A STUDY ON THE RELATIONSHIP BETWEEN THE MARTENSITE LAYER THICKNESS AND THE YIELD STRENGTH OF TMT REINFORCING BARS

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ABSTRACT

The thermo mechanically treated (TMT) bars are strengthened by a quenching process just after the rolling process. The quenching and subsequent air cooling will induce a self-tempered martensite layer at the outer rim of the steel bar. The martensite layer thickness was varied by finding discrete samples from the produced TMT. The difference in the hardness of the martensite layer and inner core was used to identify the exact thickness of the martensite layer by means of the micro-hardness tester. 0.1% proof stress was calculated as the estimate to the yield strength and a relationship between the martensite layer thickness and the yield strength was built which could predict the minimum of the martensite layer.

Keywords: TMT, martensite layer thickness, yield strength

1. INTRODUCTION

Concrete is weak under tension while steel supports concrete to overcome this weakness by forming a unique combination of construction materials. Also steel will be protected from corrosion by the application of a cement layer on the steel bars and along with the suiting thermal expansion coefficients, steel reinforced concrete has remained its position.

The quenching of the hot rolled steel rod by pressurized water creates a core-case structure of ferrite-pearlite and martensite along the rod and subsequent air cooling temper the martensite layer with the radial heat flow from the core to the surface.

This study is based on the yield strength variation of TMT bars with the changing thickness of the martensite layer.

Chemical composition and the heat treatment variations both can cause the changes in properties. In this study, the chemical compositions were assumed to be similar in the set of samples as they were obtained from the same billet which they were rolled out.

In the quality assurance process of TMT bars, the steel manufacturers use tensile testing machines to test the bars for the tensile properties. When the results are produced a significant number of products are finished. Therefore a prediction of the strength of the bars without carrying out tensile tests would offer better adjustment to the manufacturing process as well as minimize the waste.

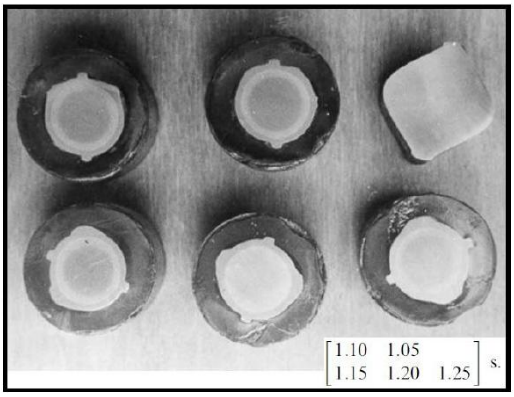

Figure 1: Changes in martensite layer with the quenching time [3]

Figure 1 exhibits the changes in martensite layer with quenching time which were studied in a research [3] carried out for obtaining a computer based modeling on artificial nural networks.

2. METHODOLOGY

The variation of the radial hardness of a cross-section of TMT bars was studied. The sudden hardness drop achieved was to be used as a basis to determine the thickness of the martensite layer. The point which shows the 50% drop of hardness was to be considered as the boundary of the martensite layer.

Samples were obtained from a commercial manufacturer of 12 mm TMT bars, which were manufactured from a single billet. 25 samples were randomly selected among those. Samples of 1 cm length of these samples were cut using hacksaw and another set of 18 inch were prepared. The first set was ground with bench grinder and ground with hand grinder with emery papers of grit 240, 400, 600 and 1200. The prepared surfaces were polished with a diamond powder and washed and dried. The Vickers hardness values along a radius for each sample were obtained using a micro hardness tester under 300 gf. Hardness vs distance graphs were plotted and the thicknesses of the martensite layer of each sample were calculated using the graphs.

The other set of samples were tested with universal tensile testing machine. The stress vs strain graphs for each sample were plotted with the use of the force and the elongation data obtained, and 0.1% proof stress for each sample was calculated using the graphs.

3. RESULTS AND DISCUSSION

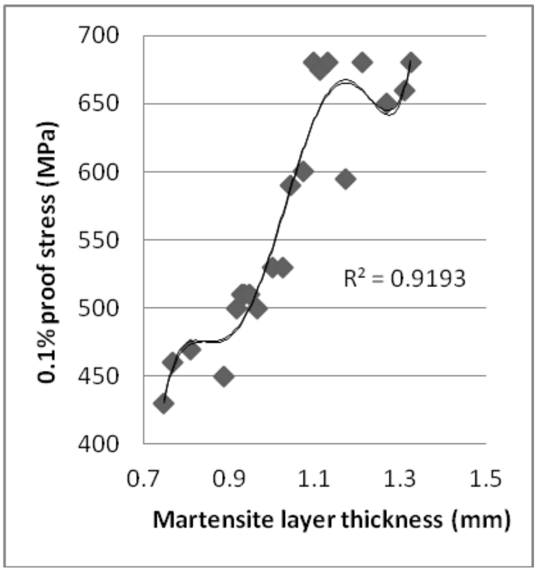

Figure 2: 0.1% proof stress vs. martensite layer thickness

The Figure 2 shows the variation of the tensile strength of the tested samples with the thickness of the martensite layer. In accordance to the SLS 375:2009 the RB 500 specification is met with the most of the samples and the minimum thickness of the martensite layer is calculated as 0.94 mm for the tested samples.

The selection of the 25 nos. of samples was carried out after chemical etching. The cross-section of the TMT rods were ground and etched in a HNO_3-ethyl alcohol mixture with excess HNO_3 and observed with the naked eye.

All the surfaces were prepared after manual cutting and grinding while dipping or immersing in water in order to avoid tempering of the sample due to the generation of the heat from the abrasion.

4. CONCLUSION

Fluctuations of the process causes the differences in the thickness of the martensite layer. The yield strength of the bars increase with the increasing thickness of the martensite layer. The minimum strength allowed for TMT bars stated in SLS 375:2009 standards can be used as a basis of developing a minimum martensite layer thickness and that was approximated to be 0.94 mm for 12 mm bars.

5. REFERENCES

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