INFLUENCE OF THE NORMALIZING ROLLING PARAMETERS ON THE TOUGHNESS OF A NB, V AND TI MICROALLOYED STEEL PROCESSED IN GERDAU PLATE MILL

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Introduction

“Rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition equivalent to that obtained after normalizing so that the specified values of the mechanical properties are retained even after normalizing”.

In general, the main metallurgical goal of the of the rolling process is to create a proper balance between the roughing and finishing stages.

The final ferritic grain size and its distribution are defined by the types of recrystallization that occur due to the utilized alloy project and rolling process. The 3 types are: Type I – Full recrystallization, Type II – Supressed recrystallization e Type III – Partial recrystallization.

I this work we investigated the influence of the normalizing rolling parameters in the toughness of a 15 mm and 30 mm thickness NbVTi microalloyed steel plate.

Materials and Methods

Table 1: Aimed Chemical Composition

%C	%Mn	%(S + P)	%(Nb + V + Tl)	N ppm
0,15	1,45	< 0,035	0,09	< 70

Table 2: Aimed Critical Temperatures

T sol. Irvine (°C)	Tnr Boratto (°C)	TAr3 Ouchi (°C)
1.218	989	750

Materials and Methods

Table 3: Tension Specification

YS [MPa]	TS [MPa]	EL [%] 5,65 $\sqrt{A_0}$
≥ 355	470 - 630	> 20

Table 4: Charpy Specification

T [°C]	Energy [J]	Size [mm]
- 20	≥ 27	10 x 10 x 55

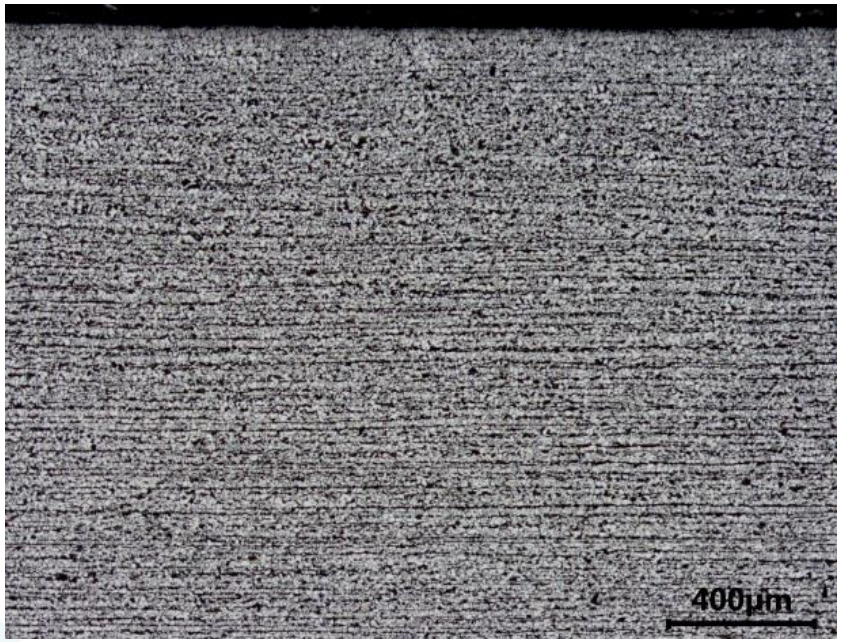
Results and Discussion

Table 5: Tension and Charpy mechanical properties obtained from samples of the 15 mm and 30 mm plates.

