SEM analysis of microalloyed steel thin slabs obtained at FEM-UNICAMP simulator

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Introduction

The seeking for new technologies that aim costs reduction, quality and productivity improvement, has pushed the steel makers to develop the *near-net shape casting* processes. One of these processes, the Thin Slabs Continuous Casting (TSCC), has been very diffused in hot strips and sheet production[1].

In the Materials Engineering Department of the UNICAMP Mechanical Engineering College (FEM) there is a group that has designed and built a TSCC Simulator[2] . In this simulator steel slabs of reduced thickness (40 to 90 mm) can be casted. After being tested with other alloys (Pb-25Sn, Cu-35Zn and AISI 1060) Nb-V microalloyed steel was melted in an air induction furnace and solidified in the water cooled copper mould of the TSCC Simulator. The microalloyed steels have great importance in pipelines for oil and gas transportation, applications that require both high tensile and yield strength, besides good toughness and weldability, properties that are the result of the combination of specific chemical composition and rolling schedule.

Experimental Procedure

The material melted in the induction furnace was API X70 steel, supplied by CST (Companhia Siderúrgica de Tubarão). Five thin slabs (40 mm thickness) were solidified in the TSCC Simulator with cooling rates higher than 1.9 °C/s, minimum value expected for TSCC[3]. The temperature curves were obtained with Pt/Pt-10Rh thermocouples installed inside the mould. From each slab was cut a sample of its central region in order to observe the most representative microstructure of the slab. The first slab was used to practice the rolling stage of the experiment. The third (C) and fourth (D) slabs showed the closest chemical composition one to another, and they are presented at table 1.

Table 1 Chemical composition (%weight)

Slab	C	Mn	Si	Al	Nb	V	N
C	0,072	0,890	0,349	0,097	0,023	0,071	0,017
D	0,073	0,990	0,384	0,078	0,027	0,071	0,013

The thin slabs were prepared to be rolled in an experimental FENN Rolling Mill, in two finishing rolling temperatures (1000 and 900°C). After reheated at 1250°C by twenty minutes, the samples were rolled, in the same condition for roughing and two different conditions for finishing. After then, they were cooled in a special apparatus[4] with a medium rate of 3.5 °C/s, and then put in a tunnel furnace to simulate the coiling stage at 550°C/s.

Results

The Scanning Electron Micrographs made in samples previously prepared, polished and etched, revealed the same as cast ferritic-pearlitic microstructure, for all slabs, with 0.14 and 0.18 μm pearlite interlamellar spacing for the slabs C and D respectively, which indicates a good repeatability of the process conditions during the casting. The SEM micrographs are showed in Figures 1 and 2.

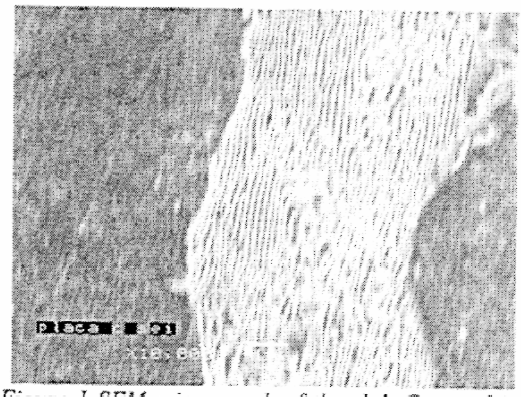

Figure 1 SEM micrograph of the slab C casted in the TSCC Simulator (Nital 2%)

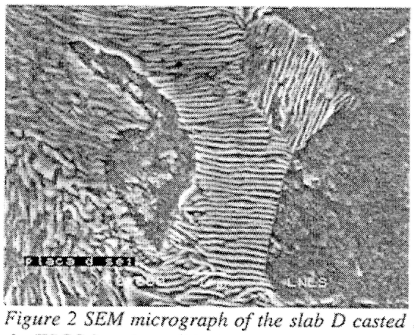

Figure 2 SEM micrograph of the slab D casted in the TSCC Simulator (Nital 2%)

The microstructures of the C and D samples after rolling are showed in Figures 3 and 4, and are very similar (ferritic-pearlitic). The percentage of pearlite varied from 5 to 10%, and it was not observed any influence of the small variation of chemical composition nor the finishing temperature on this variable.

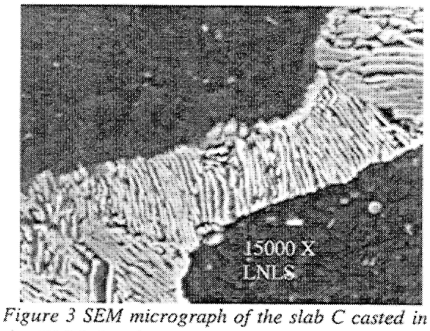

Figure 3 SEM micrograph of the slab C casted in the TSCC Simulator and rolled at 900 °C in the finishing stage (Nital 2%)

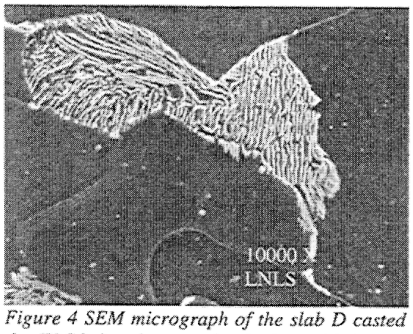

Figure 4 SEM micrograph of the slab D casted in the TSCC Simulator and rolled at 1000°C in the finishing stage (Nital 2%)

Figures 3 and 4 revealed the ferritic-pearlitic microstructure, with pearlite interlamellar spacing of 0.22 and 0.12 μm for the slabs C and D respectively, where the first one had a cooling rate of 3.3°C/s and the second 3.6°C/s after the finishing rolling.

Conclusions

The TSCC Simulator developed in the Materials Engineering Department of FEM-UNICAMP is a suitable device to simulate the solidification stage of the thin slab microalloyed steel continuous casting process.

The SEM micrographs of all slabs solidified in the TSCC Simulator showed the same as cast microstructure, ferritic-pearlitic, which indicated a good repeatability in the experiments.

The different temperatures of finishing rolling have not influenced the microstructure observed by SEM in the rolled samples, also ferritic-pearlitic for both conditions. The optical microscopy revealed a ferritic grain size reduced from 11 to 6.5 μm when the finishing temperature was lowered from 1000 to 900°C[5].

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References

[1] Birat, J. P., *La Revue de Metallurgie CIT*, Nov. 1998, p.1387-1406.

[2] Gentile, F. C., Development of prototype for simulation of slabs continuous casting. Campinas: UNICAMP-FEM, 1999, 91p. Dissertation (Master of Science).

[3] Priestner, R. and Zhou, C., *Ironmaking and Steelmaking*, v. 22, n.4, 1995, p. 326-332.

[4] Bustamante, L. A. C. *et al.*, Anais do 36° Seminário de Laminação, Processos e Produtos Laminados e Revestidos da ABM, Belo-Horizonte, M.G., Setembro de 1999, p.69-77.

[5] Sobral, M. D. C., Thermomechanical Treatment of Microalloyed Steel Thin Slabs. Campinas: UNICAMP-FEM, 2000, 89p. Dissertation (Master of Science).