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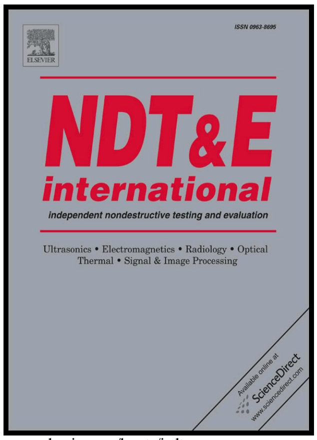

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Detection of milled 100Cr6 steel surface by eddy current and incremental permeance methods.

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Abstract

Hard milling was applied to 100Cr6 steel of 50 HRC hardness using cutting tools with different flank wear. The modified surface layers were investigated by eddy current and incremental permeance measurements at magnetizing frequencies from 0.2 to 10 kHz. The signals were studied as a function of a low-frequency magnetic field applied to the sample. Both methods showed growth of magnetically harder peak in the measured curve with tool flank wear and magnetizing frequency increase. New parameters were introduced to evaluate the flank wear and corresponding surface damage in the material. The incremental permeance method showed much higher sensitivity comparing to the eddy current testing.
Keywords: eddy currents; incremental permeance; hard milling; magnetic materials; surface characterization

1. Introduction

Last years it became popular to integrate different machining operations into a single machine tool platform such as turn/mill or mill/turn machine tools with the aim to increase throughput by reducing work handling. Due to modern microprocessor-based control of the machines and new technologies in the cutting tool production, turning and milling of hard materials can approach the accuracy achieved in the past only by grinding.

Hard milling allows the components to be machined in the hardened state, thus avoiding several expensive and time-consuming processes such as electrical discharge and hand polishing. The mold shop can start with hardened steel and produce finished surfaces that require little or no polishing. This can reduce the production time by several times.

Milling is the cutting process of a flat workpiece by a rotating tool. The cutting tool consists of a tool body and replaceable cutting inserts, usually made of cemented carbides. The "face mill" is a larger-diameter tool used for efficient milling of a wide flat surface in a small number of passes. The speed at which the piece advances through the cutter is called the feed rate.

Unfortunately, hard turning and milling can produce remarkable changes in the material surface integrity, especially in the near surface region. The modified surface usually contains so-called white layer (WL) followed by the dark layer (DL). The WL is produced when the austenitizing temperature in the machined surface is followed by rapid self-cooling, whereas the thermally softened DL is a region undergoing thermally induced overtempering below the austenitizing temperature [1].

The WL is called "white" because it is resistant against standard etchants and appears white in an optical microscope and featureless in a scanning electron microscope. Griffiths [2] attributes the WL formation to: 1) rapid heating and quenching, which results in transformation to martensite with high dislocation density and compressive residual stresses; 2) severe plastic deformation, which produces a homogenous structure or a structure with a very fine grain size. The WL has higher hardness and smaller grain comparing to the bulk. [3-