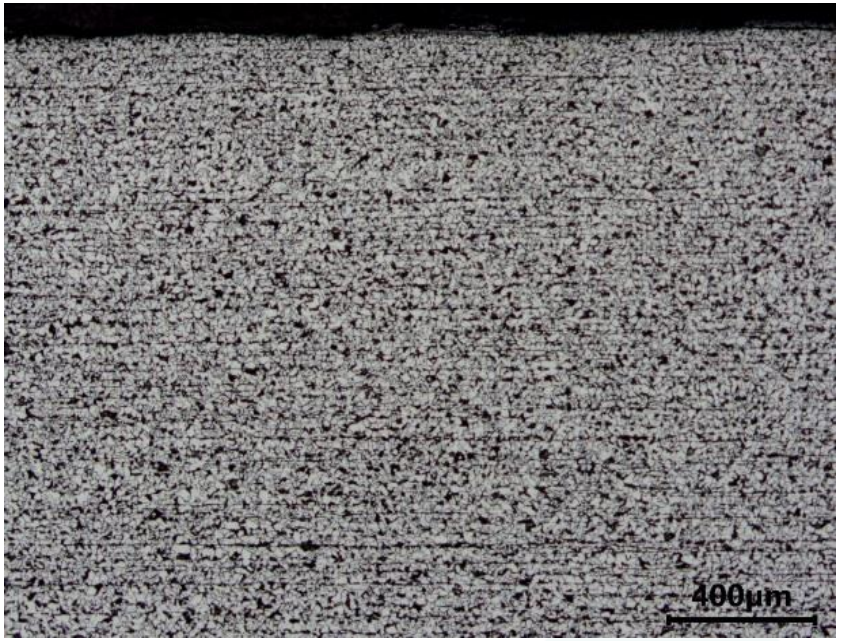
Sample	Thk. (mm)	YS (MPa)	TS (MPa)	EL (%) $5{,}65\sqrt{A_0}$	Mean Absorbed Energy(J)	Std Dev.
Moderate Toughness	15,00	399	546	30	47	4,8
Good Toughness		421	537	28	186	8,7
Moderate Toughness	30,00	400	568	22	58	3,9
Good Toughness		387	528	28	141	7,9

Results and Discussion

Figures 1a e 1b: Micrographs from the 15 mm samples with good toughness (a) and moderate toughness (b). Etching with nital 4%, 50x magnification, **surface.**



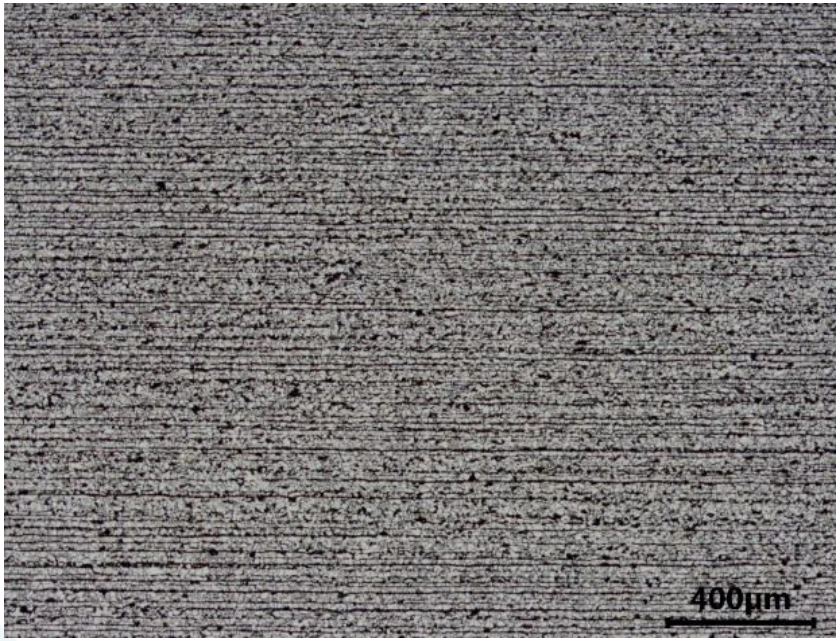
(a)



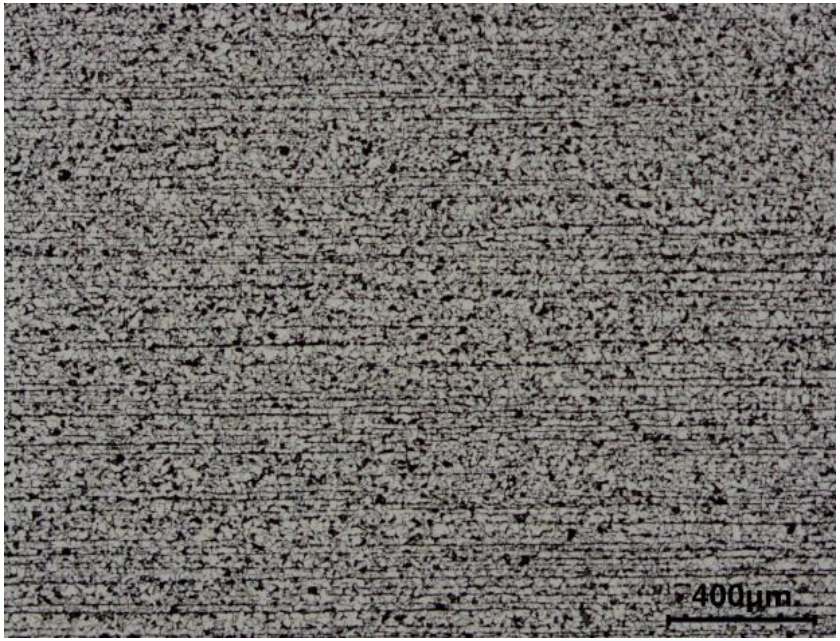
(b)

