RESEARCHES CONCERNING THE CORRELATION STRUCTURE OF PROPERTIES OF STEELS FOR METAL CONSTRUCTIONS STRONGLY REQUESTED

Stela Constantinescu[1], Maria Vlad[1]

[1]*University "Dunarea de Jos " of Galati, Faculty of Metallurgy , Materials Sciences and Environtment,*
stela.constantinescu@email.ro

Abstract: The RV52 steel plates are used to manufacture liquefied and compressed gas reservoirs, recipients and pressure vessels which operate at low temperatures, big pressures and highly loaded structures . The making technology and thermique treatment determine high properties such as : strength, wear resistance and tenacity . The normalized plate sample were studied to determine the effect of the tension release heat treatment on the properties of steel plates used for metallic welded construction . From the relations expressing the link between the strength and tenacity relation o none hand and the structural characteristics, on the other it is obvious that the only factor which leads both to increasing strength properties and decreasing transition temperature is the finishing of the ferrite grains .

Key words: *thermique treatment , strength, tenacity, ferrite grains*

1. Introduction

The plates of RV52 steel are used to manufacture liquefied and compressed gas reservoires , pressure vessels and devices operating at low temperatures and within heavily loaded metal structures.

During the processing and operation in the basic steel mass a number of phenomena can ocurr such as:lamelar spreading, fissures in the welded areas and easy breaking. Occurrence and development of these phenomena depend on the steel chemical composition and the semiblanks elaboration and processing conditions.The normalised plates of RV52 steel feature a ferite-perlite structure, the obvious tendency being that of reaching an as low as possible content of perlite with the corresponding decrease in the carbon content.The heat normalising treatment of the thick plates took place in the roller continuing furnaces from the rolling mill of SIDEX Galati observing the follwoing parameters : heating up to temperatures $A_{C3} + 20^o \div 40^o$ C, air cooling.

The analysis of the relation ship between strength and tenacity, on the one hand , and structure characteristics, on the other hand, shows that the heat tension-relieving treatment and especially, the normalising treatment considerably increase the strength /resistance and decrease the transition temperature due to the ferrite grain shrinking process [1].

Manufacturing plates of high chemical and structure homogenity leads to an isotrophy corresponding to these properties, which attracted the researchers' interest .

2. Experimental researches and results

In order to carry out the researches on the correlation of microstructure with the properties of steel RV52 , normalized and detensioned, the following working variants have been established:

- elaboration in a 50t electrical furnace of 15 t thick plates by ingot casting, normalising treatment , and sampling for heat treatment detension in laboratory;
- elaboration in a 150t converter , by 25 t ingot casting and continuing casting in slab , of thick rolled plates , normalizing treatment , and sampling for heat treatment detension in laboratory [2,3]. The chemical composition of the steel investigated is given in table 1.

Table 1. *The chemical composition of material.*

Chemical composition, [%]							
C	Mn	Si	P	S	V	Al	Ni
0,14	1,4	0,26	0,016	0,010	0,050	0,024	0,28

Sampling the steel RV52 plates before and after normalising has been carried out acc to the following scheme :

- the samples of the plates made by ingot roling have been taken from the edges and the axis corresponding to the upper, middle and bottom parts;
- the samples of the plates made by cast brame rolling have been taken from the edge and axis.

The metallographic structures of the samples without heat treatment, from the 15t steel ingots made in the electrical converter , for upper, middle and bottom sides are illustrated in figures 1a,1b,1c .

