DEVELOPMENT TAPERED PLATE ON GERDAU PLATE MILL *

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Abstract
Gerdau Ouro Branco´s plate mill started the operation in 2016 with high level technology. Stands out the capacity to produce different thicknesses in a same plate, therefore allowing special service for sectors such as building structures, bridges, shipbuilding and mechanical applications. The purpose of this study is to present the first results obtained in this innovative product in Brazil. Some slabs of EN10025-2 S355JR+AR steel were rolled and were evaluated the dimensional tolerances, mechanical properties uniformity, grain size, surface and internal qualities. In addition, a correlation was observed between slab and plate thickness reduction and internal plate quality. The results show that this technology can be used with adequate performance for these steel grades in the current market.
Keywords: Plate mill; New product; Tapered plate.

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1 INTRODUCTION

In sectors such construction (bridges and big structures) and naval (shipping building and offshore structures) it is very common that designers require thick plates with different thicknesses. Normally, the lower parts use greater thickness, while upper parts can be applied with smaller plate thickness. This is due to the loads during use [1]. Therefore, it is often necessary to use bolted joints in bridge projects, resulting in increased structure weight and cost and lower productivity during on-site erection. An example of this is shown in the following figure.

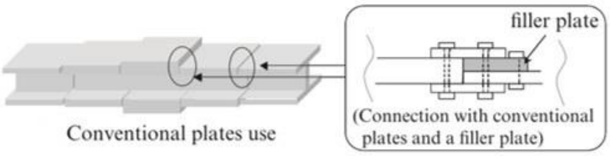

Figure 1. Conventional plate use in traditional bridge flange[1].

Many works have been carried out with the objectives of increasing steel resistance in order to reduce the structure weight, promoting cost reduction, lowering environmental impact and increasing productivity in assembly [2], [3], [4] and [5]. Combined with the development of high strength steels, new technologies have been developed by steelmakers, with highlight to the longitudinal rolling of different thicknesses in a same plate [6], [7] and [8]. The greatest motivating factor for this development was the reduction of weld length, with consequent increase in safety and in structure resistance, as applied to bridge building or shipbuilding. Ihara et al [6] show that this new solution for civil construction have some benefits: better appearance, removal of screw joints and filler plates.

Various thickness profile can be produced with this technology. Examples of the different shape profiles that can be produced at Gerdau Ouro Branco are shown in figure 2.

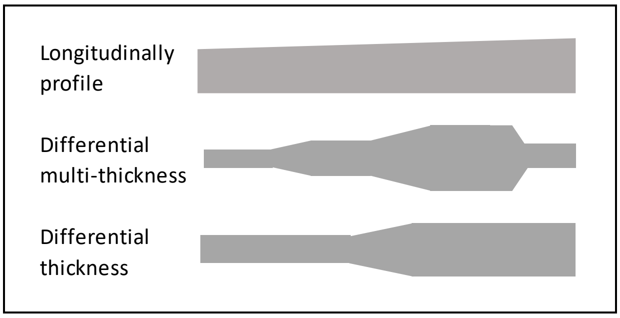

Figure 2. Different longitudinal plate profiles.

2 MATERIAL AND METHODS

In this paper, two plates of steel grade EN10025-2 S355JR+AR were rolled with different longitudinal profiles and characterized. The chemical composition for this steel grade is shown in table 1.

Table 1. Steel grade chemical composition.

Grade	C [%]	Mn [%]	Si [%]	Al [%]	Nb+V+Ti [%]	P [%]	S [%]	N [ppm]
S355	0,13 a 0,19	1,30 a 1,60	0,15 a 0,25	0,02 a 0,05	0,08 a 0,12	<0,025	< 0,01	< 80

The thickness profile according to the following picture.

