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Case study

# Fatigue fracture of cutter blade made of high-speed steel

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ABSTRACT

The quality of the surface of cyclically loaded components is very important. Many observations confirm that the root cause of the micro cracks (causing the fatigue fracture) are primarily a surface's defects appearing during production process. These surface defects can be also caused by engraving processes used to perform identification marks. This paper presents the failure analysis of broken blade of the cutter Ku 500VX. The blade was subject of standard metallographic examination, hardness measurements, fractography analysis and metallographic studies using stereoscopic, light and scanning electron microscopes. The damage of the blade was caused by changes of the structure (formation of the brittle micro dendritic structure) that occurred during manual electric engraving process when the material was heated till its melting point. As a result the stresses occurred in surface what provided to micro cracking and to propagate the fatigue fracture. The origin of this fatigue fracture was in the place where the inscription was made.


## 1. Introduction

The subject of the analysis was the broken blade of cutter Ku 500VX that was used in meat processing. The aim of the study was to determine the failure cause and to give an answer how it could be avoided. General view of broken blade with marked area of the damage is shown in Fig. 1. The performed tests included hardness measurements, fractography analysis and metallographic studies using stereoscopic, light and scanning electron microscopes.

## 2. Material and methods

Macroscopic analysis of outer surface and fracture of the blade was performed using stereoscopic microscope SMT 800 and scanning electron microscope JEOL JSM 5800 LV.

Examination on the cross-section of the blade was performed in non-etched state and after etching with reagent Mi19Fe containing 3 g of ferric chloride, 10 $cm^3$ hydrochloric acid and 90 $cm^3$ of ethanol according to polish standard PN-H-04503:1961P (what corresponds to reagent no. 26 according to international standard ASTM E407-07) using metallographic light microscope Epiphot coupled with Nikon digital camera. The paper presents a photographic documentation of characteristic structures.

Hardness measurements were made on the outer surface of the blade. The study was performed with Vickers method under the load of 10 kg (98.070 N) in accordance with standard DIN EN ISO 6507-1:1999 using Zwick hardness tester 321, running time was 15 s.

A general view of the broken blade is shown in Fig. 1. Sample for testing was taken near to damage from the marked area (Fig. 1). The broken blade was made of high-speed tool steel typically used for cutting tools. The structure was made of

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**Fig. 1.** General view of the broken blade. The arrow indicates the place where sample was taken for testing and indicates the place where the inscription (number "1") was made with engraving tool.

martensite matrix with precipitates of fine secondary carbides and undissolved primary carbides (with a light intensity of banding). No tendency to form carbides grid was observed (Figs. 2 and 3). This is a typical structure for properly heat treated high speed tool steels. The average hardness value was 456 HV10 (46 HRC).

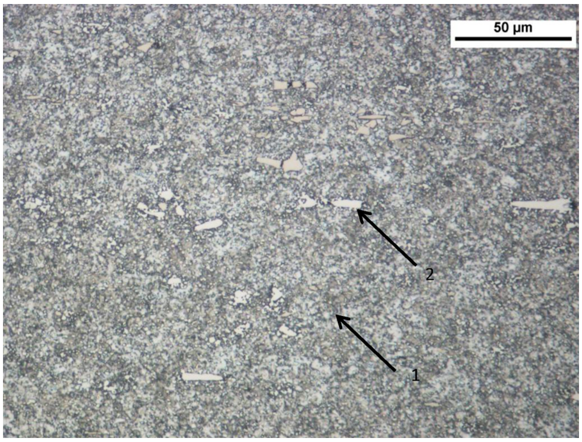


**Fig. 2.** Structure of martensite matrix with precipitates of fine secondary carbides [1] and undissolved primary carbides [2]. Light microscopy, etched with Mi19Fe.

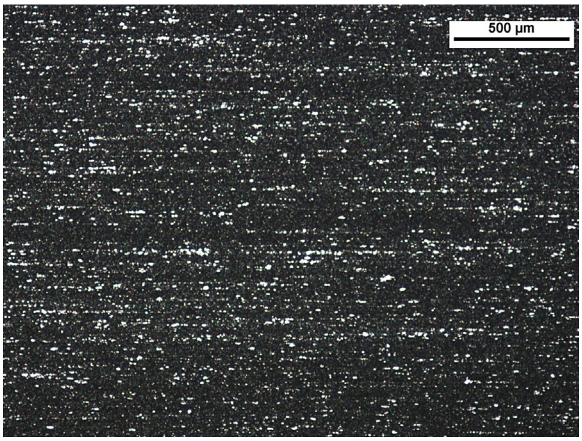


**Fig. 3.** The magnified part of area presented in Fig. 2. Structure of martensite matrix with precipitates of fine secondary carbides. No tendency to form carbides grid was observed. Light microscopy, etched with Mi19Fe.