OPTOELECTRONICS AND ADVANCED MATERIALS – RAPID COMMUNICATIONS Vol. 7, No. 11-12, November - December 2013, p. 947-951

Variation of mechanical properties with temperature for an ecomaterial

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In this paper is studied achievement tubes 73 × 5.51 mm degree N80 according to API - 5 CT, a rolling reduction extension (LRA), by thermo mechanical treatment without normalization. The regression equation was calculated from the measured temperature mechanical properties and rolling. Austenitic grain is determined by oxidation method provided in ASTM E 112. The variation in mechanical properties with temperature, as measured by a tensile test after lamination to the LRA.

(Received September 22, 2013; accepted November 7, 2013)

Keywords: Deformability, Discharge traction austenite grains

1. Introduction

The main purpose of micro alloyed steels is to obtain a high tensile strength combined with good toughness. The mechanism by which the properties that change is decreasing grain steel and lattice distortion of shape and size [1].

Micro alloyed steel is made by using one or more elements such as aluminum, vanadium, niobium, titanium, boron, etc. Each of these elements has a specific effect, whose knowledge will make it possible to determine the optimum values of processing parameters [2].

In addition to achieving an optimal balance between strength and toughness characteristics by the use of fine grain size can be obtained increasing the weld ability of the steel by lowering the carbon content to achieve the same level of tensile strength

Using micro alloyed while simultaneously reducing the carbon content of steel, lead to weight reduction per meter of pipe used in drilling [6].

Introduction micro alloyed steels used in different areas, made possible the development of very economical metal processing technologies such as thermo mechanical treatments, using products that cost price is greatly reduced due to elimination of heat treatment (normalization) with reduced metal and energy consumption [7].

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Some authors have studied in their works the most important aspects that prove the fact that carbon steel obtained through this new technology is an ecomaterial [7].

2. Materials and methods

Chemical composition limits;

The mechanical and technological characteristics; Special features: toughness, wear resistance, fatigue, corrosion

Industrial experiments were conducted on a rolling gear extension. It aimed to achieve pipes ϕ73 × 5.51 mm according to API – 5CT degree N80, on a rolling gear Extension (LRA) by thermomechanical treatment without normalization. For this we have used steel billets ϕ130 mm steel 31VMn12.

Table 1. Chemical compositions determined by product (laminated tube).

No	Element	STAS 8185-88 (for 31VMn12)	Values determined	
			min.	Max.
1	Carbon	0,28-0,34	0.3009	0.3283
2	Mangan	1,10-1,40	1.260	1.390
3	Siliciu	0,17-0,35	0.282	0.327
4	Fosfor	max. 0,035	0.01375	0.0162
5	Sulf	max. 0,035	0.01737	0.02577
6	Crom	max. 0,30	0.1344	0.1504
7	Molibden	max. 0,06	0.0308	0.0382
8	Nichel	max. 0,30	0.1128	0.1171
9	Cupru	max. 0,30	0.1396	0.1536
10	Vanadiu	0,10-0,20	0.1160	0.1332
11	Aluminiu	-	0.01522	0.01819
12	Azot	-	0.0070	0.0109

It is noted in all cases, the steel fall the provisions of STAS STAS 8185-88.

Heating for rolling LRA

Pipes reduced to LRA (mill reducer Extension) from blanks continuously hot rolled in the rolling mill.

In order to analyze the influence of the heating temperature before rolling on the final mechanical properties of the LRA pipes were divided into three groups (sets) of 10 tubes each of which has been programmed heating to temperatures 1050^0C (group I, the pipes 1 -10) at 1025^0C (group II – 11 to 20 pipes) and 1000^0C (group III – pipes 21-30).

The rolling temperature was chosen lower than those used in C-Mn steel rolling without vanadium, due to the results obtained in laboratory experiments, on the modification coefficient due to precipitation hardening and dynamic recrystallization [4].

3. Results and discussions

The mechanical properties measured by a tensile test after lamination to the LRA, all the pipes of the three groups, laminate temperatures of 1050, 1025 and 1000^0C are shown in Figs. 1.1 (a, b, c, d, e, f, g, h).

Analyzing it shows the following:

All results of 90 mechanical tests gave satisfactory results in relation to the provisions of API 5 CT / 1992 Statistical processing of these data showed that employment provisions of the standard mechanical properties API-5 CT / 1992 was made with a probability of over 98%, which is evident in practical terms is a proper situation.

Cold end of the tube (resulting from cold rolling end blanks) has an average yield slightly lower than the middle and end warm. The same conclusion is drawn in terms of tensile strength and elongation at break.

