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Failure analysis of a gear tooth facture of a rolling mill decelerator

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ABSTRACT

Metallographic examination revealed that the grain size of the material are too coarse and the tempered structure retained a thick needle martensite orientation, thus reducing the steel toughness and raising the gap sensitivity. Heat treatment experiment showed that the coarse grains mostly resulted from the ultra high-temperature quenching. The impact toughness of the gear material was too low whereas the yield ratio of the gear material was too high, with a tested value up to 0.89. The hardness of the gear material was also too high, reaching a value of HRC37. The uniformity of the gear material, such as the dispersion of sulfur-rich inclusions, is poor. Fractographic analysis indicates that a brittle multi-source fatigue fracture caused by the microstructural defects of the material.

1. Introduction

A Steel Plant commissioned the authors to make an analysis of the failure of a gear in a gear decelerator made in Germany. The gears were made of 30CrNiMo8 steel, and designed for a 25 years service life. However, both the two gear's teeth fractured only after about a decade of operation.

The first visual inspection of the gear revealed that one tooth was completely broken and the other one was only partially fractured. Gears can fail in many different ways [1–3], include fatigue [4,5], impact fracture, wear and stress rupture. The composition and structure decide the property of materials, so the intrinsic materials qualities are also of major importance for the robustness of the materials. Indeed, the composition and the structure of the materials inherit from the metallurgical process, post-processing, or heat treatment might exhibit defects that will reduce the capabilities of the steel to cope with the stress occurring in the final application.

The current study focuses on understanding the root cause of the failure of the gear decelerator by performing in-depth analyses of the materials qualities. The strategy to determine the exact failure mode was to start with a macro-analysis of the fracture to figure out where the fracture occurred and its propagation mode. Afterwards, more in-depth analyses such as chemical analysis, micro-structure analysis, hardness and other techniques to determine the mechanical properties were performed.

On the basis of the results obtained, several quenching and tempering experiments were carried out to confirm that the failure mode suggested by the set of analyses was due to the quenching process.

2. Experimental procedure

The material analyzed in this study was a 30CrNiMo8 steel gear from a German made gear decelerator. The gear had a 3.27 m external diameter and the teeth were 0.755 m wide and 155 mm height. One of the teeth was fractured completely

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