agent solid carbon dioxide and as cooling medium acetone or ethylic alcohol. We thus have a liquid cooling agent.

This cooling room [3], cylinder-shaped, is shown schematically in fig.1. Between the inner pot (1) mage of stainless steel and the exterior one (2) there is a thermal insulation(5) made of mineral cotton. At the top, the two pots are connected by a textolite flange (3) provided with a mounting (9) made of asbestos plate. Between the posts, at the bottom, there is an oak grate (6) to support the inner pot.

In order to level the temperature of the cooling agent, the room has a stirring device (4), mounted on the cover of the room through the leading hub (13) and worked upon by means of a textolite piece (14).

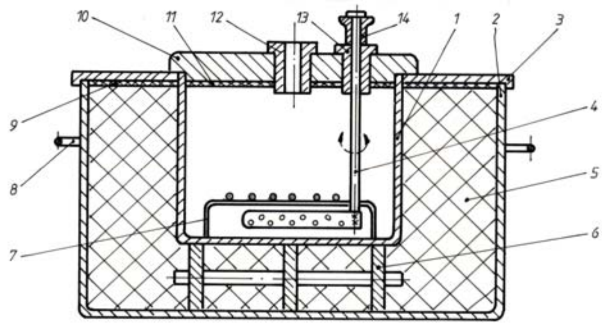

Fig.1. Cooling room with liquid cooling agent

On the bottom of the pot there is a stainless steel wire grate (7) on which the test bars to be cooled are placed.

The cooling room has a cover (10) made of textolite, muffled with asbestos (11), and meant to close the workroom at the top. The cover is provided with a leading hub (12) through which the thermometer or the thermo-couple can be introduced, in order to measure the temperature of the cooling agent.

3. THE TEST BARS USED IN THE TEST

The **34MoCrNi15X-RS** steel is used for welded joining. Unlike with other steel grades, the determination of the mechanical characteristics is carried out on test bars that are samples of rolled sections that have undergone thermal treatments.

The experiments have been carried out on Mesnager-type test bars (the groove depth h = 2 mm) that are longitudinal, respectively cross-sectional samples of semi-finished sections of ingot middle. The low temperature used for shock-bending tests was -30°C (243K).

4. THE RESULTS OF THE EXPERIMENTS AND CONCLUSIONS

As a result of the shock-bending tests at room and low temperature (-30°C) for the **34MoCrNi15X-RS** steel, we obtained medium values for every three steel charge and they were given in table 1.

Table 1. The Chemical Structure and the Values of Resilience KCU2 for the 34MoCrNi15X-RS Steel

Charge No.	C	Mn	S	P	Cr	Ni	Mo	+20°C(293K)		-30°C(243K)	
	%	%	%	%	%	%	%	L	T	L	T
								[J/cm²]		[J/cm²]	
1	0,31	0,47	0,015	0,018	1,56	1,44	0,16	96,33	53,66	65,33	43
2	0,32	0,52	0,012	0,020	1,40	1,45	0,16	171	62	123,66	40
3	0,33	0,43	0,008	0,018	1,46	1,64	0,19	166	62,66	145	45,33
4	0,32	0,44	0,010	0,018	1,55	1,45	0,21	172	90,66	148,33	66
5	0,31	0,50	0,012	0,017	1,60	1,42	0,17	166	78,33	119	54,66
6	0,33	0,44	0,022	0,024	1,46	1,42	0,22	139	68,66	85	45
7	0,38	0,57	0,010	0,016	1,54	1,45	0,22	134,6	91,33	89	61,33
8	0,32	0,55	0,016	0,018	1,55	1,51	0,18	182,6	62	141,33	56,33
9	0,34	0,57	0,015	0,018	1,46	1,49	0,17	138,6	68	93,66	46,33
10	0,33	0,47	0,020	0,020	1,58	1,44	0,17	162,3	72	118,66	58
11	0,34	0,51	0,014	0,025	1,74	1,42	0,25	148	56	91,66	35
12	0,35	0,59	0,011	0,014	1,48	1,57	0,20	186,6	118,6	137,33	82,33
13	0,35	0,44	0,013	0,018	1,51	1,54	0,17	147,6	68,33	105,33	42,66
14	0,36	0,45	0,020	0,019	1,48	1,51	0,23	155,6	66,33	107,33	44
15	0,35	0,44	0,016	0,018	1,48	1,46	0,21	131,3	60,33	108,33	46,33

The variation of resilience at low temperature according to the main elements of the chemical composition is as follows: the influence of Nickel contents - fig.2.a.; the influence of Chrome contents - fig.2.b and the influence of Carbon contents - fig. 2.c.

By analyzing the graphs in the given figures we notice that the values of resilience we obtained for test bars that are cross-sectional samples are smaller than for the longitudinal ones; yet, a certain equal distance is preserved between the variation curves, which show that different contents in **Ni**, **Cr** and **C** have no influence upon these differences.