Results and Discussion

Figures 2a e 2b: Micrographs from the 15 mm samples with good toughness (a) and moderate toughness (b). Etching with nital 4%, 50x magnification, **1/4t**



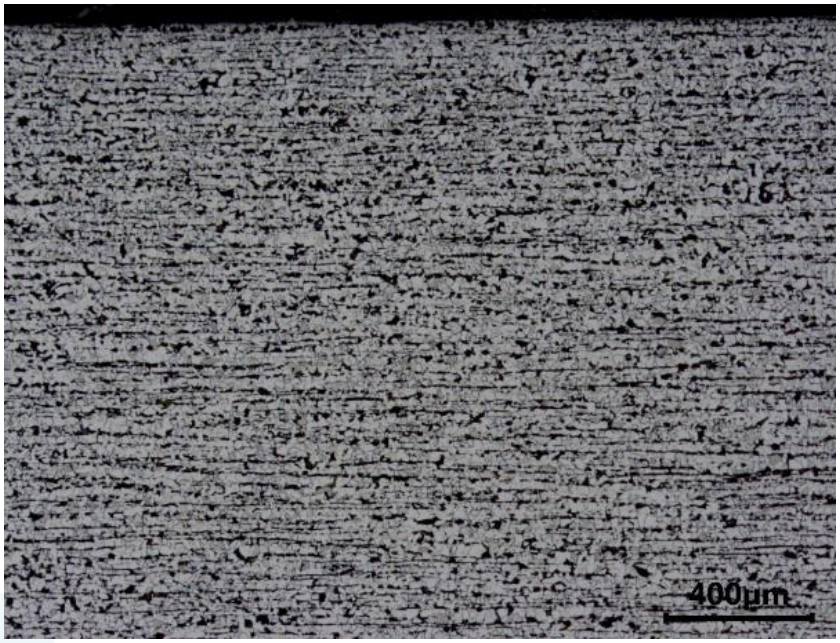
(a)



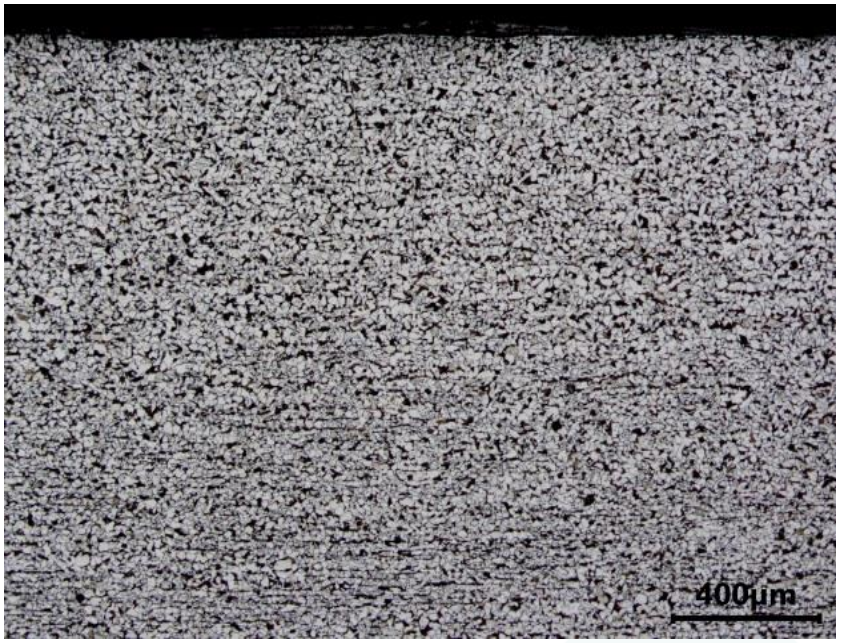
(b)

