THE INFLUENCE OF AUSTENITIC TRANSFORMATION ON THERMAL FATIGUE IN CAST STEEL MILL ROLLS

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Abstract

The influence of shrinkage caused by austenitic transformation on thermal fatigue of mill rolls made of four different cast steels was investigated. The samples were collected from the work surface perpendicularly (or close to it) to the axis of the rolls. The dimensional changes (shrinkage) associated with the austenitic transformation were determined by dilatometric examinations. A number of parameters that describe the susceptibility to thermal fatigue of investigated rolls was determined, including the greatest observed crack depth G_{max}, average crack depth G, average crack path length L, average distance between cracks and others. It was found that the shrinkage associated with the formation of austenite appears to be a main factor contributing to the nucleation and growth of thermal fatigue cracks in cast steel rolls

Keywords: thermal fatigue, austenitic transformation, cast steel, mill rolls

1. INTRODUCTION

Thermal fatigue cracks occurring on the surface of the mill rolls are related to alternating stresses that appear during hot rolling. These stresses strongly depend on temperature change range and coefficient of thermal expansion [1,2]. Thermal stresses depend on changes in microstructure [3] which are reliant on mill roll operating temperature. Changes in microstructure are also dependent on temperature range of austenitic phase transformation, described by characteristic critical points of the relevant steel [4]. Thus, the aim of the hereby study was the determination of the influence role of the shrinkage, associated with the austenitic transformation, on the thermal fatigue crack initiation and propagation in cast steel rolls.

2. MATERIAL AND METHOD

Four different cast steels: G200CrNiMo4-3-3 (roll campaign 4 095 Mg), G200NiSiCr8-4-4 (roll campaign 1 561 Mg), G200SiCrNi4-4 (roll campaign 2 578 Mg) and G120CrNiMo4-3-3 (roll campaign 2 116 Mg) were investigated. For the purposes of this study, the following parameters characterizing thermal fatigue cracks were defined: maximum crack depth g_{max}, maximum crack depth per 1 000 Mg of roll campaign $g_{max/1000}$, average crack depth G, average crack depth per 1 000 Mg of roll campaign G_{1000}, average crack length L, average crack length per 1 000 Mg of roll campaign L_{1000} [μm/Mg], average crack length per 1 mm of length of the roll working surface section L_{mm}, average crack length per 1 000 Mg of roll campaign and per 1 mm of length of the roll working surface section $L_{1000/mm}$, average distance between cracks X [μm] and average distance between cracks per 1 000 Mg of roll campaign X_{1000}. The specimens were taken from the working surface perpendicular to the axis of rolls for rolling rails. The values of shrinkage ΔL and ΔL_n, associated with the austenitic transformation, are graphically defined in **Fig. 1** [5]. These values were read from the corresponding dilatometric curves.

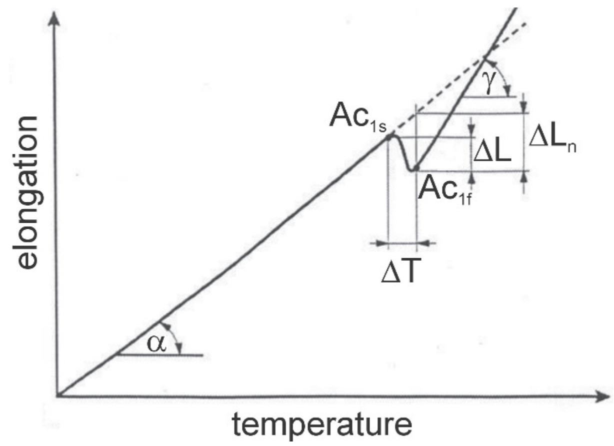
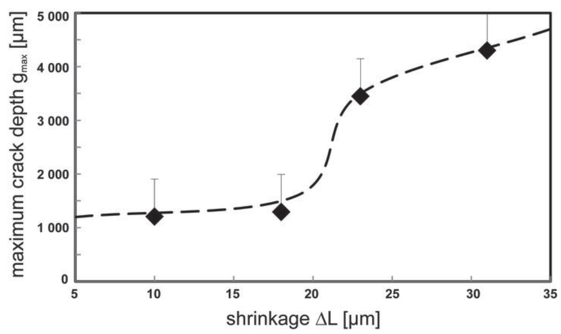


