Summary

The papers in this publication were divided into four major sections:

1. Fatigue in Fasteners.
2. Failure Evaluation and Criteria.
3. Fracture Mechanics in Fasteners.
4. Structural Integrity Criteria for Fasteners.

Fatigue in Fasteners

Fatigue evaluation is generally used to predict crack initiation under complex service load histories for a complex structural component sometimes under an aggressive environment. The most important consideration is to ensure the accuracy of cyclic stresses or strains at a local point of interest. This is achieved by finite element analyses (two or three dimensional). Engineering structural components have discontinuities (in the form of notches, holes, and grooves, etc.) that are the sites of high stress concentration.

Allaei presented an effect of nonuniformities in fasteners on localized vibration and fatigue. The work discussed is ongoing research and development of an efficient and effective mathematical model that will be capable of incorporating the dynamic characteristics of fasteners and their interface with the host structure. Endo et al. presented test methods for turbine blade fasteners to verify the use of peak stress calculated by three-dimensional elastic finite element model analysis. Skochko and Herman reviewed the factors that affect fatigue strength of low-alloy steel fasteners. The paper discussed the influence of machining and thread rolling on fatigue strength and provides design guidelines.

Failure Evaluation and Criteria

Johnson and Davis presented the United States Nuclear Regulatory Commission's approach to fastener integrity in the nuclear industry. Failure criteria and limiting states for cracked bolts were discussed by Kagan. A step-by-step discussion was given on design consideration, material selection, load selection, and fatigue prediction and crack propagation procedure. Nathisan and Porr presented the effect of grain boundary carbon on the hydrogen-assisted intergranular failure of nickel-copper Alloy K-100 fastener materials.

Fracture Mechanics in Fasteners

Zhao and Atluri presented the stress intensity factor solutions for surface and corner-cracked fastener holes. They employ a three-dimensional weight function method. Examples of the method were given for remote tension, biaxial tension, wedge loading in the hole, and simulated pin loading. In addition, the effect of the residual stress field following cold expansion was considered.

Cipolla presented the nondimensional stress intensity factor solution for a straight-fronted crack using an influence function. Several analytical approximations are examined in the development of the weight function. Cipolla concluded that the effect of bolt size and thread form are only important when the crack size is small and suggested that this effect is limited to crack depth within 2% of the net section. He also suggested that the contribution of thread to elevate K_I diminishes for cracks extending beyond 20% of the minor diameter. A companion paper by A. F. Liu presented a state-of-the-art review of the existing stress intensity factors applicable to tension bolts. Using the analytical and experimental data sets from the literature, a stress intensity equation is suggested as an engineering approximation. Liu also applied this equation to the experimental results of the ASTM task group E08.04.07 round robin evaluation of the three grooved round bar crack growth results. Liu concluded that in these tests the crack shape aspect ratio is constant ($a/b = 0.65$) for $a/d \leq 0.5$. Beyond that, the crack shape is assumed to be a straight crack front.

Structural Integrity Criteria for Fasteners

Chang and Du presented a laser speckle method for characterizing fatigue crack initiation in conditions of high-cycle fatigue. The authors claim this procedure is noncontact, nondestructive, and remote sensing. The fatigue damage information is contained in the defraction pattern, which reflects the surface roughness change as a result of fatigue-induced slip bands. The relation between the stress amplitude and the number of cycles to crack initiation is described by the authors.

Henkener et al. presented fracture control methodology for threaded fasteners in the space program. The fracture control plan classifies the fasteners as either fracture control or nonfracture critical. The authors stated that fracture control is implemented by nondestructive inspection, followed by crack growth evaluation. It is acknowledged that application of the nondestructive evaluation (NDE) technique to fastener threads is difficult to achieve. Therefore, a fabrication of NDE standards for threads is being developed, and the probability of detection using the maximum likelihood technique is recommended.

Olsen presented a general, quantitative relation between a constant tensile load and the ultimate shear strength of a fastener. He also experimentally observed that the tensile load in the fastener is greatly reduced as the material deforms in shear. The reduction in shear strength is only significant for tensile loads approaching 60% of the ultimate strength of the material. Veale et al. presented a criterion for pitch measurements of threaded gages using a coordinate measuring machine (CMM). The authors stated that, although a defined method within the United States for pitch measurement exists, it does not follow worldwide procedures. The application of CMM for measurements on both external and internal threads is discussed. This technique is still in the development stage and needs additional work.

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