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Failure Analysis of Recoiler Mandrel Shaft Used for Coiling of Rolled Steel Sheet

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Abstract : The primary function of a shaft is to transfer power. The shaft can be cast or forged and then machined to the final shape. Manufacturing of ~5 m length and 0.6 m diameter shaft is very critical. More difficult is to maintain its straightness during heat treatment and machining operations, which involve thermal and mechanical loads, respectively. During the machining operation of a such forged mandrel shaft, a deflection of 3-4mm was observed. To remove this deflection shaft was pressed at both ends which led to the development of cracks in it. To investigate the root cause of the deflection and cracking, the sample was cut from the failed shaft. Possible causes were identified with the help of a cause and effect diagram. Chemical composition analysis, microstructural analysis, and hardness measurement were done to confirm whether the shaft meets the required specifications or not. Chemical composition analysis confirmed that the material grade was 42CrMo4. Microstructural analysis revealed the presence of untempered martensite, indicating improper heat treatment. Due to this, ductility and impact toughness values were considerably lower than the specification of the mentioned grade. Residual stress measurement of one more bent shaft manufactured by a similar route was done by portable X-ray diffraction(XRD) technique. For better understanding, measurements were done at twelve different locations along the length of the shaft. The occurrence of a high amount of undesirable tensile residual stresses close to the Ultimate Tensile Strength(UTS) of the material was observed. Untempered martensitic structure, lower ductility, lower impact strength, and presence of a high amount of residual stresses all confirmed the improper tempering heat treatment of the shaft. Tempering relieves the residual stresses. Based on the findings of this study, stress-relieving heat treatment was done to remove the residual stresses and deflection in the shaft successfully.

Keywords : residual stress, mandrel shaft, untempered martensite, portable XRD
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