

Failure analysis of an EDM machined mold-printing die used for the production of truck spare parts



S. Leptidis^a, D.G. Papageorgiou^{a,b}, C. Medrea^{a,*}, I. Chicinaș^c

^a Piraeus University of Applied Sciences, Department of Mechanical Engineering, 250 Thivon & Petrou Ralli Ave., 12244 Aegaleo, Greece

^b Stassinopoulos-Uddeholm, Steel Trading S.A., 20 Athinon Str., 18540 Piraeus, Greece

^c Technical University of Cluj-Napoca, Department of Materials Science and Engineering, 103-105 Muncii Ave., 400641 Cluj Napoca, Romania

ARTICLE INFO

Article history:

Received 2 April 2015

Accepted 6 August 2015

Available online 12 August 2015

Keywords:

Fatigue failure

Mold-printing die

PM steel

Truck wheel cover

EDM machining

ABSTRACT

A company produces truck wheel covers as spare parts for the local market. The production of these parts is based on a progressive die performing consecutive forming and selective cutting stages throughout the initial circular steel sheet. The failure occurred to the final stage of manufacturing, as the die marks, by mold-printing, the assembly configuration of the wheel cover onto the wheel rim. The paper presents a thorough failure analysis of the broken tool. The investigation includes preliminary examination, hardness measurements and chemical analysis. In depth microscopic examination was carried out using stereoscope and optical and electron microscopy. The failure mechanism was investigated from macroscopic and microscopic perspective and conclusions regarding the crack initiation and propagation were conducted and analyzed. The causes that led to the total fracture were discussed. The design of the tool and improper surface roughness are considered to be the main causes of the failure. Some complementary recommendations were proposed so to enhance the production rate of the specific tool.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction and background information

Nowadays, the powder metallurgy (PM) steels are used in a wide range of industrial applications, such as mechanical parts with complex shapes and improved properties, produced by using environment friendly technology. Steel makers and tool manufacturers, currently facing a growing competition, seek for the production of tools with advanced features which will lead to extended tool life and fewer downtimes. A great amount of studies have been focused on PM processing of steels. The influence of porosity on the fracture behavior was studied in depth [1] and the role of material density on the fatigue behavior was underlined [2]. Due to porosity of PM materials, the procedure for characterization of their microstructure was reviewed [3]. The crack formation mechanisms and defects to the powder compacts [4] during unloading and ejection [5] were analyzed. The role of processing conditions on the wear resistance of products was investigated [6]. New test device was developed to facilitate the wear evaluation [7]. Different types of coatings by various techniques were developed [4,8–10], and new alloyed steels were produced [11,12], in order to increase tools' life span. Researchers develop procedures in designing-against-wear PM components [13]. Studies regarding the machinability of PM steels lead to the ascertainment of the influence of machining parameters and tool edge geometry [14] and to the clarification of the effect of chemical composition on workability [15]. New cutting techniques using PM tools were proposed as feasible and economic for massive production [16]. The effect of heat treatment in lifetime of PM components was investigated [5,17]. Cryogenic treatment was applied to improve mechanical properties [18] and the influence of tempering on microstructural transformation was

* Corresponding author.

E-mail addresses: s.g.leptides@gmail.com (S. Leptidis), d.papageorgiou@uddeholm.gr (D.G. Papageorgiou), cmедrea@teipir.gr (C. Medrea), lonel.Chicinaș@stm.utcluj.ro (I. Chicinaș).

studied [12]. The factors influencing fatigue life of powder superalloys was investigated [19], fatigue crack behavior in service conditions of PM steels in relation to their microstructure was analyzed [20] and fatigue limit values were estimated and experimentally determined [21].

PM steels are preferentially used in tooling industry including tools for multi-tasking dies, due to their higher mechanical properties compared to conventional ones. Traditionally, dies are customized for the massive production of a large variety of metal products. During process, the work metal will pass through several stages, and different tools or operations will be used. The production potential of a die determines the quality of the metal-formed product and the production cost [22]. Growing competition in tool making provoked by low cost producers, lead to insufficient performance of the dies, deteriorating significantly the initially predicted working life and increasing downtimes. In this context, poor die performance is studied with interest, in order to provide recommendations regarding failure prevention [19,23–25] and repairing options [26,27].

