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BANDED STRUCTURE DISPERSION OF ASTM A588 GRADE B STEEL AFTER SUCCESSIVE LOW COOLING RATE HEAT TREATMENTS

Daniele dos Reis Soares

Gianfranco de Mello Stieven

Jorge Teófilo Barros Lopes

Federal University of Pará, Augusto Corrêa St., 1 - Guamá, Belém - PA, 66075-110

dani_ddrs@yahoo.com.br

gianfrancostieven@yahoo.com.br

teofilo@ufpa.br

Abstract. *This study aims to verify the elimination of banding structures present in the ASTM A588 steel, due to the hot rolling process, through heat treatments with low cooling rate. Previous studies show that only by rapid cooling a banded structure could be eliminated. After the conditions of treatment of normalizing and annealing, the homogenization of the studied specimen was observed, contrary to the aforementioned section.*

Keywords: *ASTM A588, Banded structure, Heat treatments.*

1. INTRODUCTION

The class A588 covers high-strength low-alloy structural steel and it is used in buildings and welded bridges where saving in weight or added durability are important. These steels contain small amounts of alloying elements to achieve their strength in the hot-rolled or normalized condition. The principal strengthening of these steels is derived from precipitation of finely dispersed alloy carbides and grain refinement (Albrecht and Naeemi, 1987; Yang and Chen, 1991). Therefore, maintaining the innate characteristics of these steels is extremely important, however, it can happen that their properties are modified depending on the processes that the steel is subjected causing the appearance of nonhomogeneous structures, which can decrease the quality of the steel. Banding is a typical structure resulting from hot work, which is usually manifested by the formation of alternating bands of perlite and ferrite or other constituents with significant variation of carbon content. Such mechanism is linked to the segregation of substitutional elements. When the steel is austenitized, the segregation of the substitutional ones is not eliminated, due to the low diffusivity of these elements. Thus, by the anisotropy of the chemical composition in different regions of the steel and by the different behavior in the transformation of austenite decomposition, it begins in the poorer regions in alloying elements and stabilizes this phase. However, the literature shows that only heat treatments with a high rate of heat extraction are able to eliminate banding (Colpaert, 2008). In this way, this study aims to investigate the use of thermal treatments such as annealing and standardization in ASTM A588 grade B steel in order to eliminate banding structures.

2. EXPERIMENTAL PROCEDURE

For the accomplishment of the study in question, the studied steel was submitted to the annealing and normalizing thermal treatments.

The temperature adopted for full annealing was 840 ° C, determined in according to the formulation below plus 50°C suggested by ASM Metals Handbook (1991), as in Eq. (1).

$$AC_3(°C) = 910 - 203\sqrt{C} - 15,2Ni + 44,7Si + 104V + 31,5Mo + 13,1W - (30Mn + 11Cr + 20Cu - 700P - 400Al - 120As - 400Ti) \quad (1)$$

Soaking time of 90 minutes, determined in accordance with the dimensions of the specimen (1 1/2"). Residence time in the oven: 24 hours. For normalizing, the operating temperature also consisted of 840 ° C, soaking time: 90 minutes,

cooling through calm air. To reveal the microstructures resulting from the heat treatment process was used 2% Nital reagent (2 ml HNO₃ in 98 mL of ethano) attack by immersion for 7 seconds.

3. RESULTS AND DISCUSSION

The Table 1 shows the chemical composition of the studied steel, which is denominated NBR 7007 AR350COR or ASTM A588 Grade B.

Table 1. Chemical composition of ASTM A588 Steel Grade B.

Chemical Element	C	Si	Mn	Cr	Mo	Ni
Percentual of Specie	0.092	0.1	1.38	0.517	0.016	0.339

The Figure 1 shows the microstructure belonging to the material prior to treatments with magnification of 200X. It is possible to verify that, due to the lamination process, the structure presents bands of martensite and ferrite or other constituents with significant variation of the carbon content.