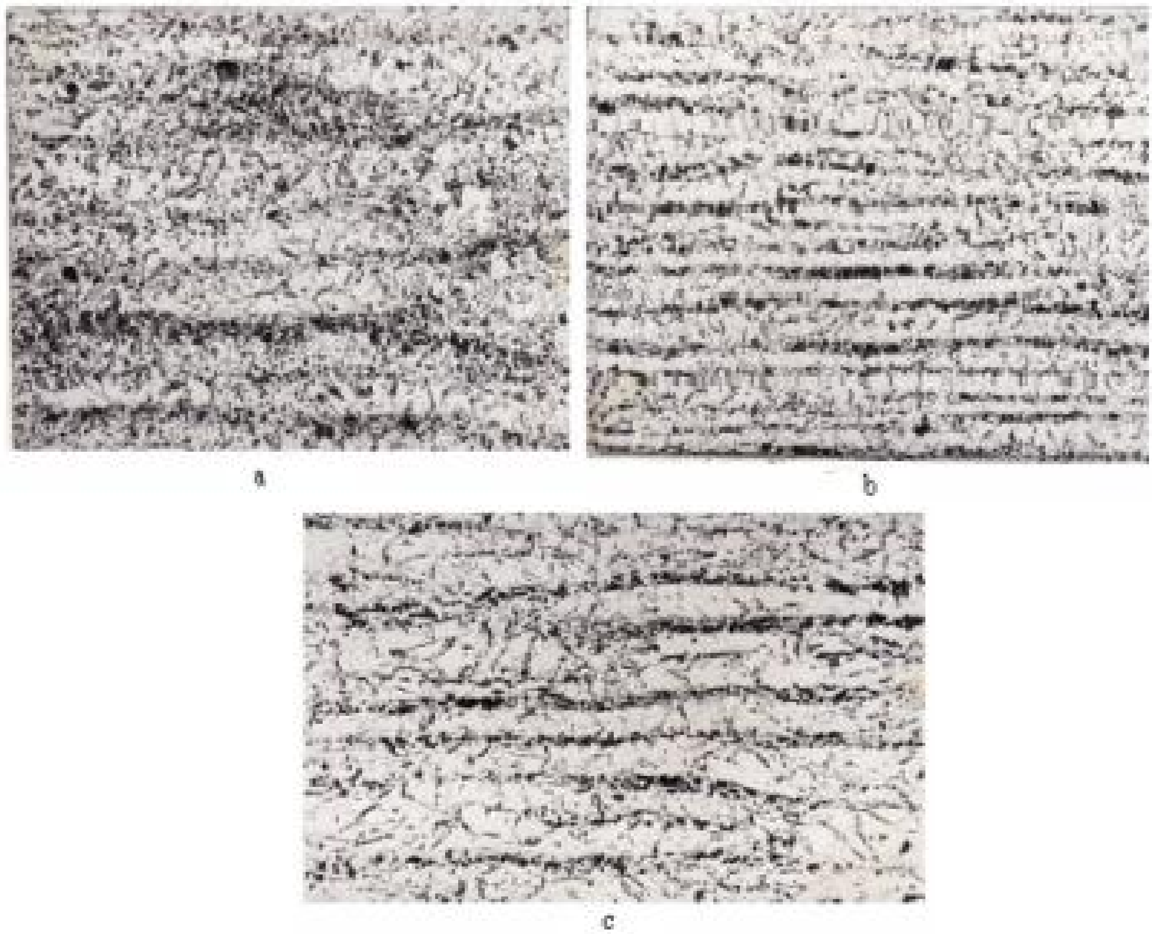


Figure 1. *Metallographic structures of the samples without heat treatment from the 15t steel ingots made in the electrical converter : a) upper; b) middle; c)bottom*

The samples have been taken from the central axis of the plate corresponding to : a) upper side/head, b) middle part ; and c) bottom side/foot of the ingot [4].

The microscopic structures of the plates made from steel elaborated in the LD converter and continuously cast, positions edge and axis, are illustrated in figures 2a, 2b.

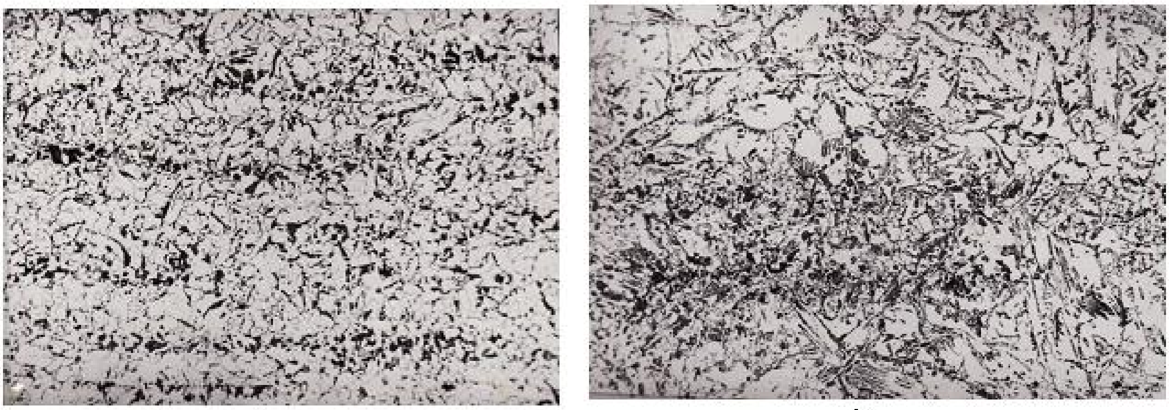


Figure 2. *Metallographic structures of the plates made from steel elaborated in LD converter : a) edge; b) axis*

