CONSIDERATIONS UPON DISPLACING DISLOCATIONS IN STEEL MoCrNi15

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Abstract: *The aim of these researches is to establish the optimum parameters in case of thermo cycles at welding moulds of material MoCrNi15.*

Key words: *secondary phases, critical space, resistance characteristics.*

1. Generalities

It was studied in many papers the way the mechanical properties and resistance characteristics influence the material submitted to cold hammering (extension of grains), less in case when takes place crystalline modification (processing through welding). As you can see in Figure 1.

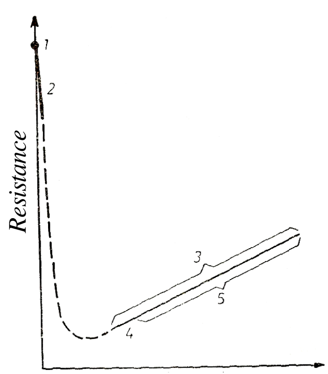

Fig. 1. *Variation resistance depending on density of dislocations*: 1 - *theoretical resistance*; 2 - *resistance of filiform crystals*; 3 - *the real resistance of materials and alloys*; 4 - *resistance of non cold hammered materials*; 5 - *resistance of cold hammered materials and alloys*

Following the way resistance varies depending on number of imperfections (density of dislocations) it is found out that depending on theoretical resistance, the measured one is versus 100…10000 smaller [2].

The theory of dislocations is one of the important problems of modern research, and realizing metallic materials with controlled dislocation density is a problem of future technique with a very special practice importance.

Steel brand MoCrNi15 is part of thermo resistant steels group, symbolized according EN 10027 and is frequently used in fields that function at temperatures between 450 ^{0}C and 560 ^{0}C.

2. Chemical, Structural and Mechanical Characterization of Steel MoCrNi15

Thermo resistant alloyed steel (with sum of alloying elements under 5%) theoretically have characteristics of thermo resistance which are dependent on the present particles of carbides.

There can be differentiated three classes of carbides, depending on their crystalline net:
- cubic net: TiC, V_4C_3 (VC), N_3C;
- hexagonal compact net: Mo_2C, MoC,

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W_2C, WC;

- ortorombic net: Fe_3C, Mn_3C.

Out of the researches performed it was evidenced the dependence between mechanic characteristics and dimensions of particles of secondary phases from the basic metallic matix.

Considering the particles of secondary phases as obstacles in displacing dislocations, there is a critical space over which appears the significant deterioration of characteristics of long term resistance.

Generally in the group of alloyed thermo resistant steels in the interval of high temperatures there appears the process of shortness through reverting to temperature inferior to creeping. This type of shortness produces decreasing of tenacity of weldable steel and has at its basis a series of mechanisms, among which I remind:

- hardening of basic metallic mass by precipitation of some carbides of type M_2C;
- structure modification in areas adjacent limits of grains, therefore of precipitation of some compounds of Ni, Cr, Mo and consequently a decrease of level of alloying in these areas of thermo resistant steels.

The chemical composition of thermo resistant alloyd steel used at tests MoCrNi15 according STAS 8184-87 is presented in Table 1.

The mechanical characteristics of resistance, deformability and tenacity established by trials of short time have high values which are preserved also in case of prolonged heating at temperatures of 450 ^{0}C - 560 ^{0}C.

Content of elements for MoCrNi15 Table 1

Steel brand	**Chemical composition [%]**							
STAS 8184-87	C	Mn	Si	Cr	Ni	Mo	S max	P max
MoCrNi15	0.5-0.6	0.5-0.8	0.15-0.35	0.6-0.8	1.3-1.6	0.15-0.30	0.030	0.030

3. Simulation of Thermic Cycles

Knowing thermo cycles from the thermic influenced area of welded joining shows a special interest for foreseeing metallographic structures and mechanical characteristics resulted, and this reason determined a deeper approaching of these processes both theoretically and experimentally.

It is remarked the fact that thermo cycle of welding is characterized by the high speed of heating and reduced time of maintaining at high temperature. These peculiarities generate a high gradient of temperature over which is lapped over a gradient of cooling speed [1].

Having in view this fact, we started prevailing samples from the same material MoCrNi15 with dimensions $5 \times 10 \times 60$ mm, using simulator for Smitweld LS 1402 welding.

Welding parameters:

• Peak temperature T_V = 1400 ^{0}C + 1100 ^{0}C + 800 ^{0}C;

• Heating speed:

- high speeds of heating 45-50 ^{0}C/s;
- slow speeds of heating 25-30 ^{0}C/s;

• High speeds of cooling:

- cooling high speeds 20-25 ^{0}C/s;
- cooling slow speeds 10-15 ^{0}C/s.

Choosing of these parameters was realized on the basis of the theory and tests according to which hardening of materials for moulds is never done in water in order to avoid inner tensions and danger of cracking (linear dislocations) [4].

In Table 2 there were presented the welding parameters depending on the number of thermic cycle.

