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Case study

Failure analysis of a diesel generator connecting rod

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ABSTRACT

This paper presents the results of a failure analysis investigation conducted in a connecting rod from a diesel engine used in the generation of electrical energy. The investigation included an extensive analysis of the con-rod material as well as the fracture zone. The investigation involved the following experimental procedures and testing techniques: visual inspection, fractography, magnetic particle inspection, chemical analysis, tensile and hardness testing, metallography, and microanalysis. The connecting rod was fabricated from an AISI/SAE 4140 low alloy steel; chemical composition, mechanical properties and microstructure were appropriate for the application. The connecting rod fractured at the body in a section close to the head; the origin of the fracture was located at the con-rod lubrication channel. The lubrication channel exhibited an area containing a tungsten based material, presumably from a machining tool, embedded in its surface as a result of a deficient manufacturing process. This area acted as nucleation site for cracks that propagate through the connecting rod section by a fatigue mechanism, reducing its section and finally producing its catastrophic failure.

1. Background

Connecting rods are mechanical components that convert the piston alternative motion in the crankshaft rotational motion. They are subjected to a complex state of stresses which includes compression stresses associated to the pressure exerted by the combustion gases, and tensile stresses related to the inertia of the components in motion, either alternative or rotational [1,2]. Failures in con-rods have been reported in the literature, being associated to fatigue, overload bending, bearing failure, improperly adjusted bolts, spalling, and assembly deficiencies [3–9].

This paper presents the results of a failure analysis investigation conducted in a connecting rod from a diesel engine (18 V, four-stroke) used in the generation of electrical energy. The continuous output of the engine was 10.5 MW, at 600 rpm; before the failure of the con-rod it accumulated 35836 service hours, working with a load factor of 80%. The connecting rod (total length: 1463 mm, weight: 134 kg) had a drilled channel along its body, through which pressured lubrication oil was transported to the piston pin. Fig. 1 shows the failed con-rod, which fractured in the body section, close to the head.

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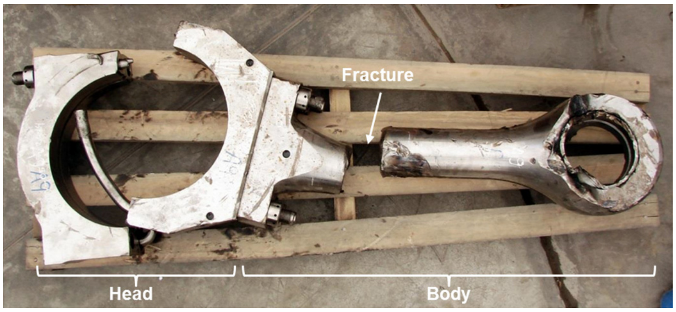

Fig. 1. Failed connecting rod.

2. Experimental procedures

The first stage of the analysis was the visual inspection of the connecting rod and the analysis of the fracture surface.

Then, a comprehensive characterization of the con-rod material was conducted; samples were removed from a zone away from the fracture zone (Fig. 2 shows the location of samples for the tests, as well as the dimensions of the con-rod) in order to carry out the following tests: chemical analysis, hardness test, metallographic analysis, and tensile test. Chemical analysis was conducted with a Bruker Magellan Q8 atomic emission spectrometer, according to ASTM E415-14 [10]. Tensile tests were conducted in longitudinal samples (2) located at the mid radio of the body of the con-rod, tests were conducted according to ASTM A370-15 standard [11] using a Zwick Roell Z250 tensile test machine. Hardness testing was conducted according to ASTM E384-11e1 standard [9] employing a Zwick Roell ZHV30 hardness tester (9 indentations). Samples for metallographic analysis were prepared according to ASTM E3-11 [12] and ASTM E407-07(2015)e1 [13] standards, they were mounted in epoxy resin and subjected to a grinding and polishing processes with sand paper and diamond paste, respectively. Samples microstructure was revealed after chemical etching with a 2% Nital solution; the analysis was carried out with a Leica M2 optical microscope, equipped with a digital camera.

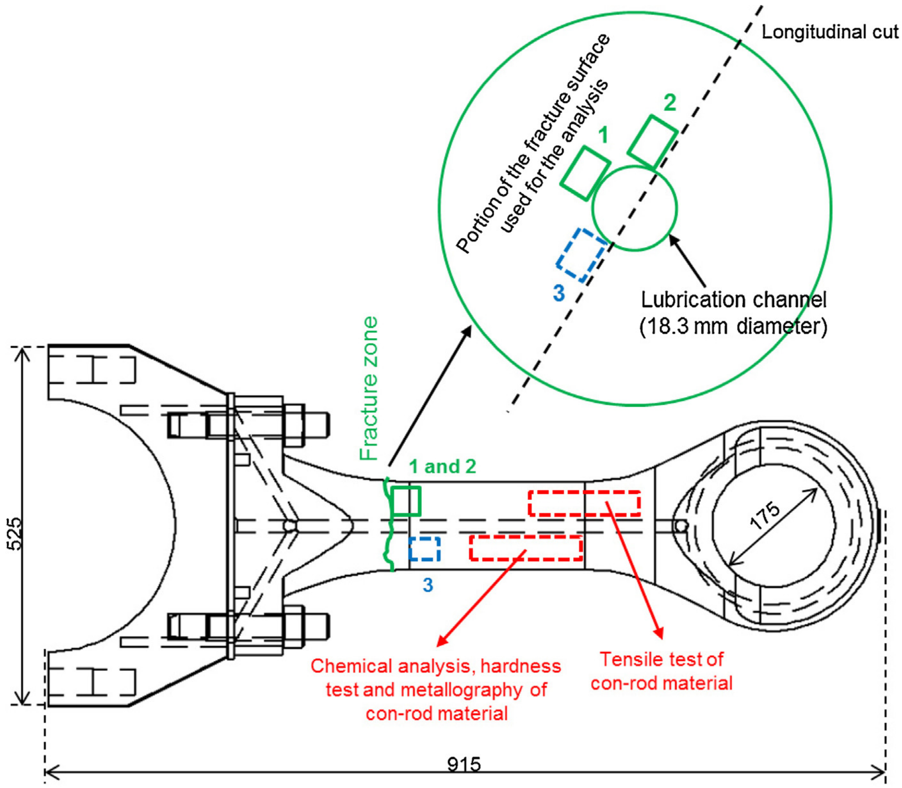

Fig. 2. Location of samples for the analysis of the con-rod material and the fracture zone.