Metallographic slifs have been sampled from the normalized plate samples. The slifs have been prepared in longirudinal cross –section acc to the classical procedure [5,6]. Determinations have been performed acc to STAS 5949-95, and the results are given in table 2 .

Table 2 . *Non- metalic inclusions score*

Score	*Types of non- metalic inclusions*				*Total score over the same field*
	Sulphides S)	Oxides OL+OP	Silicați SF+SP(SN)	Nitrides NT+NA	
	Non- metalic inclusions score				
1	2	3	4	5	6
a	1 0,5 1	1,5 1,5 1	1 1 1,5	0,5 0,5 0,5	4 3,5 4
Max. score from types of inclusions	1	1,5	1,5	0,5	
b	0,5 0,5 1	1,5 1,5 0,5	1,5 1,5 1,5	0,5 0 0	4 3,5 3
Max. score from types of inclusions	1	1,5	1,5	0,5	
c	1 1 1	0,5 1,5 1	1 1 1,5	0,5 0 0	3 3,5 3,5
Max. score from types of inclusions	1	1,5	1,5	0,5	

The elaboration technique has also been assessed by determining the non- metalic inclusions score as shown in table 2.

The impurest zones, irrespective of the sample position, are those corresponding to the upper and middle side of the ingot . In the axis purity is lower as compared with the sample edge [7,8]. When elaborated in the electrical furnace, a higher purity is reached than that in a converter. In the case of continuing casting, the differences reported between edge and axis are considered higher that with ingot casting. The purity results show that the C, Mn and S segregation zones are also zones which include the non-metallic inclusions [9,10].

A typical image in terms of purity is given in figure 3 .

Figure 3. *Typical aspect of purity of RV52 steel plates, without attack.*
Magnified x100

Micro-structural measurements have confirmed the presence , in the max C and Mn segregation zones , of higher perlite proportions of these substances as shown in figures 1a,1b,1c and 2a,2b.

The metallographic structure of the heat treated plates is given in figure 4 which highlights a fine-granulation ferrite-perlite structure [11,12].

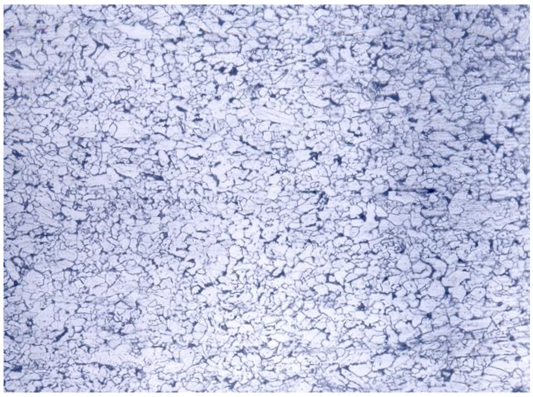
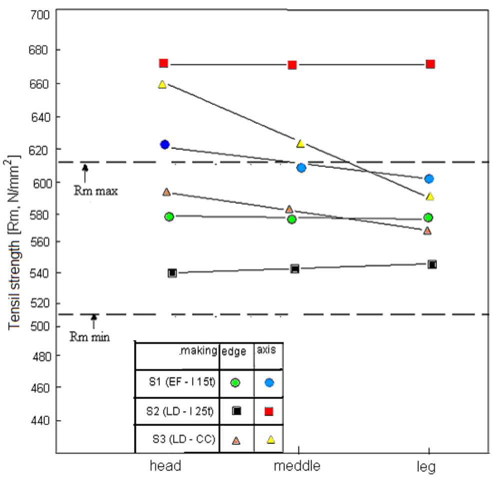
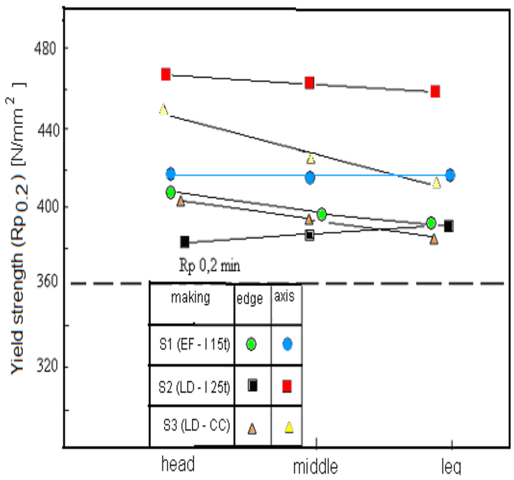