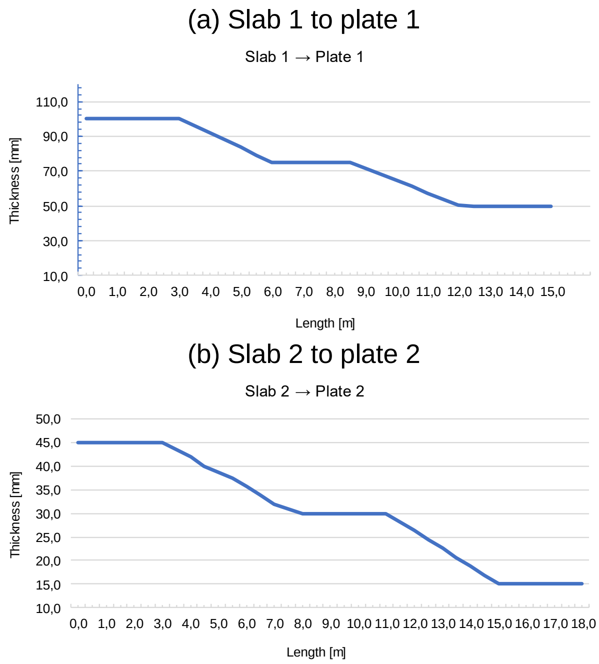

Figure 3. Plates thickness profile.

The slabs were cast using Dynamic Soft Reduction. Before rolling, the slabs were evaluated by macro etching. The sampling position is shown in figure 4.

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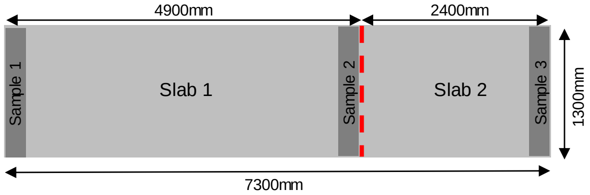


Figure 4. Slab samples for macro etching.

Plate samples were taken according to the scheme shown in figures 5 and 6. The sampling position on the width was based on the results observed on the slab macroetch samples and plate ultrasonic test.

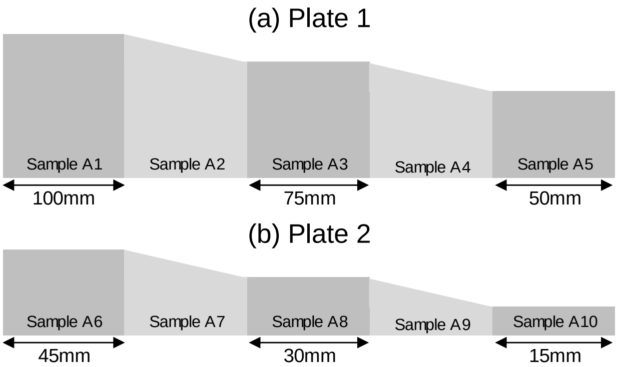


Figure 5. Plate sample design.

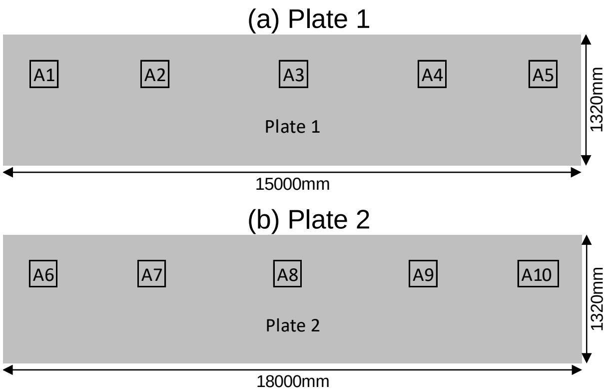


Figure 6. Sample position on plates

The mechanical properties, microstructure, grain size, segregation and micro hardness were evaluated for each plate sample. It is important to note that the samples were cut in the same position related to width plate.

3 RESULTS AND DISCUSSION

The macro etching images for transversal slab samples are show in figure 7.

