cbecimat26
26° Congresso Brasileiro de Engenharia e Ciência dos Materiais
22 a 26 de novembro de 2026
Costão do Santinho
Florianópolis-SC

Thermal Characterization of ferritic to the martensitic phase D6 Steel

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Introduction

D6 tool steel is a high-carbon, high-chromium cold-work steel characterized by high wear resistance and moderate toughness. In the annealed condition, its microstructure consists mainly of a ferritic matrix containing chromium-rich carbides. After quenching, the matrix transforms into martensite, while a significant fraction of these carbides remains undissolved. These microstructural changes can directly affect the thermal transport properties of the material.

Objective

This work aims to investigate the influence of quenching on the thermal diffusivity of D6 tool steel by comparing its annealed and quenched conditions.

Methodology

D6 steel samples were heated to 1200 °C and subsequently quenched in oil to obtain a predominantly martensitic matrix. Thermal diffusivity was measured before and after heat treatment using the Laser Flash method proposed by Parker et al. (1962)[1], which determines thermal diffusivity from the transient temperature response produced by a short thermal pulse applied to one surface of the sample.

In addition, the heat capacity was measured using Newton's law of cooling by analyzing the material's cooling curve.



Figure 1. CO_2 Laser.

Results and Discussion

Before quenching, the thermal diffusivity and specific heat capacity were found to be 5.56 mm²/s and 470 J/(kg·K), respectively, The obtained value is in good agreement with the reference value[2]. After quenching, the thermal diffusivity decreased to 3.33 mm²/s, while the specific heat capacity increased to 1030 J/(kg·K). These results indicate that quenching significantly altered the thermal properties of the material, increasing its heat-storage capacity while reducing its ability to conduct heat.

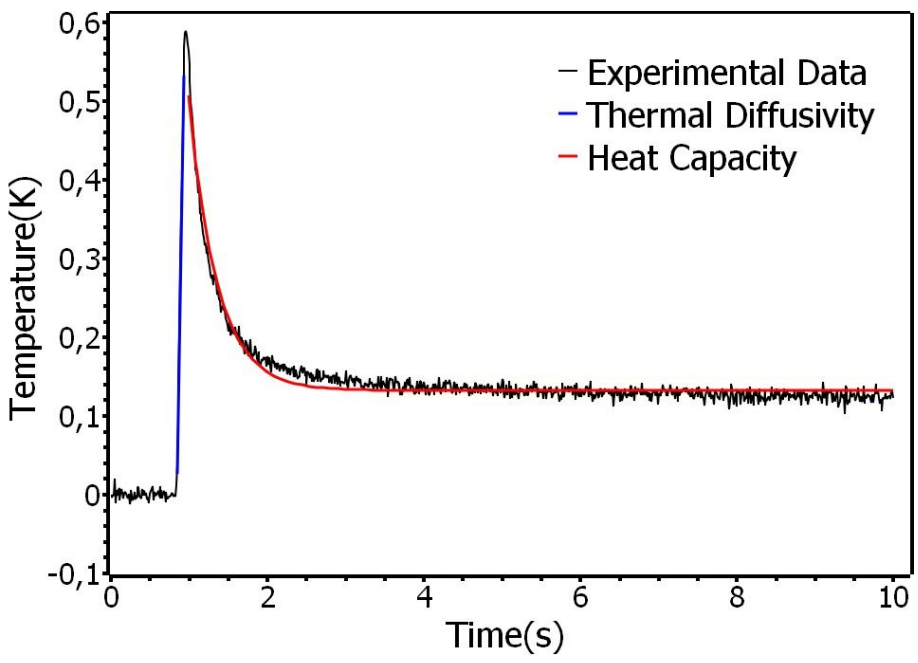


Figure 2. Example of a fit applied to the experimental data.

Conclusion

Quenching significantly affected the thermal properties of D6 steel. The thermal diffusivity decreased from 5.56 to 3.33 mm²/s, while the specific heat capacity increased from 470 to 1030 J/(kg·K). These results indicate an increased capacity for thermal energy storage and a slower thermal response after quenching.

Acknowledgments

The autors would like to thanks to FAPES, CAPES, CNPq for financial support and PPGFis-UFES and UFES.

References

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[2] B. Hallstedt, "Use of CALPHAD Thermodynamics to Simulate Phase Formation during Semi-Solid Processing," *Solid State Phenomena*, **141–143**, 641–646 (2008). DOI: 10.4028/www.scientific.net/SSP.141-143.641.