Figure 4. *Micro-structure of normalized RV52 steel plates Magnified x 100*

Variations and distributions of the mechanical properties : ultimate strength (R_m), yielding point ($Rp_{0,2}$), breaking elongation (A_5%), resilience on-v-grooved longitudinal samples, tested to -20 ^{o}C and –50^{o}C, from upper, middles and bottom sides are graphically illustrated in figures 5,6,7,8.



Sample position in comparison with the ingot
Figure 5. *Tensil strength (Rm) values distribution of samples in various zone of the sheet*



Sample position in comparison with the ingot
Figure 6. *Yield strength ($Rp_{0.2}$) values distribution of samples in various zone of the sheet*

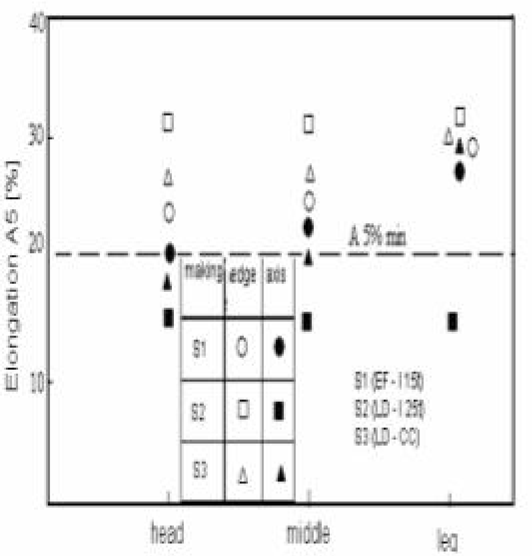


Figure 7. *Elongation A_5 values distribution of of samples in various zone of the sheet*

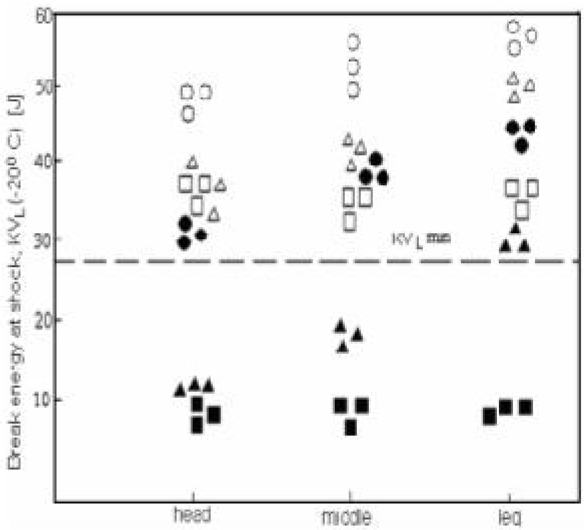


Figure 8. *Break energy at shock (KV_L) values distribution on the longitudinal piece test at --20^0C.*

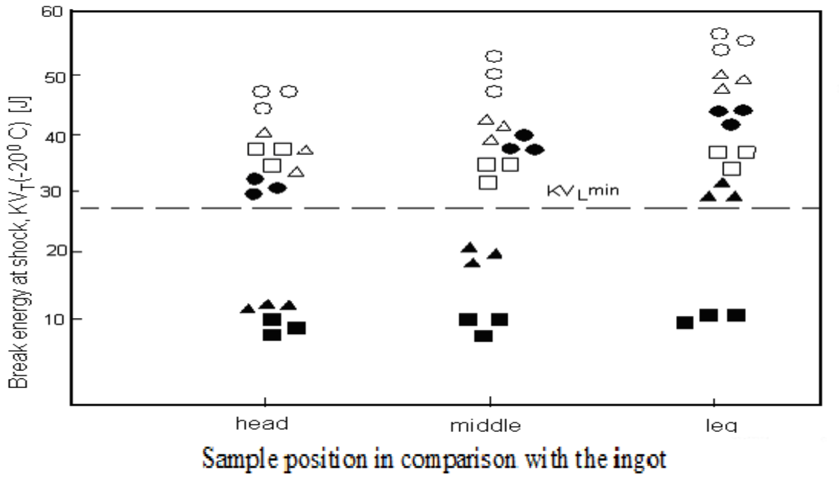


Figure 9. *Break energy at shock (KV_T) values distribution on the transverse piece test at -20^0C.*