Fig. 1 Graphical definition of shrinkage ΔL and ΔL_n caused by austenite formation during heating

3. RESULTS AND DISSCUSION

The influence of shrinkage values ΔL and ΔL_n, associated with the austenitic transformation, on the measured parameters (g_{max}, $g_{max/1000}$, G, G_{1000}, L, L_{1000}, L_{mm}, $L_{1000/mm}$) is summarized in **Fig. 2** and **Fig. 3** and the dashed lines indicate the suggested relationship. The relationship between measured density of the thermal fatigue cracks (defined as average distance between cracks X) and shrinkage ΔL and ΔL_n is presented respectively in **Fig. 4** and **Fig. 5**. As it can be seen, the increase in shrinkage caused by austenite formation seems to favor the development of the thermal fatigue cracks (**Fig. 2** and **Fig. 3**). Similarly, the crack density increases (the average distance between cracks decreases) with increasing the shrinkage (**Fig. 4** and **Fig. 5**).

a)



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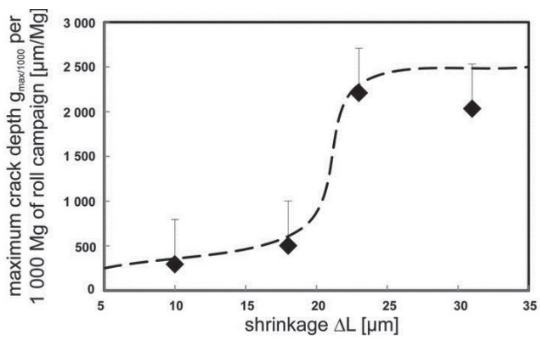

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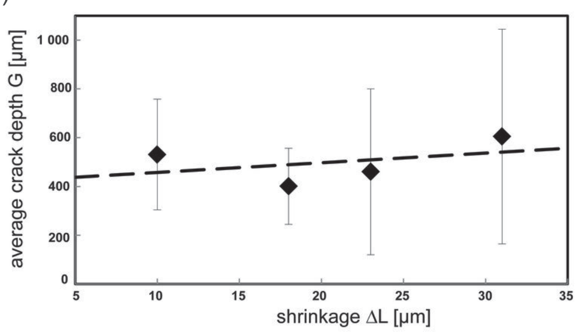

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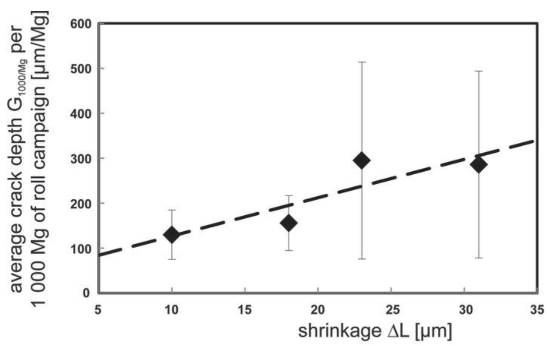