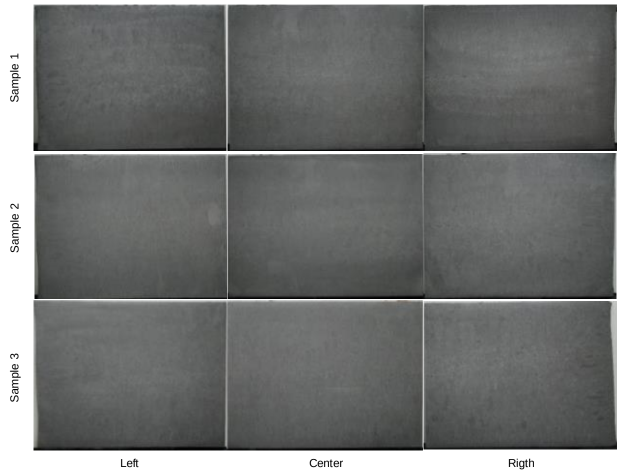


Figure 7. Macro etching results for slabs.

The macro etching results according Mannesmann rate met the product specifications and are displayed in table 2.

Table 2. Macro etching results for each slab sample.

Steel Grade	Slab sample	Segregation index	Crack index
	1	1	0
S355	2	1	0
	3	1	0

The internal slab quality was good for these applications. This is further evidenced by the good ultrasonic test results of the plates according EN 10160-S1E1 standard.

Visually, the plate quality was very good according figure 8.

Figure 8. Plate photography on plate yard.

The thermographic picture (figure 9) shows that the temperature profile of this plate was good. This indicates that the mechanical properties must be as expected.

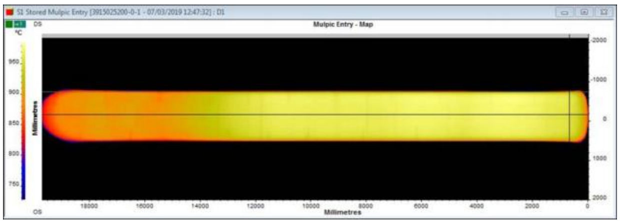
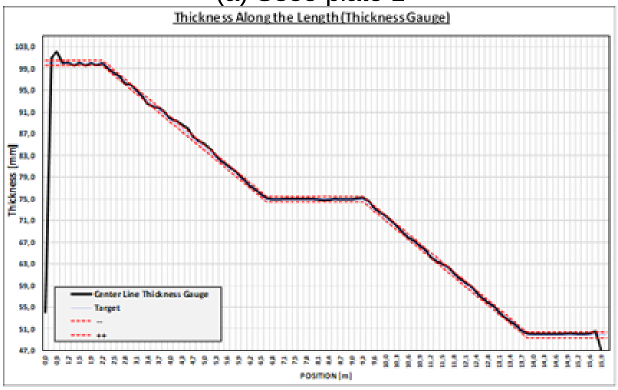


Figure 9. Plate thermal profile.

The thickness profile was evaluated and compared with what was predicted by the rolling model.

(a) S355 plate 1



(b) S355 plate 2

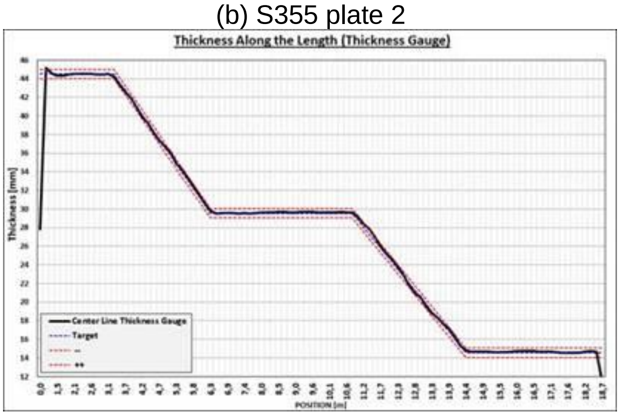


Figure 10. Real thickness profile.

The different values of thickness at the beginning and end of plates are discarded during trimming cutting.

The plates results for mechanical properties are show in next pictures.

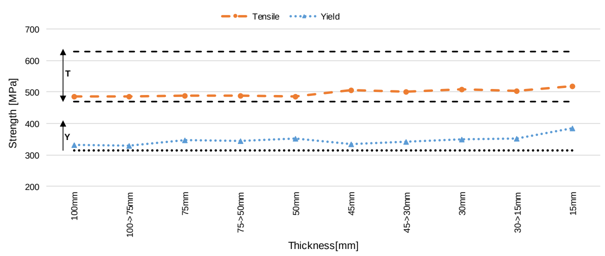


Figure 11. Strength results.