The resilience of the cold- deformed and heat-treated samples under the above mentioned conditions has been determined at temperatures of - 20^{o}C şi – 50^{o}C, acc to figures 9.

In order to establish the influence of the heating temperature subsequent to cold deformation of the samples subject to 4%,8% and 12% degree of deformation , these have been treated acc to the treatment cycle described below :

- heating: 250^{0}C; 500^{0}C; 650^{0}C;
- exposure: 160 min. As a result of 2 min/ mm exposure;
- air cooling. [%]

From the analysis of the tension-relieving graphics, it has been found that :

- as a result of the tension-relieving heat treatment at 250 ^{o}C, the shock ultimate strength at -20^{o}C and –50^{o}C decreases with respect to the values of of the samples from plates of 4%,8% and 12% degree of deformations , and the values of the normalized samples figures 10, 11.
- determining the shock behavior is more obvious when the degree of deformation is higher.
- with degrees of deformation of 12%, the shock ultimate strength at -20 ^{o}C and –50^{o}C takes lower values than those min admissible as indicated by STAS 11502-90.

- heating to 650°C results in recovery of the tenacity properties of RV52 steel , without having reached the level of normalization.
- heating at 250°C has disastrous consequences, because tenacity is completely damaged both with respect to normalization and deformation states;

- by heating at 500°C, the values of the shock ultimate strength increase as compared with those rached by cold deformation, while keeping however the influence of the cold deformation, i. e. lower values for higher degrees of deformation [13,14].

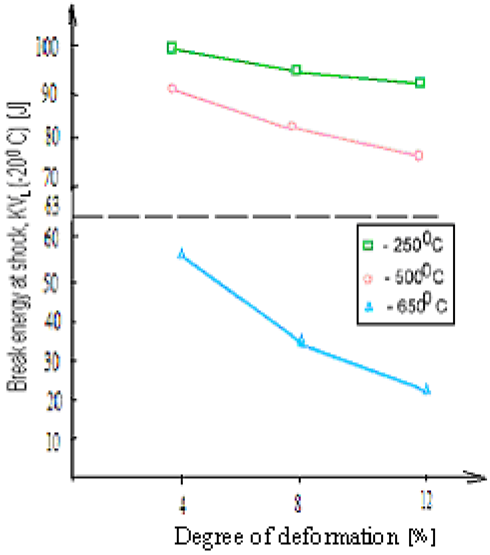


Figure10. *The influence degrees of deformation and heting for values break energy at shock, KV_L (-20°C)*

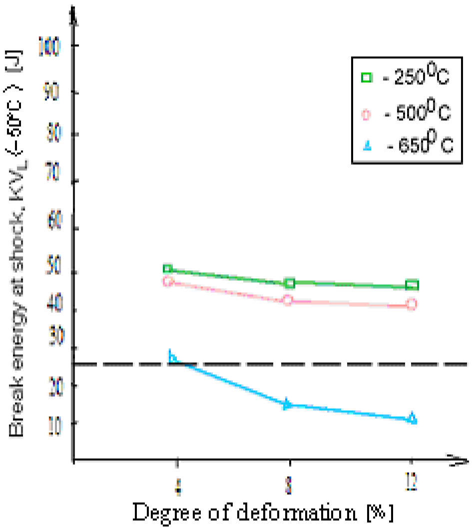


Figure11. *The influence degrees of deformation and heting for values break energy at shock, KV_L (- 50°C)*

3. Conclusions

The researches were focused on determining the factors that cause properties variation in different zones of the RV52 steel plates manufactured by Arcelor Mittal Galati .

In order to obtain highly improved properties a good correlation should be achieved between the conditions of elaboration, deformation and heat treatments highlighted by the chemical composition and structure .

The cold plastic deformation of low degrees of deformation: 4, 8, 12% results in poorer tenacity properties as compared with the normalised state values , which is more sensitive with higher degrees of deformation.

