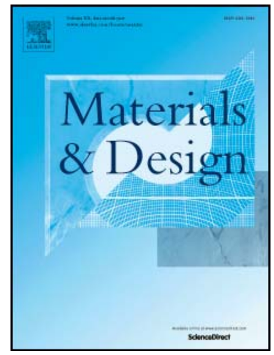

Numerical simulation and experimental investigation on the induction hardening of a ball screw

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PII: S0264-1275(15)30343-9
DOI: doi: 10.1016/j.matdes.2015.08.094
Reference: JMADE 502

To appear in:

Received date: 20 May 2015
Revised date: 11 August 2015
Accepted date: 19 August 2015

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Abstract: To improve the distribution of the hardened layer and avoid potential defects, the effects of induction hardening parameters on the hardened layer were researched using the finite element method (FEM). A FEM model of single coil induction hardening was built, and temperature curves on the surface region of a ball screw were attained by numerical simulation. The hardenability and phase transformation of 55CrMo steel were researched by experiment. The simulation and experimental results show that the temperatures Ac1 and Ac3 rise with increasing heating rate. Non-uniformity of temperature at the groove region can lead to non-uniformity of austenitization and hardness. High temperature can result in cracks, coarse grain size and overheating defects at the groove tip. Martensite produced during cooling transforms into tempered martensite due to the residual heat, and the remaining austenite transforms into martensite at a low cooling rate. A 5010-type ball screw cannot attain a hardened layer with the thickness of 2.5 mm at the groove bottom without defects at the groove tip by single coil induction hardening. Multiple induction coils with a certain gap would be helpful to improve the uniformity of temperature and hardness.

Keywords: Induction hardening; Austenitization; Hardness; Ball screw

1 Introduction

The ball screw is among the most important functional parts in high-speed CNC machine tools, and the main form of damage to ball screws is contact fatigue wear. To maintain precision and prolong the useful life, it is necessary to improve the hardness distribution of the hardened layer of the ball screw [1-2]. At present, induction hardening is the most useful method to improve the mechanical performance of the ball screw. Some researchers have used a coating magnetizer [3], multiple coils or a tilted coil [4] to improve the uniformity and depth of the induction hardening layer for the ball screw.

Induction hardening is a surface treatment method in which a metal part is heated by induction heating and then cooled in a quenchant, such as water, oil or high-pressure gas. During induction hardening, the quenched metal undergoes a phase-transformation of austenite to martensite, and the hardness of the quenched part increases. The induction heating process uses the principle of electromagnetic induction to heat the surface layer of a work-piece. By placing a conductive material into a strong alternating magnetic field,