Engineering Failure Analysis 18 (2011) 783–788

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Failure analysis of cutting die used for the production of car racks

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ARTICLE INFO

Article history:
Available online 31 December 2010

Keywords:
Failure analysis
Cold working die
Cutting tool
Machining

ABSTRACT

The failure of a cutting tool intended for the production of car racks was investigated. The tool consisted of two parts, the mould and the counter-die. The die, made of AISI O1 steel and designed for cutting metal sheets up to 2 mm thick, failed during the final grinding process, before performing any production service. Recorded history was collected, with data concerning the material selection, the manufacturing conditions and the final heat treatment. The die was inspected visually and than photographed. Hardness measurements and chemical analysis were performed in order to identification the tool material. A representative sample was subjected to magnetic-particle inspection for the emergence of surface cracks. Specimens were examinated by optical and electron microscopy (SEM). The type of failure and the principal factors that caused it are studied, and some suggestions are presented, in order to avoid similar failures.

1. Introduction

Cold working tool steels are considered to be the most common class of tool steels intended for applications at temperatures below 200 °C, such as various cutting tools, forming dies and measuring instruments. Dies are the most critical components, due to their high cost, fine tolerance and exceptional mechanical properties, like the capability of retaining high values of hardness, the combination of high strength and toughness, and good wear resistance [1]. Furthermore, the die-steels are usually alloyed and used after hardening and tempering, so that good hardenability and tempering resistance can be achieved [2].

Each die is designed and manufactured for a specific application and a definite lifetime. Toolmakers, in cooperation with scientific researchers continuously seek for innovative improvements in tool lifetime. Krishnadev and Jain [3] suggested that the productivity of tool steels could be improved through sound material selection and heat treatments. The effect of heat treatments on microstructure and hardness of common steels used in cold-forming was presented by Gojic [4]. Studies have also been conducted to increase the endurance of steels by improving their wear resistance. Bourithis et al. [5], compared the wear properties of two commercial cold working tool steels in order to select the most suitable material. Wagner et al. [6], studied three common methods used for surface treatment and proposed the optimisation of tool surface locally adapted to the load, for the improvement of the tool technology. New methods of coating deposition on cold working tool steel have also been investigated [7,8].

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doi:10.1016/j.engfailanal.2010.12.020