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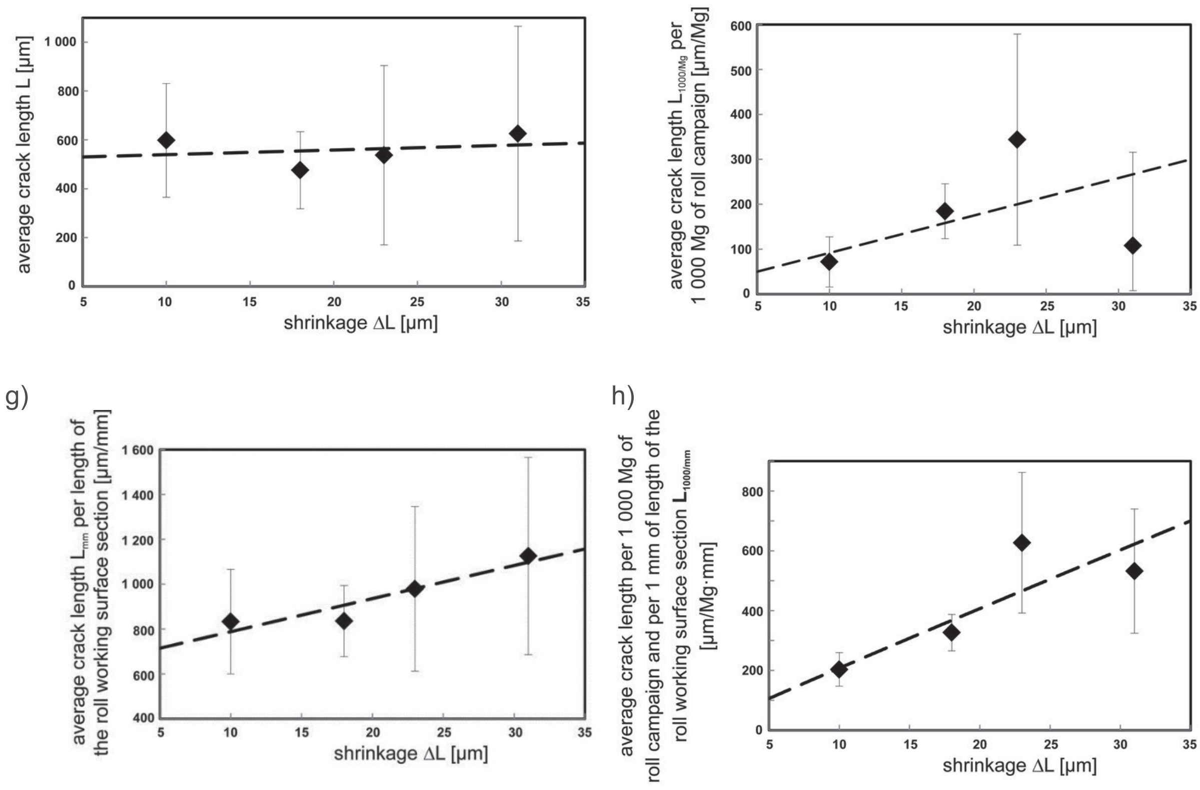
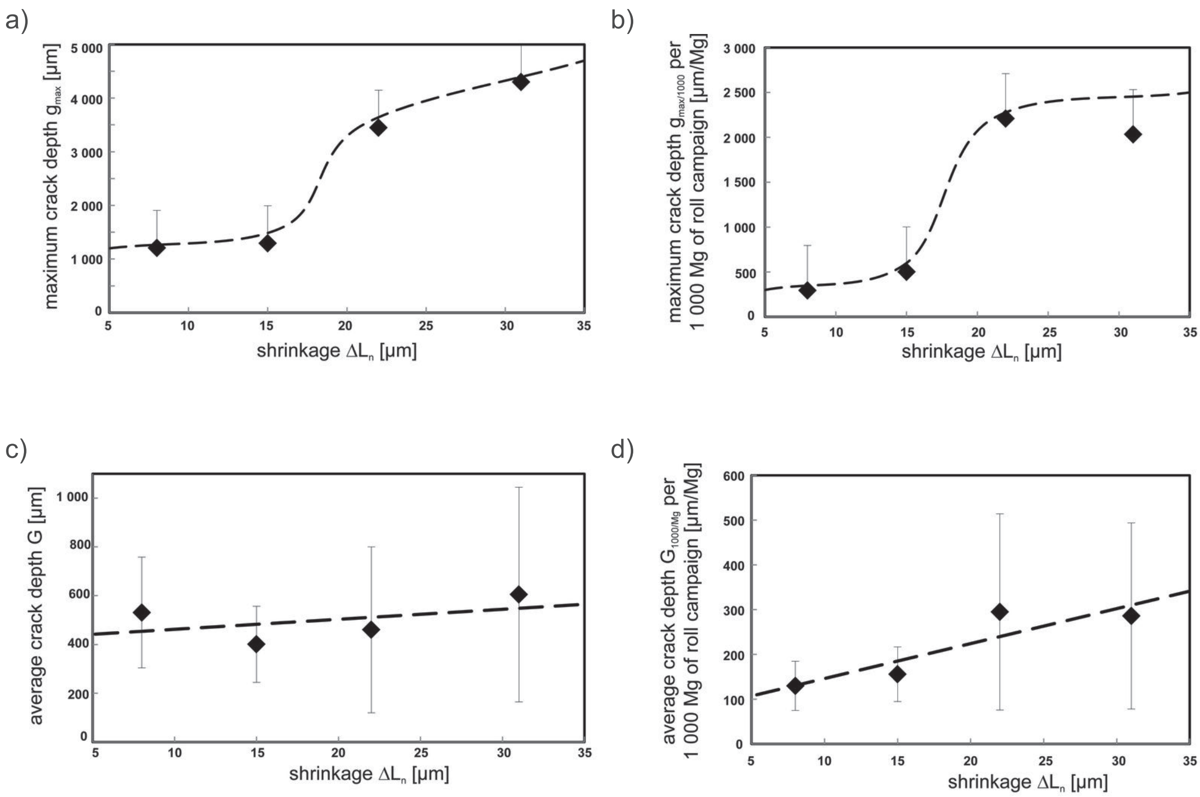