This paper refers to the failure analysis of a die manufactured from PM steel, intended for the production of truck wheel covers. Similar errors that are time and money consuming will be minimized by understanding the causes that lead to the failure. Moreover, the conclusions and recommendations can be useful in enhancing wheel covers production rate and performance.

2. Experimental procedure

The paper refers to the failure analysis of a die used in manufacturing of spare parts for trucks. Historical data was collected. Non-destructive tests were performed, including visual inspection and dimensional evaluation. A complete photographic file was created. Due to improper storage, the piece was received with extensive areas of corrosion even inside the fractured surfaces. After visual inspection, corrosion products were removed by sandblasting. The piece was photographed in two stages; just as delivered and after the mechanical cleaning. Samples were selected and prepared for destructive testing. The piece was cut in two main parts using a cutoff wheel. The upper part, containing the working surface, was segmented by W-EDM method. Suitable samples were selected for specific examination tests as can be seen in Fig. 1.

The working surface was examined using stereoscope. Hardness measurements were carried out on different locations of the surface of the die. Chemical analysis was performed using an optical emission spectrometer. The steel microstructure on the cross section of the working surface was analyzed using a light microscope. Representative fracture surfaces were examined by scanning electron microscopy and X-ray analysis was carried out using an EDX spectrometer.

3. Results and discussion

A company produces spare parts for the automotive local market. Truck wheel covers are manufactured using 2–2.5 mm thick sheets, of cold rolled (DKP) low carbon steel or austenitic stainless steel. The shape and dimensions of finished products are obtained in a progressive die, mounted in a hydraulic press, that performs consecutive forming and selective cutting stages. During the last stage, the die marks, by mold-printing, the assembly configurations of the wheel cover onto the wheel rim. In the case of DKP steel,

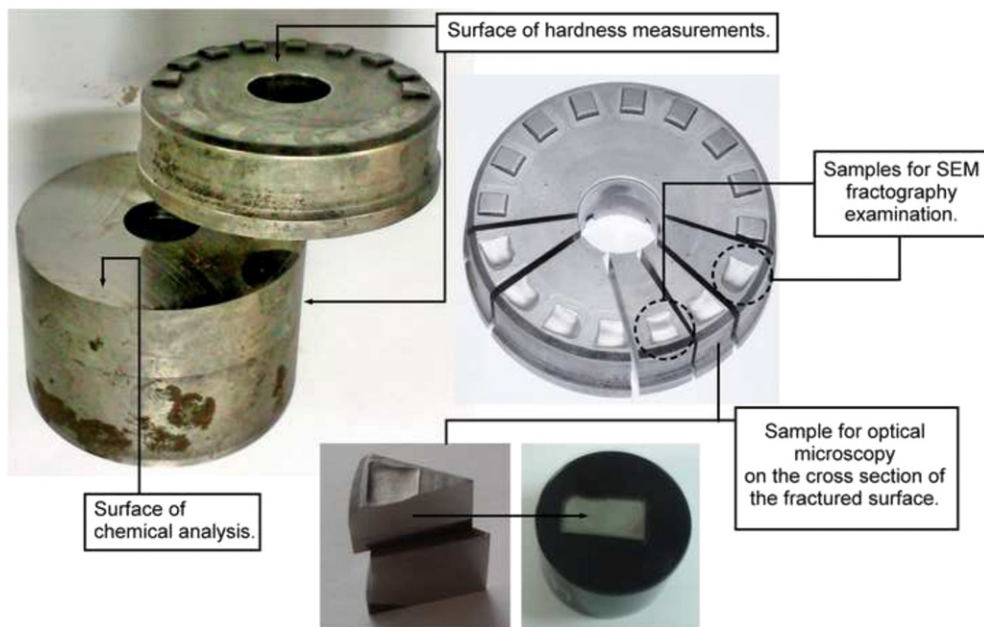


Fig. 1. Fragmentation of the failed die and samples' selection.

Download English Version:

<https://daneshyari.com/en/article/768378>

Download Persian Version:

<https://daneshyari.com/article/768378>

[Daneshyari.com](https://daneshyari.com)