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Mixed Mode Fracture Analyses Using Finite Element Method of Edge Cracked Heavy Annulus Pulley

Authors : Bijit Kalita, K. V. N. Surendra

Abstract : The pulley works under both compressive loading due to contacting belt in tension and central torque due to cause rotation. In a power transmission system, the belt pulley assemblies offer a contact problem in the form of two mating cylindrical parts. In this work, we modeled a pulley as a heavy two-dimensional circular disk. Stress analysis due to contact loading in the pulley mechanism is performed. Finite element analysis (FEA) is conducted for a pulley to investigate the stresses experienced on its inner and outer periphery. In most of the heavy-duty applications, most frequently used mechanisms to transmit power in applications such as automotive engines, industrial machines, etc. is Belt Drive. Usually, very heavy circular disks are used as pulleys. A pulley could be entitled as a drum and may have a groove between two flanges around the circumference. A rope, belt, cable or chain can be the driving element of a pulley system that runs over the pulley inside the groove. A pulley is experienced by normal and shear tractions on its contact region in the process of motion transmission. The region may be belt-pulley contact surface or pulley-shaft contact surface. In 1895, Hertz solved the elastic contact problem for point contact and line contact of an ideal smooth object. Afterward, this hypothesis is generally utilized for computing the actual contact zone. Detailed stress analysis in such contact region of such pulleys is quite necessary to prevent early failure. In this paper, the results of the finite element analyses carried out on the compressed disk of a belt pulley arrangement using fracture mechanics concepts are shown. Based on the literature on contact stress problem induced in the wide field of applications, generated stress distribution on the shaft-pulley and belt-pulley interfaces due to the application of high-tension and torque was evaluated in this study using FEA concepts. Finally, the results obtained from ANSYS (APDL) were compared with the Hertzian contact theory. The study is mainly focused on the fatigue life estimation of a rotating part as a component of an engine assembly using the most famous Paris equation. Digital Image Correlation (DIC) analyses have been performed using the open-source software. From the displacement computed using the images acquired at a minimum and maximum force, displacement field amplitude is computed. From these fields, the crack path is defined and stress intensity factors and crack tip position are extracted. A non-linear least-squares projection is used for the purpose of the estimation of fatigue crack growth. Further study will be extended for the various application of rotating machinery such as rotating flywheel disk, jet engine, compressor disk, roller disk cutter etc., where Stress Intensity Factor (SIF) calculation plays a significant role on the accuracy and reliability of a safe design. Additionally, this study will be progressed to predict crack propagation in the pulley using maximum tangential stress (MTS) criteria for mixed mode fracture.

Keywords : crack-tip deformations, contact stress, stress concentration, stress intensity factor
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