Fig.2.a shows an increase in the value of resilience alongside with the increase in the contents of **Ni**. For the longitudinally sampled test bars the value KCU2/-30 is higher than the minimum one required for room temperature tests (KCU2 = 62,5 J/mm²). Even for the cross-sectionally sampled test bars taken from charges having contents in **Ni** higher than

1,6%, KCU2/-30 is higher than KCU2. These results prove that nickel is the alloy element that ensures steel a high tenacity even at low temperatures.

The chrome contents required by this steel grade are 1,40... 1,70%. Fig.2.b shows a decrease of resilience KCU2/-30 when the contents in chrome increase.

Fig.2.c. proves that resilience KCU/-30 has a maximum value for both longitudinally and cross-sectionally sampled test bars, when the contents in carbon are 0,34%, which corresponds to the mean of the interval 0,30%...0,38% carbon, requested by this steel grade.

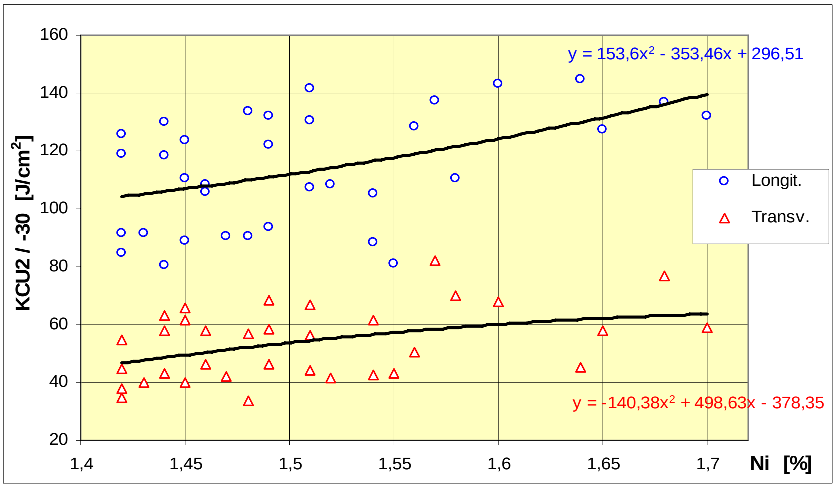

Fig.2.a. The variation of resilience KCU2/-30 according to the contents in Ni

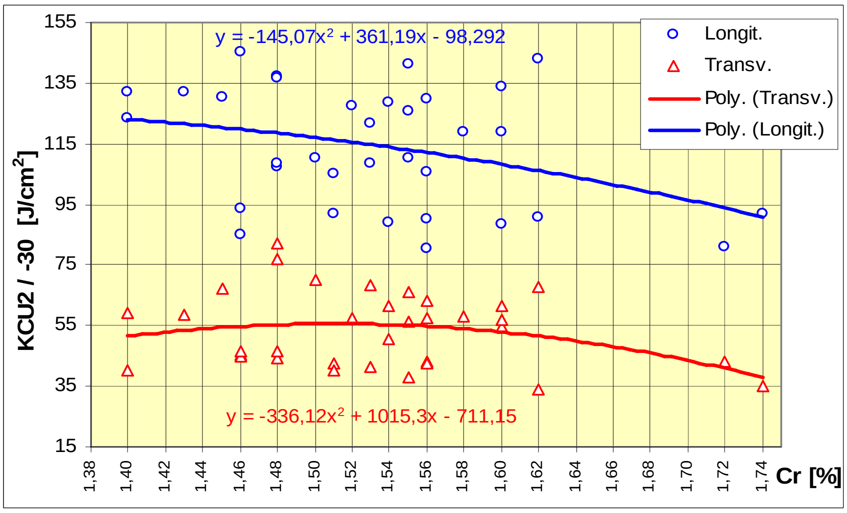

Fig.2.b. The variation of resilience KCU2/-30 according to the contents in Cr

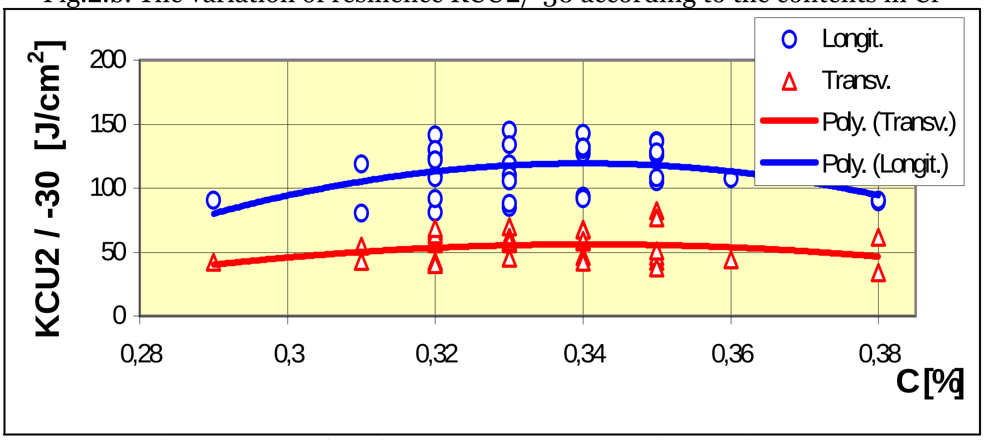

Fig.2.c. The variation of resilience KCU2/-30 according to the contents in C

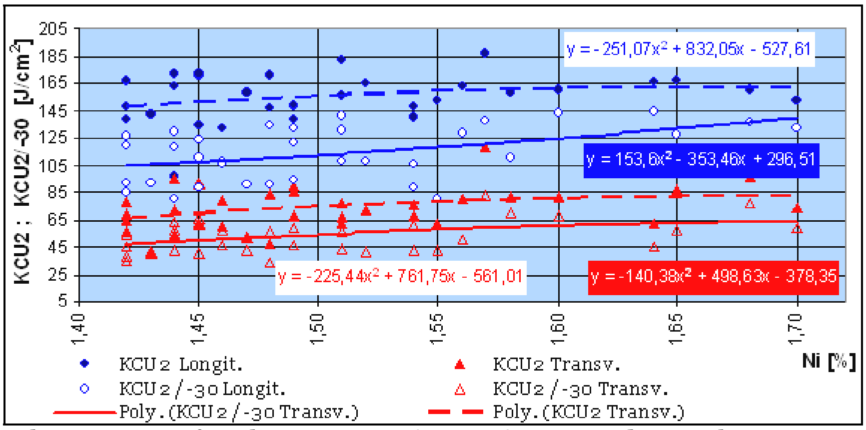

