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EXPERIMENTS REGARDING THE FABRICATION OF THE HIGHER STRENGTH STEELS PLATES

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ABSTRACT

The normalizing of ferritic-pearlitic steels is a heat treatment, which consist of reheating into the austenite and subsequent air-cooling. For greater thickness, e.g. 100 mm, variations in the requirements may be permitted or required for particular applications but a reduction of the required impact energy is not allowed. The most important cote of the cost can be eliminated if the process normalizing rolling is applied.

KEYWORDS: higher strength steels, normalizing, structural applications

1. Introduction

The normalizing of ferritic-pearlitic steels is a heat treatment, which consist of re-heating into the austenite and subsequent air-cooling. Its names derive from the fact that any micro-structural changes caused by the production process, by overheating during forming or by hardening, will be reversed resulting in a homogeneous microstructure. Normalizing is the standard technology for steel castings and is often applied for forging and heavy rolled products, when high processing temperatures are common. As a result, the coarse microstructure will become more homogeneous and grain refined, which guarantees both higher strength and better toughness.

In the "normalizing rolled" process, the rather high finish rolling temperature of 1050 ºC for normal processing of a 60 mm plate generates a rather coarse microstructure. If such a plate is processed in the lower austenite region at, for example, 880 ºC, its microstructure will be equivalent to that of steel in the normalized condition. Such finishing temperatures occur naturally with thinner gauges. For thicker material the rolling schedule has to be adjusted by introducing a delay time. In order to maintain the output of the mill, processing schedules have been developed, which allow for the simultaneous processing of more than one slab.

2. Experimental study

The LRS – E steel used for the structural applications is in conformity with LR Rules. The chemical analysis prescribed for the LRS-E steel sheets was tested and the results confirm equivalence with the LRS norms (Table 1).

The continuous cast slabs have been rolled at No. 2 heavy plate rolling mill and submitted to thermal treatment in the normalizing furnace. Subsequent to the normalizing treatment, the sheets were US controlled according to SEL 072-77 standard. The parameters of the casting are in Table 2.

The results obtain of the mechanic tests and at the micro-structural analysis are presented in Tables 3 and the Figures 1-3.

Table 1. *The chemical composition for the LRS-E steel*

C	Mn	Si	P	S	Al	Nb
[%]						
0.15-0.18	0.95-1.10	0.15-0.30	max. 0.025	max. 0.010	0.020-0.060	0.030-0.050

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Table 2. *The principal fabrication parameters for the LRS – E steel*

Tundish steel temperature		ºC	1530
Casting time		minutes	59
Casting rate		m/min	0.74
Slab size		mm	250x1550
Slab heating temperature		ºC	1280
Slab/plate rolling temperature	start	ºC	1180
	end	ºC	860
Plate thickness		mm	100
Normalizing temperature		ºC	886

Table 3. *Steel grade: LRS E, sample 180-longitudinal tests, plate thickness 100 mm*

Sample	180-1 L	180-2 L	180-3 L	180-4 L
Section (mm)	Ǿ 14	Ǿ 14	Ǿ 14	Ǿ 14
Original gauge length Lo (mm)	70	70	70	70
Final gauge length Lo (mm)	91	91	91	90
Maximum force Fm (N)	84500	85500	83400	84500
Flow force F (N)	57500	60000	5500	58000
Proof stress at 0.2% (N/mm^2)	374	390	359	377
Tensile strength R_m (N/mm^2)	548	555	545	549
Total breaking elongation A (%)	30	30	30	28
Charpy V-Notch test 20 ºC(J) Percentage crystallinity, % Lateral expansion (mm)	191-157-135 91-80-77 2.32-2.45-2.63	143-147-143 80-80-85 2.42-2.43-2.45	180-140-138 80-88-80 2.11-2.31-2.63	165-188-176 81-90-86 2.57-2.51-2.55
Charpy V-Notch test 0 ºC(J) Percentage crystallinity, % Lateral expansion (mm)	141-149-136 85-85-77 2.29-2.32-2.32	151-166-164 85-81-80 2.30-2.52-2.40	150-142-145 851-80-85 2.18-2.25-2.34	159-153-180 80-85-88 2.37-2.31-2.23
Charpy V-Notch test -20 ºC(J) Percentage crystallinity, % Lateral expansion (mm)	124-117-115 75-72-66 1.98-2.08-1.92	120-110-114 60-72-66 2.02-1.96-2.04	124-111-125 75-60-72 1.96-2.09-2.15	139-144-134 80-85-77 2.42-2.36-2.29
Charpy V-Notch test -40 ºC(J) Percentage crystallinity, % Lateral expansion (mm)	43-62-70 21-33-38 1.56-1.39-1.34	62-72-43 33-38-21 1.39-1.56-0.87	51-47-51 26-26-27 0.62-0.65-1.10	47-52-81 26-26-44 0.55-0.65-0.92
Charpy V-Notch test -60 ºC(J) Percentage crystallinity, % Lateral expansion (mm)	14-11-13 11-12-11 0.52-0.71-0.42	10-9-9 11-11-12 0.91-0.83-0.67	9-9-8 11-12-11 0.41-0.36-0.73	16-11-12 17-11-12 0.98-0.71-0.65
Strain age Charpy tests -40 ºC(J)	8-7-6	6-6-8	7-18-10	8-8-8
Strain age Charpy tests -60 ºC(J)	5-5-6	5-5-5	6-5-5	5-6-6
Bend Tests	satisfy	satisfy	satisfy	satisfy