Statistical correlation between the rolling temperature and mechanical properties were highlighted by means of regression. The equations of this cube, which is the upper limit of the correlation coefficients of significance (for the number of data used in the analysis are presented in Table 1).

On the basis of these data were determined according to the optimum rolling temperature of all the three analyzed characteristics, yield strength, tensile strength and elongation, as shown in Fig. 2.

Based on these data show that the optimal heating temperature for lamination is from 1000 to 1050^0C temperature taking into account the accuracy of the heating carried out during the course of experimentation it is considered that can be met.

Table 2. The equation of mechanical properties (y) and the measured temperature expansion (x) and the LRA.

No.	Feature	Area of the pipe	The regression equation based on the temperature (X)	Correlation coefficient
1	Yield strength ($R_{p0,5}$) (N/mm^2)	cold end	It has not been found dependence	
		hot end	$y = 1{,}310 \times 10^6 - 3758 x + 3{,}572 x^2 - 1{,}13 . 10^{-3} x^3$	0.5341
		middle	$y = - 963040 + 2770 x - 2{,}6547 x^2 + 8{,}47738 . 10^{-4} x^3$	0,5606
2	Tensile strength, R_m (N/mm^2)	cold end	$y = 466904 + 1{,}366{,}44 x - 1{,}33 x^2 + 4{,}317 . 10^{-4} x^3$	0,3557
		hot end	$y = 194{,}4 - 0{,}648 x$	0,5381
		middle	$y = 827067 - 2345 x + 2{,}2177 x^2 - 6{,}988 . 10^4 x^3$	0,4211
3	Elongation A_2, (%)	cold end	$y = 30992 - 90{,}28 x + 0{,}08767 x^2 - 2{,}837 . 10^{-5} x^3$	0,3631
		hot end	$y = - 17640 + 51{,}595 x - 0{,}0509 x^2 + 1{,}6276 . 10^{-5} X^3$	0,4161
		middle	$y = - 21261 + 60{,}61 x - 0{,}0575 x^2 + 1{,}8177 x^3$	0,3524

Limit values for a significance probability 25-30: 0,90-0,3233; 0,95-0,3809; 0,99-0,4869

Austenitic grain

The analysis was carried out provisions API – 5 CT Tube, was in all cases ferrite-pearlitic with a fine grain – score 8-9, ASTM – E112. The results of the measurements are summarized in Table 3.

Table 3. The results of metallographic analysis (grain size and structure of the strings).

No.	Feature	Group 1			Group 2			Group 3		
		cold end	means	hot end	cold end	means	hot end	cold end	means	hot end
A. Average ferrite grain size (ASTM – E 112)										
1	minimum	8	8	8	7	8	8	7	8	7
2	maximum	9	9	9	9	9	9	8	9	9
B. Average structures strings (STAS 7626)										
1	minimum	3-4	1-2	1-2	2-3	2	2-3	4	2	2
2	maximum	4,0	4	4	4	3-4	3	4	3	3

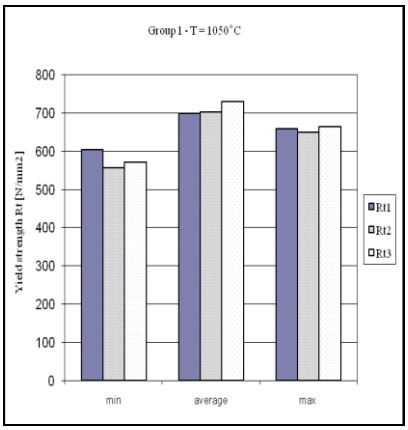
Austenitic grain (the characteristic trend of increasing the size of the grain), as determined by the oxidation set out in ASTM E112, the value was equal to 7.0.

The structure lined pipes, pipe feature laminated structure that occurs due to segregation of sulfur and phosphorus [5].

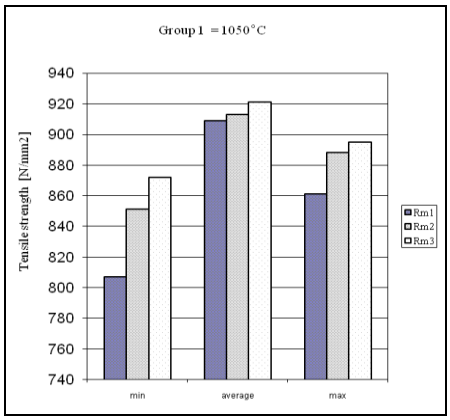
In the experimental group showed that the structure in row no effect on the level determined, to obtain the mechanical properties in a negative way, the fine grain material. Note that the structure in strings of maximum score four inner wall is at the limit, explained by segregation. Aspects of the material structure shown in Fig. 3.