Following samples breakage, the tests results were systematized in diagrams in order to establish the most unfavorable thermic cycle as well as the optimum thermic cycle.

Table 2

Variation of welding parameters depending on thermic cycle

Thermic cycle	T_{max} [^{0}C]	V_{inc} [^{0}C/s]	V_{rac} [^{0}C/s]
1	1400	45	20
2		30	20
3		45	10
4		30	10

In Figure 2 there are shown the average values obtained following the mechanical trials:

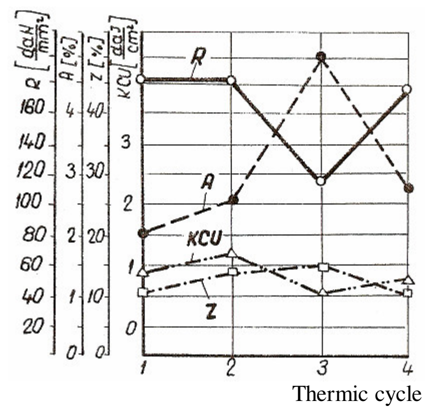

Fig. 2. *Variation of mechanical properties depending on thermic cycle*

From this picture one can notice the resistance at breaking and impact resistance decreases when materials were quickly heated and slowly cooled. Also one can notice that the most favorable values of impact resistance and mechanical resistance were obtained in case of materials slowly heated and then quickly cooled [1].

The microstructure was studied on broken surfaces of samples, after grinding, polishing and metallographic attack with nital (2% HNO_3 in ethylic alcohol).

The microfractographic analysis of breaking surfaces of samples subjected to thermic cycles, performed with electronic microscope TESLA shows the following [3]:

• At samples subjected to thermic cycles 1 (quick heating at temperatures of de 1400 ^{0}C, followed by a quick cooling) as it can been seen in Figure 3.

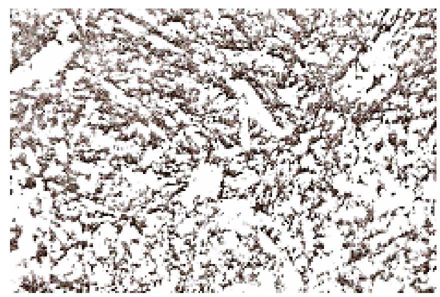

Fig. 3. *Trial 1* (*Atac Nital 2%, 500$_x$*)

- the structure is martensitic and contains rather important quantities of residual austenite ≈15%) and this is rather dangerous due to further changes the residual austenite undergoes.

• At the samples subjected to thermic cycle 2 (slow heating at temperatures of 1400 ^{0}C, followed by a quick cooling) as it can be seen in Figure 4.

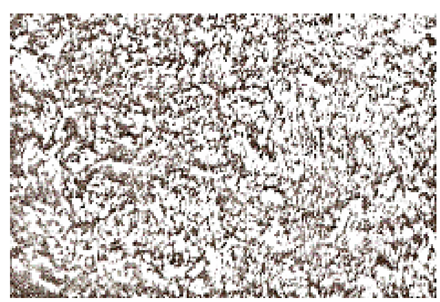

Fig. 4. *Test 2* (*Atac Nital 2%, 500$_x$*)

- the structure is martensitic and contains residual austenite. It is obtained an uniform distribution of austenite in the basic mass of martensite which is extremely fine.

• Steel MoCrNi15 may show an acicular structure as it can be seen in Figure 5.

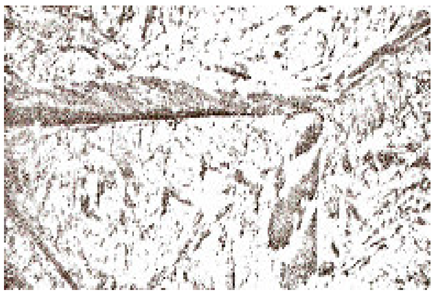

Fig. 5. *Test 3* (*Atac Nital 2%, 500$_x$*)

- This structure obtained according to cycle 3 (quick heating followed by a slow cooling), must be avoid because non homogeneities that may appear may be centers of advancing of dislocations.

• A certain homogeneity of steel structure MoCrNi15 may be noticed in Figure 6.

Fig. 6. *Trial 4* (*Atac Nital 2%, 500$_x$*)

- This structure obtained according to cycle 4 (slow heating, followed by slow cooling), is also martensitic (HV = 619), with content of residual ($\approx$10%).

4. Conclusions

• Mechanical properties and structure of MoCrNi15 steel are influenced by the form of thermic cycles they were subjected to;

• The thermic cycle that provoke an important modification of microstructure and a maximum decrease of mechanical properties are those where heating speed has high values (>140 ^{0}C/s), and the cooling speed has small values ($\approx$10 ^{0}C/s);

• Thermic cycles that present the most reduced influence upon microstructure and mechanical properties, are those where heating speed is reduced ($\approx$35^{0}C/s) (>25^{0}C/s).

References

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