Fig. 2 The influence of shrinkage ΔL, associated with the austenitic transformation, on the measured parameters (g_{max}, $g_{max/1000}$, G, G_{1000}, L, L_{1000}, L_{mm}, $L_{1000/mm}$)



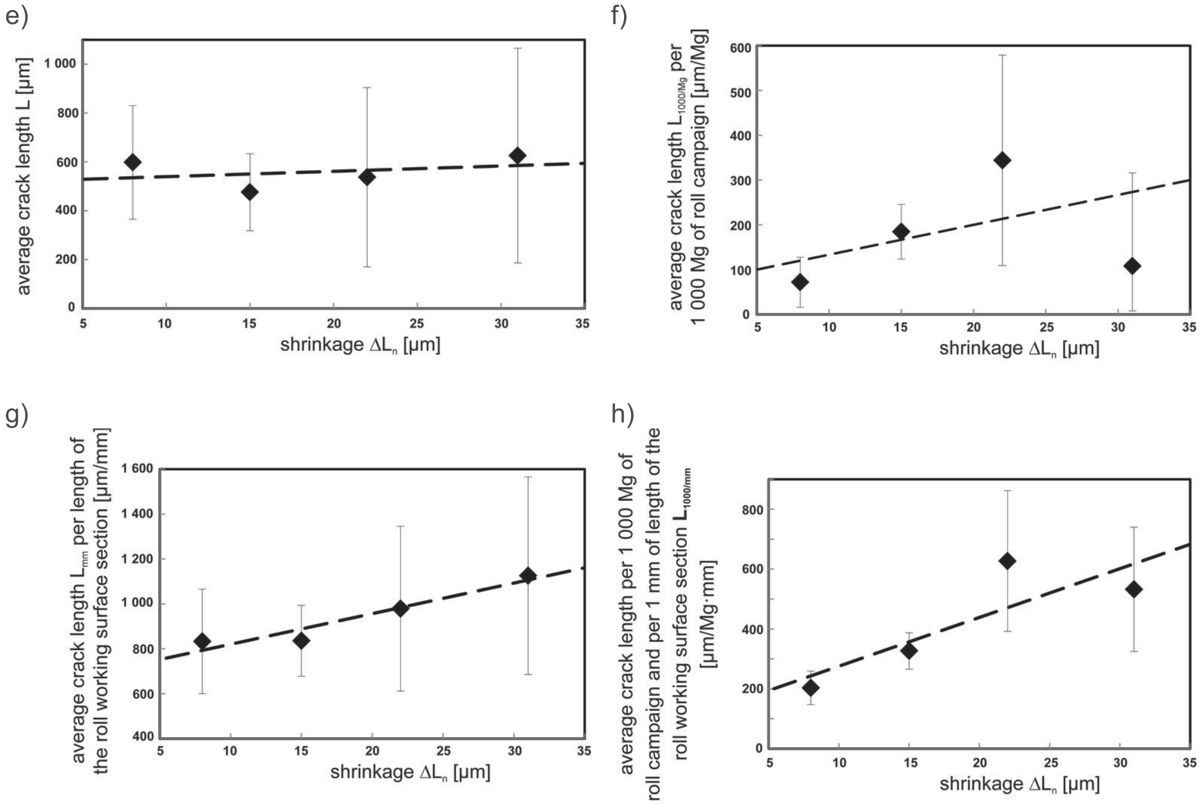


Fig. 3 The influence of shrinkage ΔL_n, associated with the austenitic transformation, on the measured parameters (g_{max}, $g_{max/1000}$, G, G_{1000}, L, L_{1000}, L_{mm}, $L_{1000/mm}$)

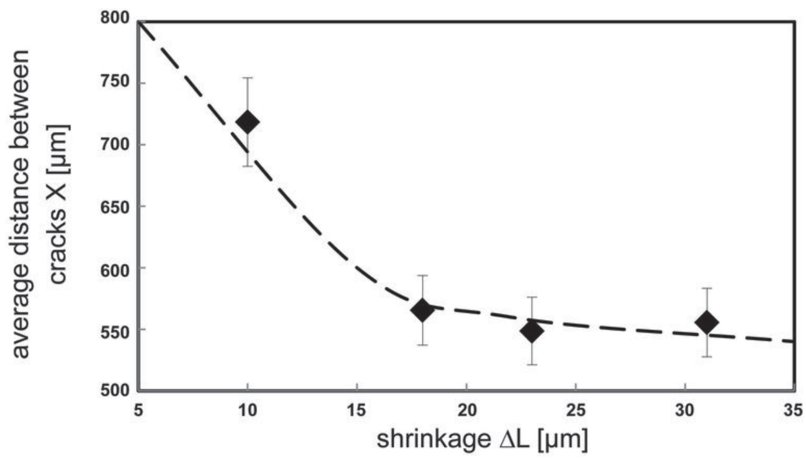


Fig. 4 The influence of shrinkage ΔL, associated with the austenitic transformation, on the density of the thermal fatigue cracks

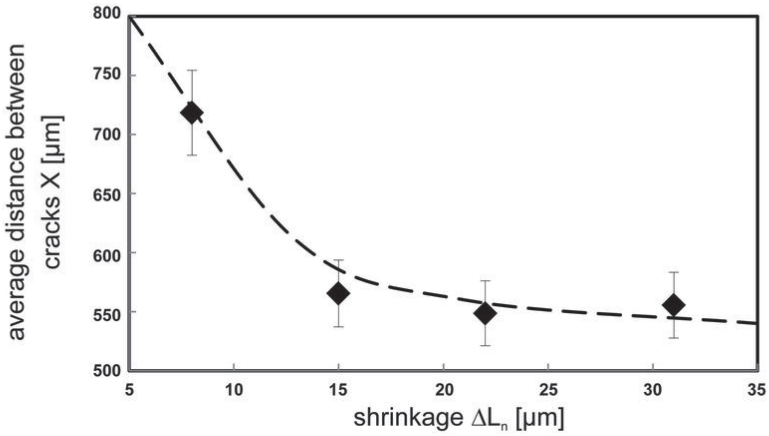


Fig. 5 The influence of shrinkage ΔL_n, associated with the austenitic transformation, on the density of the thermal fatigue cracks

CONCLUSION

The results obtained in this study allow to formulate the following conclusions:

- The measured parameters (g_{max}, $g_{max/1000}$, G, G_{1000}, L, L_{1000}, L_{mm}, $L_{1000/mm}$ and X) were proposed for the first time and they well describe the thermal fatigue phenomenon in cast steel rolls.
- The shrinkage described as ΔL and ΔL_n, associated with the austenitic transformation, plays a significant role in the thermal fatigue crack initiation and propagation in cast steel rolls.
- Increase in shrinkage caused by austenite formation promote the initiation and development of the thermal fatigue cracks. Crack density increases (the average distance between cracks decreases) with increasing the shrinkage.

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