Results and Discussion

Figures 3a e 3b: Micrographs from the 30 mm samples with good toughness (a) and moderate toughness (b). Etching with nital 4%, 50x magnification, **surface.**



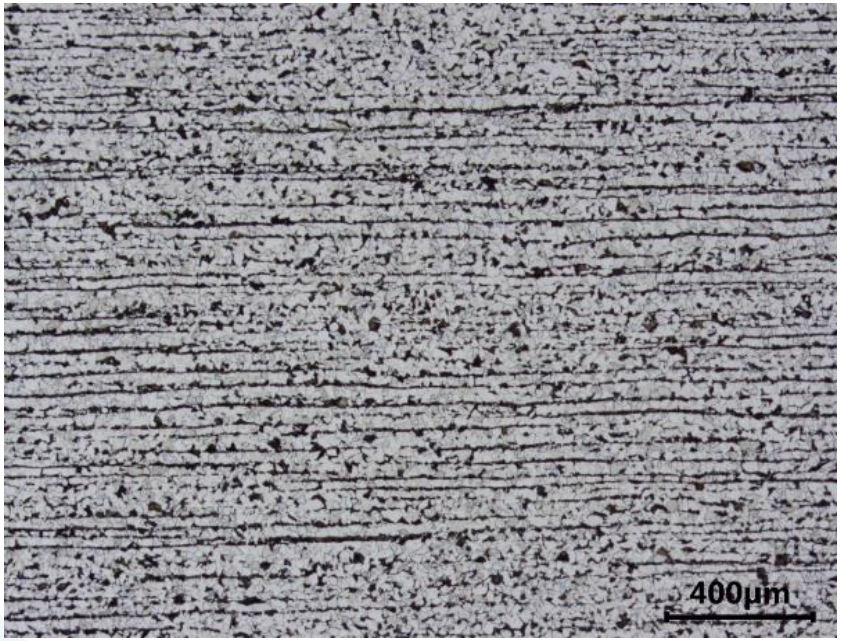
(a)



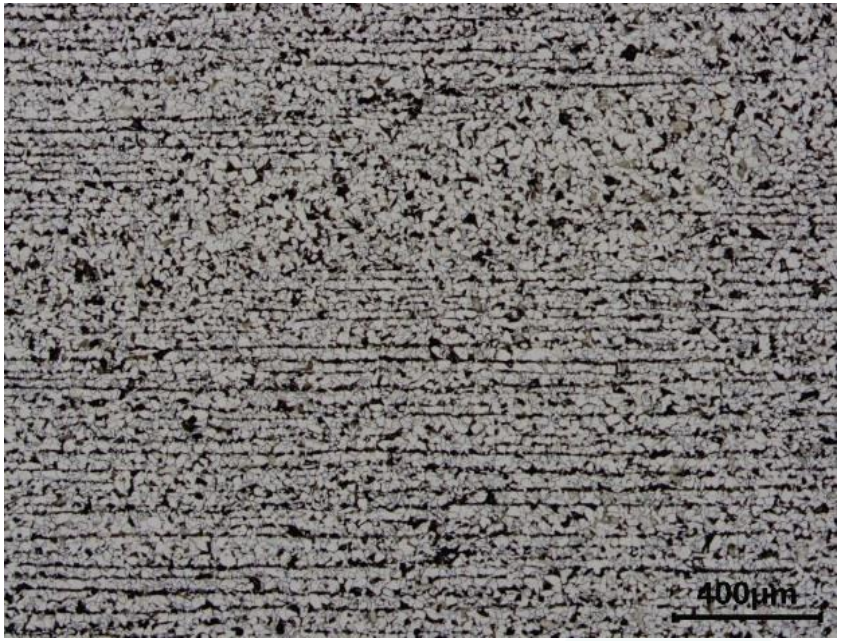
(b)

Results and Discussion

Figures 3a e 3b: Micrographs from the 30 mm samples with good toughness (a) and moderate toughness (b). Etching with nital 4%, 50x magnification, **1/4t.**



(a)



(b)

