X-RAY DIFFRACTION MEASUREMENT OF RESIDUAL STRESS IN THE DAMAGED BLADE SAMPLE OF GAS TURBINE ENGINE

[1]Shouwen Shen, [2]Alaaeldin H. Mustafa, [1]Ihsan Taie, [1]Gasan Alabedi, [1]Syed R. Zaidi

[1]Research & Development Center, Saudi Aramco, Dhahran 31311, Saudi Arabia
[2]Mechanical Services Shops Department, Saudi Aramco, Dhahran 31311, Saudi Arabia

X-Ray diffraction (XRD) measurement of residual stress can be a powerful tool for failure analysis. If the residual stresses are known, it will be possible to predict the operational reliability of mechanical parts. XRD phase identification and residual stress measurement were performed on the sample of one damaged blade from an aero-derivative gas turbine engine. The engine is one of a fleet of 24 engines in use at Saudi Aramco that are used as driver for super pumps. The blade of the engine was removed with the rest of the set after few hundred hours of operation. The reason for removal was due to the damage of the leading edges of the blades resulted from impurities in the fuel forming as solid in the fuel nozzle and fly with the airflow to cause the damage to the cooling holes in the leading edges of the blades. PANalytical X'Pert PRO X-Ray Diffractometer with Cu $K\alpha$ radiation was used for phase identification and stress analysis. XRD phase identification showed that the blade surface is chromium (Cr) based super-alloy. The stress analysis using $\sin^2\psi$ method was performed in the longitudinal and transversal directions on the blade sample. The values of residual stresses were calculated from interplanar spacings d_{310} of Chromium (Cr) at 115 degree 2θ. The stress analysis indicated that the longitudinal direction has a tensile residual stress (206.4 ± 45.4 MPa) whereas the transversal direction has a compressive residual stress (-256.2 ± 49.3 MPa). The tensile stress was probably formed in the high temperature environment by the centrifuge-like force in the operation of the engine. There is a crack potential along the longitudinal direction of the blades due to the tensile residual stress. Based on stress analysis, it is suggested that the rotary speeds of engines should be under certain limitation to protect the blades from crack and failure.