Fig.3 The variation of resiliences KCU2/ KCU2/-30 according to the contents in Ni

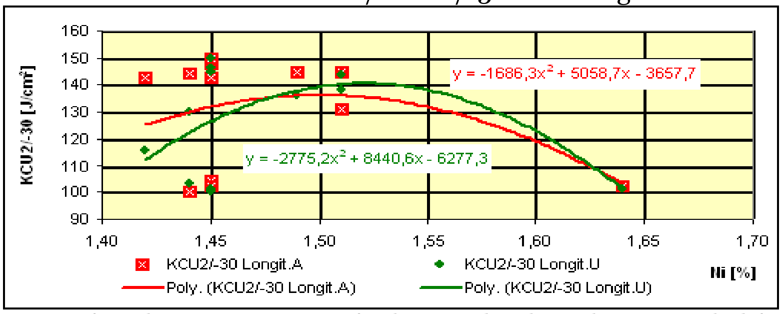

Fig.4.The variation of resilience KCU2/-30 for longitudinal test bars sampled from ingot butt, respectively ingot crop, according to the contents in Ni

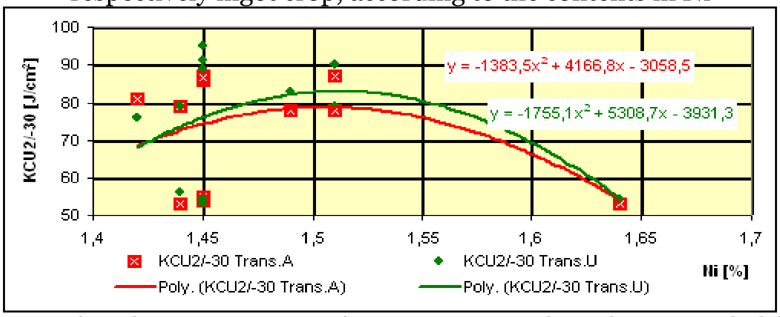

Fig.5. The variation of resilience KCU2/-30 for cross-sectional test bars sampled from ingot butt, respectively ingot crop, according to the contents in Ni

Fig.3 gives the comparative variation diagrams for resiliences at room temperature (KCU2) respectively at low temperature (KCU2/-30), for test longitudinal and cross-sectional bars, according to the contents in nickel.

The maximum values of resiliences correspond to the contents of 1,7% Ni, which represents the top limit of the domain requested by this chemical structure and steel grade.

For the **34MoCrNi15X-RS** steel we performed tests at -30°C on test bars coming from ingot butt (**A**), respectively ingot crop (**U**).

The variation of resilience for low test temperatures depending on the contents in nickel and the place of sampling is given as follows: for the longitudinal test bars sampled from ingot butt, respectively crop - fig.4 and from the cross-sectional test bars sampled from ingot butt, respectively crop - fig.5.

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