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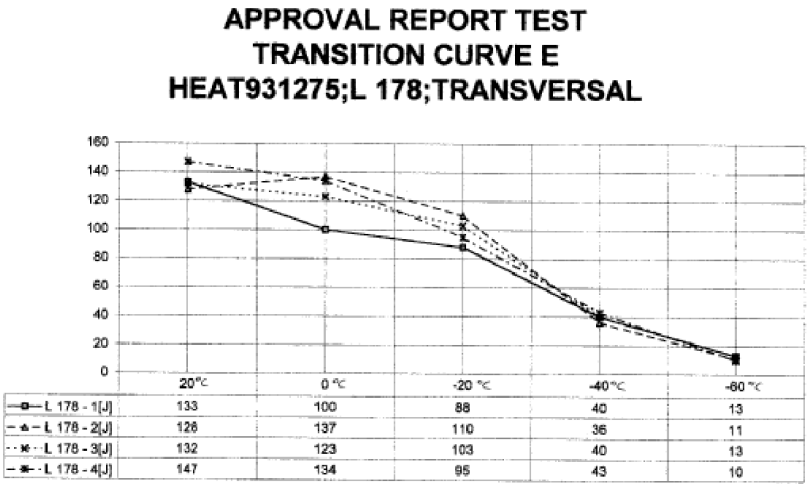

Fig. 1. *Approval report test transition curve – transversal position*

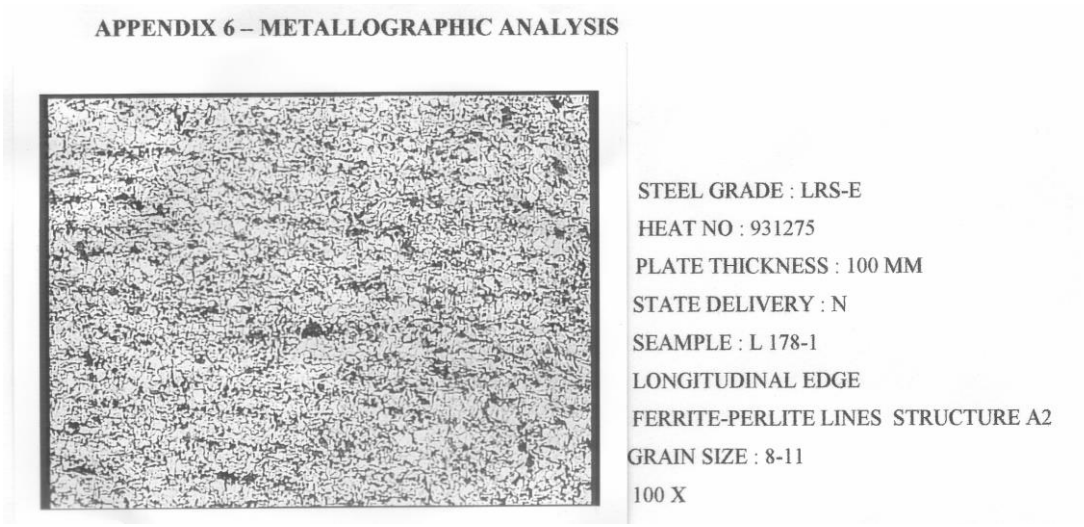

Fig. 2. *Metallographic analysis for longitudinal edge*

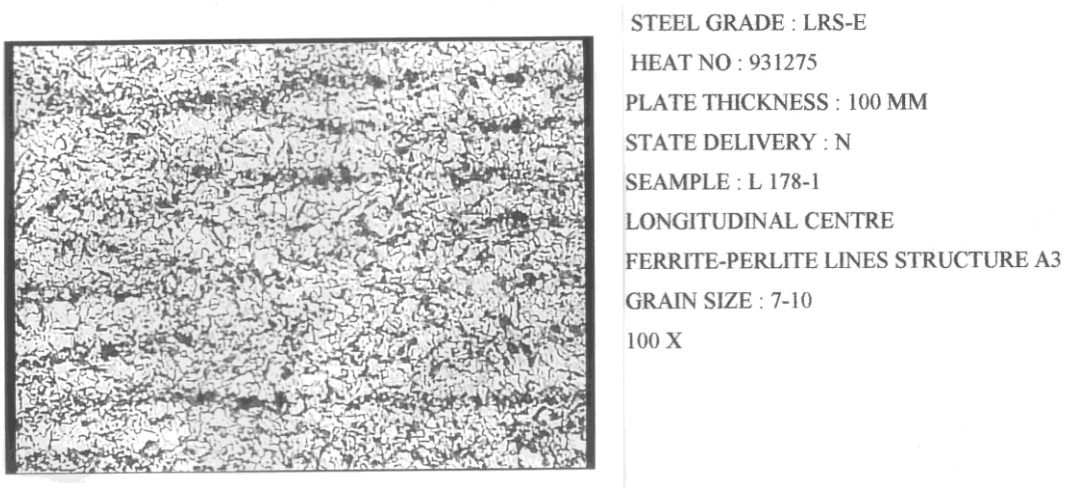

Fig. 3. *Metallographic analysis for longitudinal centre*

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3. Conclusions

In order to realize a program for extended a fabrication authorization of the higher strength steels plates for ship or other structural applications Grades A, B, C, D and E, on effectuated an researches and experimental series which consists in:

- chemical analysis;
- Baumann sulphur print;
- metallographic analysis;
- ultrasonic control.

For this analysis we on refer to the Romanian standards for the grain size, microstructures and the sulphur print.

The results obtained lead to the conclusion that the fabrication of the higher strength steels plates for ship or other structural applications, LRS-E3 type, is accepted, because there are in conformity with the impose norms.

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