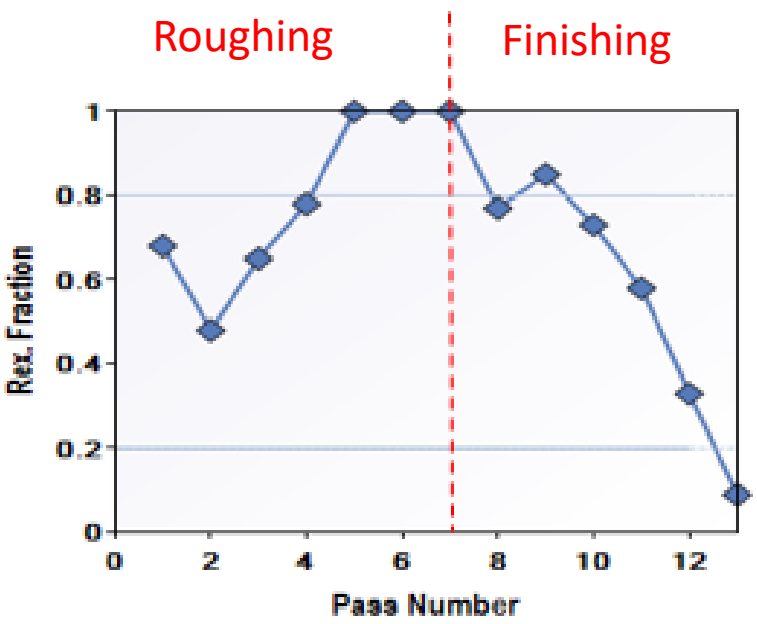
Results and Discussion

Table 6: Actual ferritic mean grain size in the 15 mm and 30 mm samples

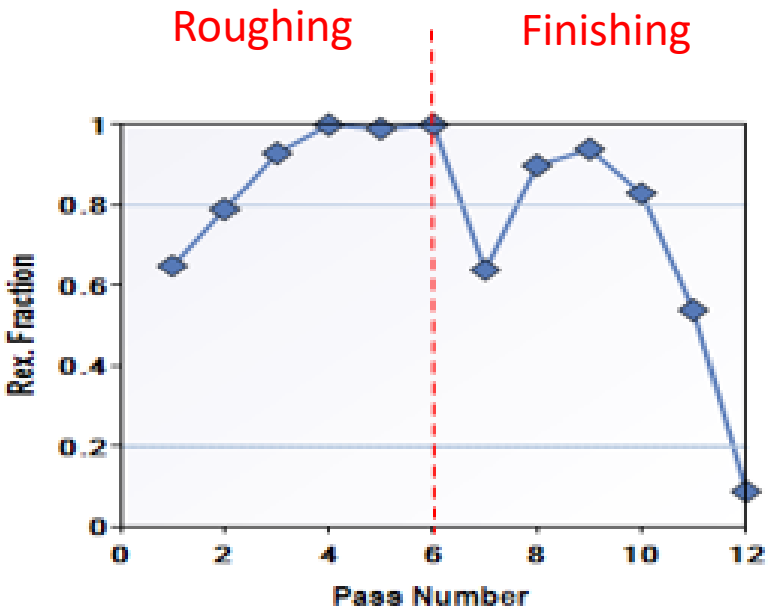
Sample	Thk. (mm)	Mean Grain Size (µm)	Std. Dev.
Moderate Toughness	15,00	8,2	1,3
Good Toughness		6,0	1,2
Moderate Toughness	30,00	8,4	1,4
Good Toughness		8,9	1,3

Results and Discussion

Figures 5a e 5b: Graphs showing the recrystallization percentage after each pass calculated by the MicroSim model for the 15 mm thickness plates based on the actual process parameters.



(a) Good Toughness



(b) Moderate Toughness

Results and Discussion

Table 7: Types of recrystallization predicted for the 15 mm thickness plates, according to the MicroSim model.

Plate	% Reduction			Accumulated Deformation
	Full	Supressed	Partial	
	(Tipo I)	(Tipo II)	(Tipo III)	
Good Toughness	73,1	61,8	23,0	0,91
Moderate Toughness	81,5	26,0	21,5	0,55

