Effect of Non-Metallic Inclusions (NMI) On Crack Formation In Forged Steel

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ABSTRACT

Effect of NMI on rejection of forged steel component from an industrial unit is presented in this work. The approximate length and diameter of the rejected cylindrical steel specimen were 800 mm and 730 mm respectively. Ultrasonic phased array system (total focusing method) was used to locate and identify the defects. Few subsurface cracks were found in the rejected sample of quench tempered steel acquired after forging process. Defects were clustered near the core of the specimen. X-Ray Computed Tomography (XCT), Scanning Electron Microscopy (SEM), optical metallographic and image analysis, Optical Emission Spectrometry (OES) techniques were used for defect and material characterization. Ultrasonic phased array transducer system and XCT confirmed the presence of approximately 100 µm wide and 10mm long cracks. Optical and SEM images suggested that the cracks were discontinuous in nature and revealed predominant presence of MnS and Al_2O_3 inclusions along with traces of SiO_2 and SiC inclusions. Further, alumina inclusions were found to be clustered near the core of specimen, which is the crack zone. Cracks could have been initiated due to quench stress and augmented by the clustered alumina inclusions and propagated through the grain boundaries which are high energy sites. Strain analysis using EBSD was performed in a sample near the crack to study the distortion of crystal lattice around the alumina inclusions. Considerable strain distribution could be observed in the matrix containing alumina inclusion, but strain seems to be relieved near the crack. It is demonstrated that alumina inclusions in the matrix acted as a stress concentration factor and led to the crack initiation mechanism.