When comparing the austenitic grain score 7 (average diameter of grain 30 μ m) according to ASTM E112, scoring 9 ferritic grain (average diameter 15 μ m) that the deformation occurred in fully recrystallized austenite. Theoretically, if recrystallized austenite deformation occur and already precipitated particles, the ferritic grain were very low (score 11 – grain diameter – 8 μ m) and higher mechanical properties, removing material strength class N 80 (actually achieve a controlled rolling).

Based on these results it can be concluded that steel 31 VMn12 led to obtaining a fine grains, according to the provisions in this regard in API 5 CT/1992. Hot rolled all areas had a fine ferritic grain (score according to ASTM E 112) between 8 and 9.



a



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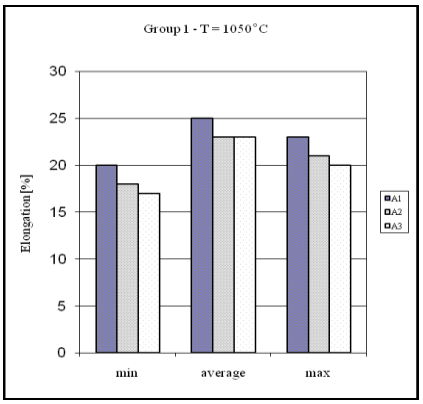

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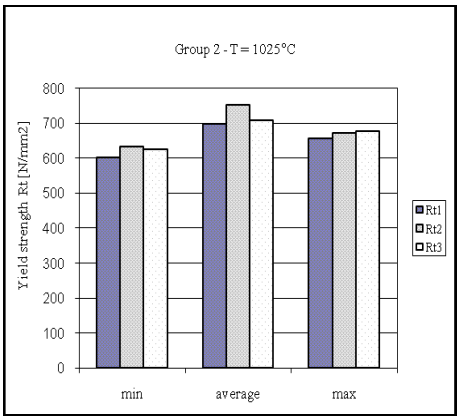

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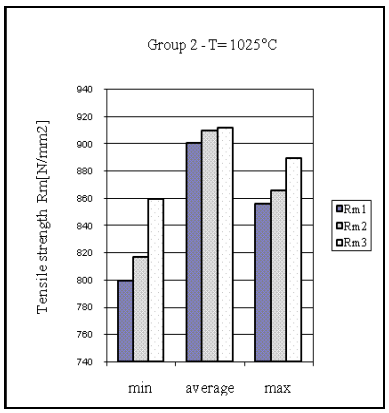

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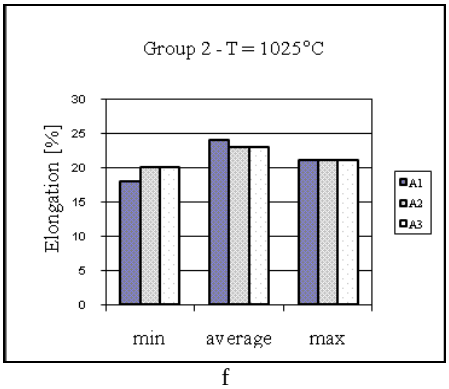

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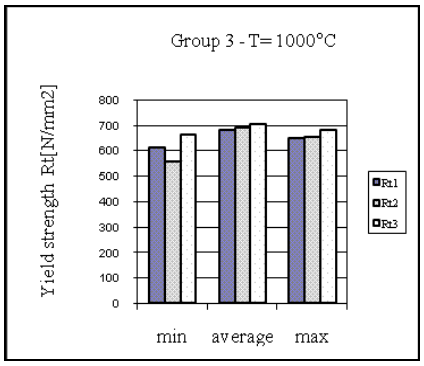
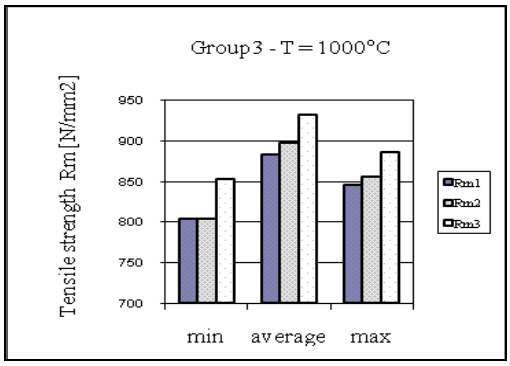