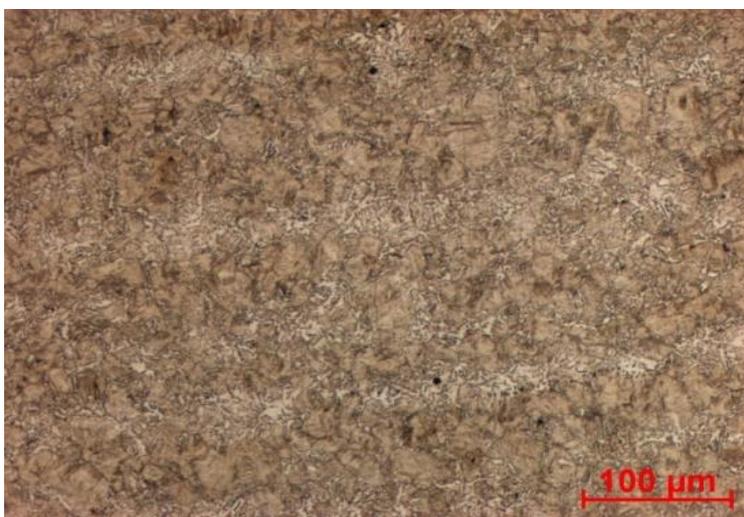


Figure 1. Microstructure of ASTM A588 steel without treatment

The original martensitic structure studied in the untreated part after annealing is capable of releasing tensions left by various consequences of the above process from the diffusion of carbon out of the grain by reducing the tetragonal martensitic twinning and microhardness of the material. From the moment that substitutional atoms have austenitization preference and, consequently, austenite decomposition, different regions of the microstructure will have to segregate carbon in the first instance, which favors the banding formation again. This explains the bundled formation at this stage of the study, which can be compared with the literature in Fig. 2.

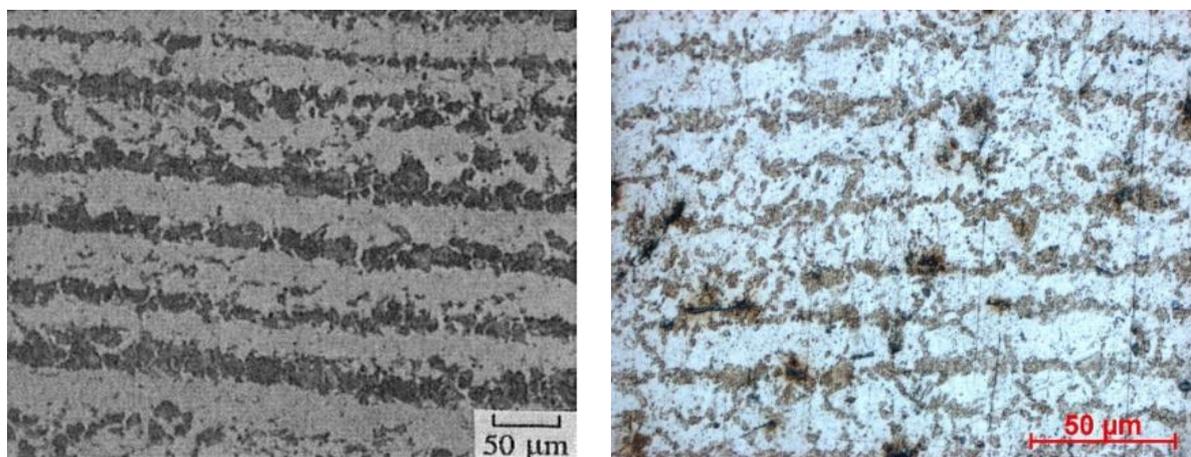


Figure 2. Banded structure from Badeshia, (2006) (left) and this study (right).

According to the literature the heat treatments of normalizing and annealing are unable to eliminate the banding (Colpaert, 2008). However, Fig. 3 shows the microstructure of the bonded steel after the normalizing treatment, which shows the homogenization of the part, dispersing the pearlitic and ferritic bands. It is important to emphasize that the part has also undergone annealing, so it can not be said that only the normalizing was responsible for such a phenomenon, but rather an annealing - normalizing composition.

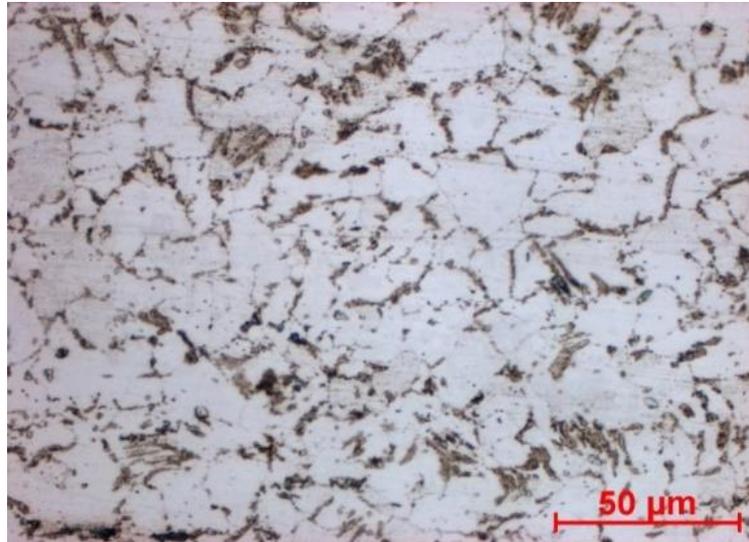


Figure 3. Steel ASTM A588 after normalizing treatment, 500X.

4. CONCLUSIONS

Therefore, banded structure was found in the specimen without heat treatment due to the forming process. The normalizing and annealing heat treatments were able to distribute partially the cited structure, which is contrary to current literature and affirm that only treatments involving rapid cooling of the austenitic field eliminate or reduce banding.

5. REFERENCES

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