The best values of shock ultimate strength both at -20°C and –50°C have been obtained after a tension relieving treatment at 650 °C for 6 % degree of deformation

The measurements of the sulphide , carbon and manganese segregation , purity, microscopic structures and the mechanical properties in these zones have all shown that :

The C, Mn, and S segregation phenomena and therefore the variation of the properties acc to different directions are much more obvious in a less careful elaboration in the 150t converter, as compared with the elaboration in the vacuum-degasing electrical furnace.

The chemical, structural and properties anisotropy is much more obvious in case of 25 t ingot casting as compared with 15t ingot casting.

In case of ingot plates , the segregation and anisotropy phenomena are more pregnant in the plate axis than in its edges, i. e. In the upper and middle sides than in the bottom side.

Taking into account the results obtained , in order to diminish the chemical segregation which causes the structure modification and properties anisotropy , it is necesary to take technological steps able to eliminate this phenomenon. Such steps should include both the elaboration technological parameters (casting temperature, vaccum technology) and the casting parameters (ingot size) along with the use of some raw materials (liquid cast iron, refractory staff) which should cause a min. impurification of the steel.

4 References

[1] Constantinescu, S., *Metals properties and physical control methods*, Didact şi Pedag. Publishing House , Bucureşti , 2004.

[2] Constantinescu S. , Drăgan V., *Destructive and nondestructive testing of metals*, Ed. Evrika Brăila , 2000.

[3] Walanbe T., *Mechanical proprieties of Cr-Mo steels after eleveted temperature service*, Partea I: Document II S-IX-116-79; Partea II: Document II S-IX-1167, 1990.

[4] Steven N., Jise, Steel , 1989, Vol.193, p.141

[5] Sugiyama T., Kobe Seel Engineering Reports,1995, Vol.25, nr.4, p.4.

[6] Constantinescu S., Drugescu E., *Studies on Mechanism and Kinetics of Phase Transformation in Superficial Layers Using Unconventional Procedures*. Research Contract no. 5005, Galati 1995, p. 53- 88.

[7] Constantinescu S., Drugescu E.,Radu T., *Practical application of AE of the different grades of steel*, in Proceedings of the 25thEuropean Conference on Acoustion Emission Testing " EWGAE 2002 " Prague Czech Republic , 11 –13 september, 2002 , p. 135-143.

[8]Constantinescu S., *Influence of manufacturing process on chemical and structural homogeneity of welded pipe sheets for tanks and vessels working under pressure*, in Proceeding of the International Conference on Advances in Materials and Processing Technologies, september 18 – 21 , 2001, Leganes, Madrid, Spain, p.57 .

[9] Constantinescu S., Researches on the optimum heat treatment for the low alloyed steels used at high temperatures, Metalurgia Internațional , nr. 6 /2005 , ISSN 1582- 2214 , p.3-7 .

[10] S. Constantinescu, L. Orac ,*Characterization of steels in terms of their physical and mechanical properties*, Buletinul Institutului Politehnic din Iasi, Tomul LI II (LV II) , fasc. 3, ISSN 1453 – 1690, p.51-58, 2007

[11]Vlad M., Constantinescu S, Stratulat, E. *Improvent of steel sheet corrosion resistance by thermic coverage method with zinc-alluminium alloys*, Annals of „Dunarea de Jos" University of Galati, Fascicle IX Metallurgy and Material Science, ISSN 1453 – 083X, 2007,Vol. 1, p. 32-38.

[12] Constantinescu S., *Non-distructive control of hot – rolled products, BRAMAT 2007*, International Conference on Materials Science and Engineering, February 22-24, 2007, Braşov , ISSN 1223 – 9631, p.241-246.

[13] Constantinescu, S., Orac L., *Mechanical Properties of thin films investigated using micromachining techniques*, METAL 2010, Ostrava, Czech Republic ISBN: 978-80-87294-17-8, p.926-931,2010 TANGER, spol.s.r.o., www.METAL2010.com

[14] Radu, T. ,Constantinescu, S., Vlad, M., . *Morphologies of Widmanstatten structures and mechanism formation in steels*, Journal of Materials, Science Forum Vol. 636-637, pp 550-555, Trans Tech Publications, Switzerland,2010, ISSN 1662-9752, www.scientific.net / M6F. 636- 637.550