g



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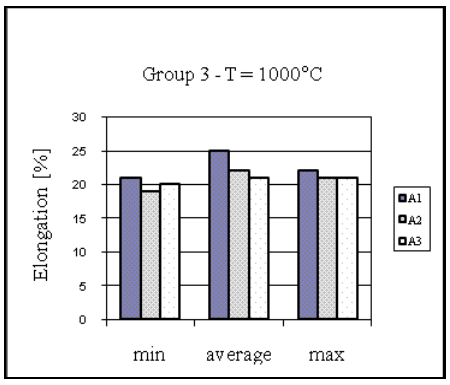

i

Fig. 1. Changes in mechanical properties on the temperature, as measured by a tensile test after lamination to the LRA.

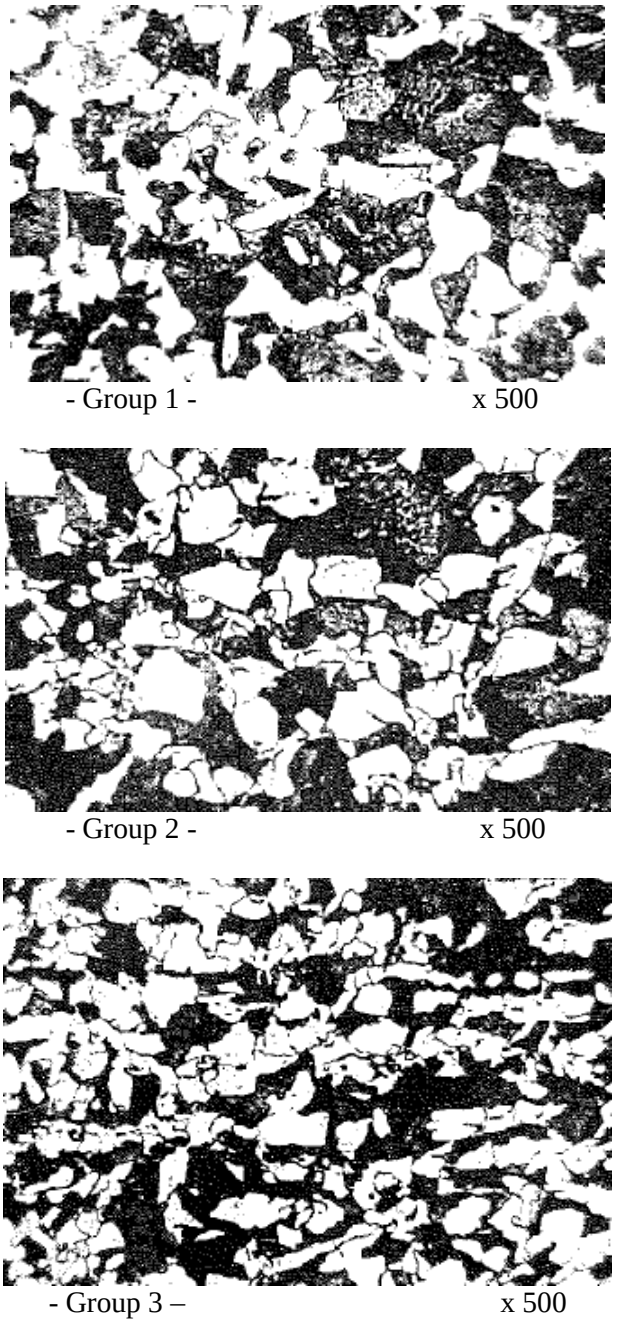

Fig. 2. Aspects of the experimental group structure pipe (attack NITAL 2%).

4. Conclusions

Following the production of an experimental batch of tubing ϕ73,03 × 5,51 mm steel 31VMn12 revealed the following: by regulating the temperature of deformation reduction mill – extension can be achieved tubing degree N80, thus obtaining the corresponding properties of the delivery status of "normalized";

The probability of assigning the property is 97.5%.

In the rolling process must satisfy the following conditions:

Average temperature in LRA-rolling pipe should be between 1040-1060^{0}C;

The temperature variation along the length of the pipe must be max. 50^{0}C.

Steel 31 VMn 12 provides austenitic grain size (and consequently ferritic) fine, eight score 7-9 satisfying from this point of view the conditions of standard API 5CT.

Based on the results for the experimental group was monitored manufacturing several batches and different pipe sizes.

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