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Failure analysis of a diesel engine piston-pin

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Abstract

A diesel engine piston-pin used in a truck was smashed in four when servicing. The longitudinal and transverse cracking happened on the failed piston-pin. The cracks initiated from the internal hole surface and propagated toward the external circle. The occurrence of beach marks or fatigue striations on the fracture surfaces of all crack origin regions indicates that fatigue fracture is the dominant failure mechanism of the piston-pin. The internal hole and external circle surfaces are specified to be carburized. The microstructure and the microhardness profiles on the external circle and internal hole surface regions were examined to determine the depth of the carburized layer. However, not only was no carburized layer found on the internal hole surface, but also the serious decarburization occurred on the surface region of the internal hole. Appearance of decarburization in the internal hole surface decreases intensely the fatigue strength of the internal surface so that the crack initiated from the internal surface and propagated toward the external circle, at last the fatigue fracture occurred. Improper carburizing technology is responsible for the appearance of the decarburization on the internal hole surface.

Keywords: Piston-pin; Fatigue fracture; Carburization; Decarburization; Failure analysis

1. Introduction

It was reported that the abnormal sound sent out from engine in running of the truck. The engine was disassembled in the automotive repair shop. It was found that piston-pin was smashed in four and cylinder liner, piston and connecting-rod were damaged. The accumulated service mileage of the engine is 140,00 km. The failed piston-pin is made of 20Cr steel. The internal hole and the external circle surfaces are specified to be carburized. The paper describes the detailed metallurgical investigation on the failed piston-pin and a fractographic study. The possible failure reasons were assessed.

2. Experimental methods

The chemical composition of the failed piston-pin material was analyzed by spectroscopy chemical analysis. The microstructure of the carburized layer on the external circle and internal hole surfaces and core region was

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observed by scanning electron microscopy (SEM) on a Philips XL-30 scanning electron microscope and Olympus GX51 optical microscope. Macrohardness measurement of the core material and the external surface (HRC) for the failed piston-pin were conducted. Microhardness profiles from the surface to the interior in different regions of the external circle and the internal hole were made on a MH-6 Vikers meter with a load of 1000 g to determine the depth of the carburized layer. According to the Chinese standard (GB 9450) [1], when the hardness value of the position measured is equal to HV_1550, the depth from the position with HV_1550 to the surface is defined as the depth of the carburized layer. The depth of the carburized layer on the external circle and the internal hole surfaces are specified as 0.8–1.2 mm and more than 0.5 mm, respectively, and depth sum of carburized layer on the external circle and the internal hole surfaces is specified to be less than 2.5 mm. The fractured surfaces were analysed by visual and SEM observations to study failure mechanism.

3. Results

3.1. Visual examination

Fragments of the failed piston-pin were put together, which are shown in Fig. 1. The failed piston-pin had fractured into four fragments (labelled 1, 2, 3, and 6) (Fig. 2) and in order to observe the fracture surface in detail, fragment 3 was open slowly along the original crack propagation direction and it separates into three parts (labelled 3, 4 and 5, seen in Figs. 1 and 2). Matched fractures are shown in Fig. 3. In order to analysis conveniently, the arc fragments of the cylindrical piston-pin are spread to make up a plane figure (Fig. 4).

From the cracks propagation path on the fractures (Figs. 2 and 3), it can be determined that there are seven strips of extending cracks and 11 crack origins (labelled A, B, C, D, E, F, G, H, I, J and K in Fig. 4) on the six

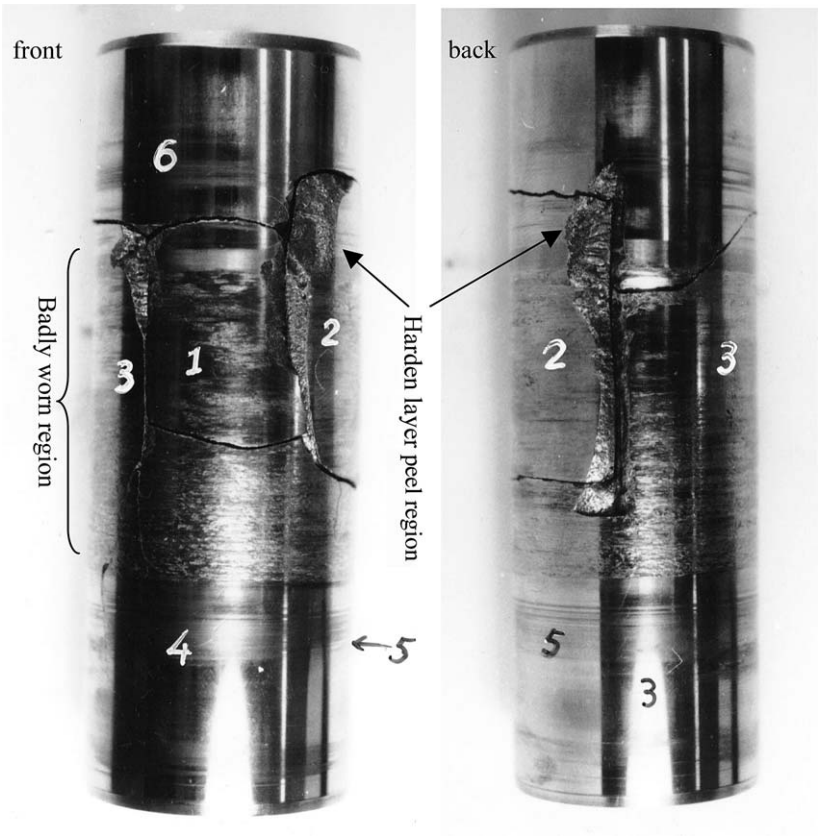

Fig. 1. Failed piston-pin.