Results and Discussion

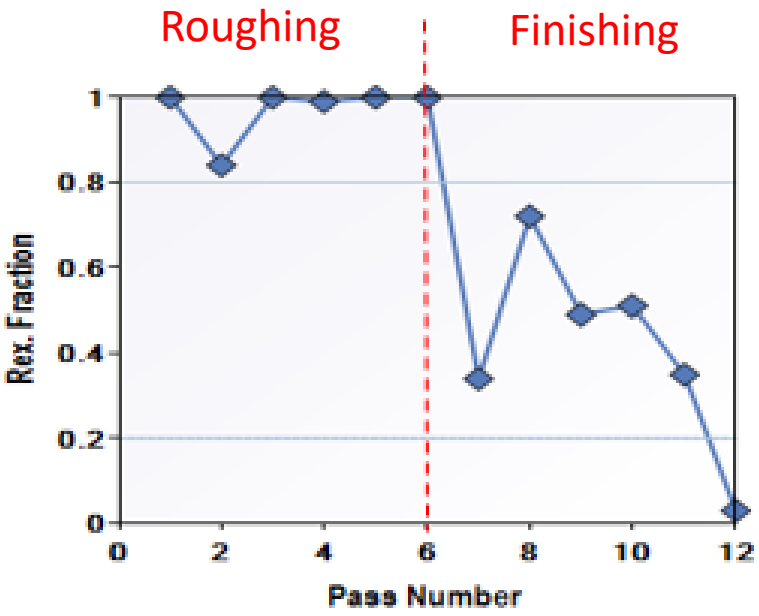
Table 8: Microstructural evolution for the 15 mm thickness plate, according to the MicroSim model

Plate	Grain Size - µm			
	Austenitic post Rolling			Ferritic
	Mean	Maximum	Zd*	
Good Toughness	9,3	133	14,3	9,3
Moderate Toughness	14,5	132	9,1	14,5

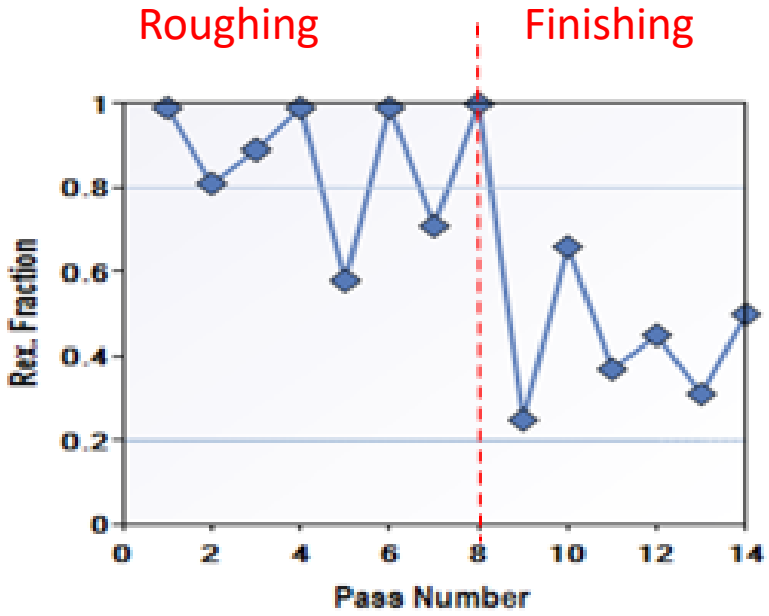
*Zd = Maximum/Mean

Results and Discussion

Figures 6a e 6b: Graphs showing the recrystallization percentage after each pass calculated by the MicroSim model for the 30 mm thickness plates based on the actual process parameters.



(a) Good Toughness



(b) Moderate Toughness

Results and Discussion

Table 9: Types of recrystallization predicted for the 30 mm thickness plates, according to the MicroSim model.

Plate	% Reduction			Accumulated Deformation
	Full	Supressed	Partial	
	(Tipo I)	(Tipo II)	(Tipo III)	
Good Toughness	45,9	61,4	14,4	0,53
Moderate Toughness	23,1	77,0	0	0,70

Results and Discussion

Table 10: Microstructural evolution for the 30 mm thickness plate, according to the MicroSim model

Plate	Grain Size - µm			
	Austenitic post Rolling			Ferritic
	Mean	Maximum	Zd*	
Good Toughness	19,2	199	10,4	14,5
Moderate Toughness	11,8	162	13,8	12,9

*Zd = Maximum/Mean

Conclusion

The fundamental aspects related to toughness, microstructure, mean grain size and plate thermomechanical processing were presented.

The microstructural difference presented in the studied samples was insufficient to justify the toughness difference.

The analysis using MicroSim showed interesting results that helped to explain the otained toughness values.

Regardless of the results, it is still necessary to analyze a much larger number of cases to reveal in a more precise and reliable the relationship between the thermomechanical process and the final microstructure in order to correlate the mechanical processing data with the materials toughness.

Thank you!