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Corrosion investigation of stainless steel water pump components

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ABSTRACT

Two components of a water pump installed in a casting shop for recirculation of cooling water experienced severe and accelerated corrosion after two months in service. The received pieces of the water pump assembly were a shaft and a conical tube, which was used as connector with the impeller. The shaft exhibited circumferential pitting corrosion behavior in specific areas where it was in contact with another pump component. Light optical microscopy and Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy were mainly used as analytical techniques for corrosion process evaluation and for the identification of the morphology and chemical composition of corrosion products, in order to draw safe conclusions concerning the type of the corrosion and the respective root-source. The main findings of the investigation indicated that pitting corrosion was the dominant failure mechanism for both water pump components influenced by the presence of aggressive environmental conditions, characterized by the presence of chlorides and sulfates that accelerate corrosion process above a certain temperature range ($T > 50–55$ °C).

1. Introduction and background information

The mostly known eight forms of corrosion were referred in a classical corrosion literature [1]. A summary of corrosion mechanisms occurred in chemical process industry is presented in Ref. [2]. Stress corrosion cracking (SCC) and pitting corrosion of stainless steels constitute a critical research field due to the extensive use of such components in special applications in manufacturing and chemical industry under harsh operating conditions [3]. The damaging role of chloride ions and their influence on stimulation of SCC mechanism in stainless steel components in process industry are addressed in various research works, see for instance Refs [3–6]. Transgranular and intergranular SCC were detected in case of naphtha hydrotreater furnace tubes [7]. The detrimental effects of corrosive species, such as Cl and S is underlined also, in case of localized corrosion of steel piping elbow in oil-gas separation system started from inorganic compounds contained in the crude oil [8]. The influence of corrosion environment in combination to fatigue related processes is reviewed in Ref [9]. Fatigue failure in rotating equipment is assisted by local stress concentration which is a crucial factor enhancing the risk of crack initiation [10].

Two components of a water pump installed in a casting shop for recirculation of cooling water experienced severe and accelerated corrosion after two months in service. The received components of the water pump assembly constituted a shaft and a conical tube, which worked as a connector with the impeller (Fig. 1). The shaft exhibited severe pitting corrosion in specific areas in connect with another pump component (Fig. 2).

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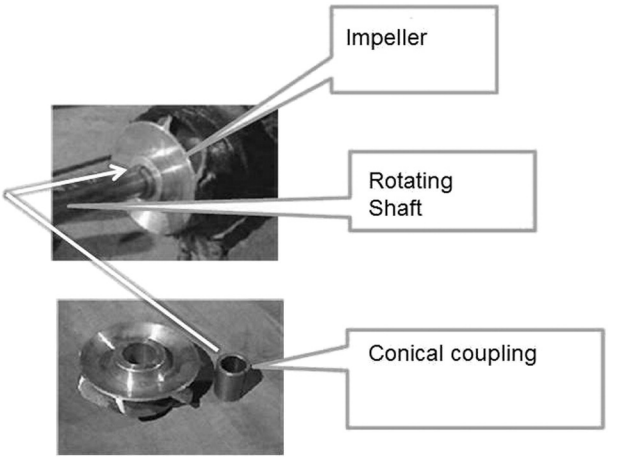

Fig. 1. Images illustrating the components' assembly of the pump.

2. Experimental procedure

Macroscopic observations of the failed components were performed with a high definition digital camera and a stereomicroscope. In order to reveal the main failure mechanisms, microscopic observations were carried out using scanning electron microscopy (SEM) equipped with an energy dispersive x-ray spectrometry (EDS) detector for elemental chemical analysis of selected areas. Cross-sections of the failed components were prepared using hot-mounting, wet grinding up to 1200 grit SiC paper and polishing with diamond and silica suspensions. Metallographic examination was conducted using an inverted optical microscope.

3. Results

Two components of a water pump which experienced severe and accelerated corrosion after two months in operation. The chemical composition analysis by Optical Emission Spectroscopy showed that both materials match approximately to AISI 403 (UNS No. S40300) heat treatable stainless steel (Table 1). No internal defects, such as inclusions or other discontinuities that could be considered as preferential sites for corrosion initiation were found.

The shaft exhibited significant circumferential pitting corrosion in specific areas that were in contact with another pump component (Fig. 3). Sections transverse to the axis of symmetry of the shaft were prepared in order to reveal the pits' morphology and investigate corrosion products elemental composition.

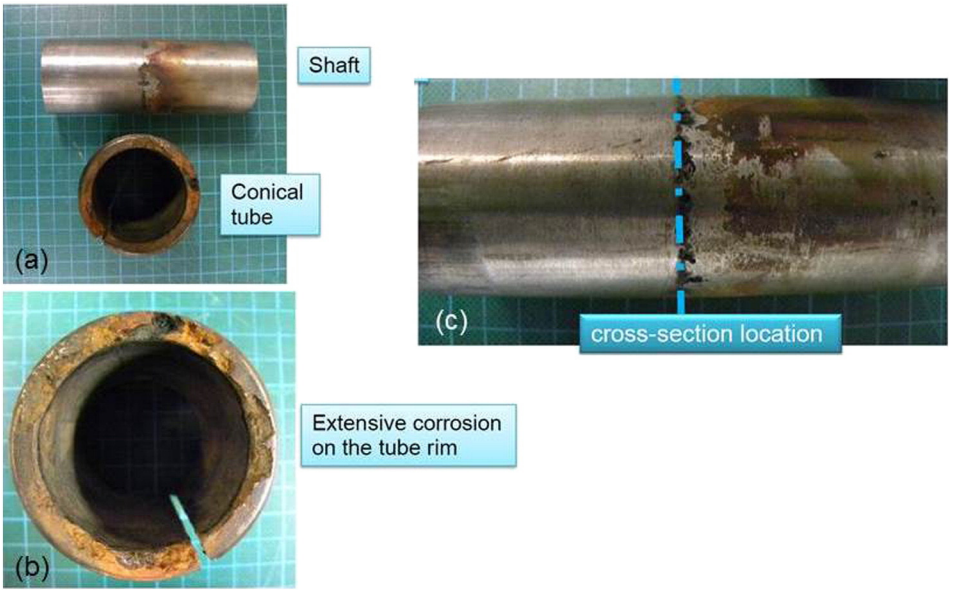

Fig. 2. Macrographs showing the corroded coupling and shaft parts of the pump.

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