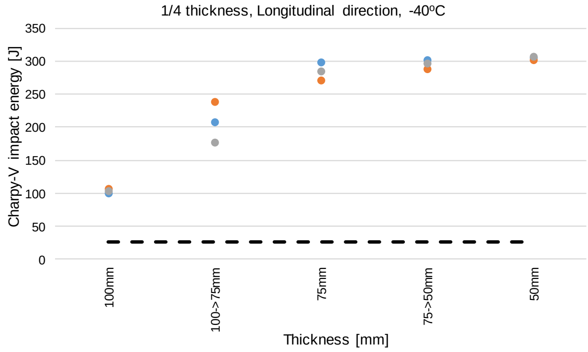


Figure 12. S355 charpy results.

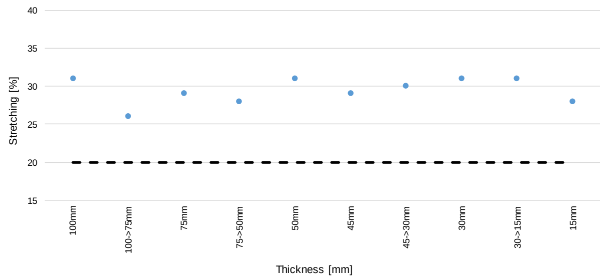


Figure 13. S355 elongation results.

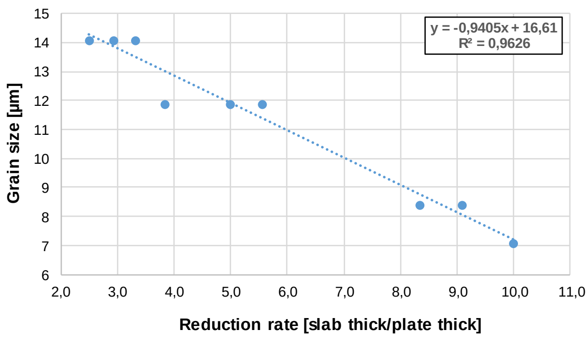


Figure 14. S355 grain size results.

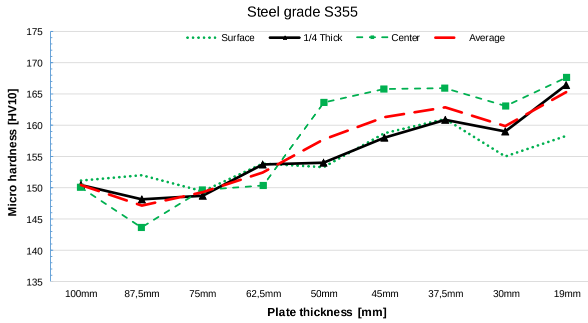


Figure 15. Micro hardness results.

All mechanical properties results have met the products specifications along the longitudinal direction.

The microstructures show that for the different thickness the ferritic grain refinement occurs as the reduction rate increase [9].

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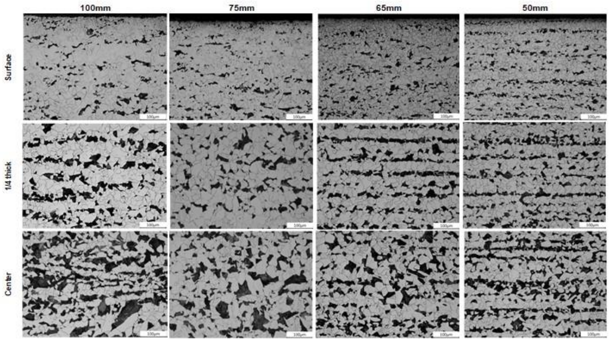

Figure 16. Microstructure for different thickness.

4 CONCLUSION

This new product will allow an innovative solution to serve the civil and naval construction markets with significant gains in productivity, cost reduction, lower environmental impact and greater sustainability [10,11,12].

The mechanical properties results show uniformity along the plate length and guarantee capacity to provide plate with different thicknesses in the longitudinal rolling direction, Tapered Plates.

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