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Experimental Evaluation of the Effect of Thread Angle on the Fatigue Life of Bolts

Er. Shuhaib Mushtaq* , Dr. Nazir Ahmad Sheikh**
*Research Scholar, Department of Mechanical Engineering, National Institute of Technology, Srinagar , India
** Assistant Professor, Department of Mechanical Engineering, National Institute of Technology, Srinagar, India

Abstract : The present work is concerned with fatigue strength, obtained by plotting the S-N Curves for determining the fatigue life of various thread geometries of bolts under cyclic loading. The stress equations obtained from Majzoobi are being used for calculations of core stress "σ_{core}" produced due to cyclic loading, which is being carried usually by the first thread of the bolt. The higher stress concentration occurs in the root of first threads.The experimental work has been carried out for five different thread profiles of varying flank angles, having six samples of each profile. The fatigue testing on each profile has been performed under cyclic loading, in order to obtain the number of cycles to failure of a particular specimen. The results obtained experimentally have been compared with the work of Gane . Finally the work is used to obtain the failure life of bolts, which means which thread profile has higher fatigue life or simply higher strength to failure. As strength is of direct use to the designer regarding the safety of structures.
Keywords: Fatigue, ISO Bolts, Thread, Pitch, Diameter

I. Introduction

Bolts and screws play an important role in the performance of machinery. The majority of these fasteners are subjected to fluctuating loads, leading to the well known phenomenon of fatigue which is responsible for most of the premature failure in bolts. The word fatigue has been derived from fatigare which means 'to tire' in the widely accepted terminology in engineering and scientific vocabulary for the failure of materials under cycling loading. It has been estimated that fatigue contributes to approximately90% of all mechanical service failures. The term fatigue has been defined as changes in properties which can occur in metallic materials by the repeated application of stress and strain. When a metal is subjected to alternating loads after many reversals the whole character of metal may change. Fatigue cracks as presented by Higgins [1] almost always initiate at free surfaces, usually external surfaces but also internal surfaces if the metal contains defects such as voids and cracked second-phase particles. Common external surface defects include geometric notches and surface roughness. Fatigue crack nucleation and growth occurs in the following stages. Stage I. Crack initiation usually starts at a notch or other surface discontinuity. Even in the absence of a surface defect, crack initiation will eventually occur due to the formation of persistent slip bands (PSBs), so called because traces of the bands persist even when the surface damage is polished away. Slip bands are a result of the systematic build up of fine slip movements in the order of only 1 nm. However, the plastic strain within the PSB can be as much as 100 times greater than that in the surrounding material. The back-and-forth movement of the slip bands leads to the formation of intrusions and extrusions at the surface, eventually leading to the formation of a crack.The presence of geometrical discontinuities (holes, changes of section) causes stress concentrations which increase the stresses locally and influence resistance to fatigue. Stress concentrations occur in bolts at the thread roots, thread run-out and at the radius under the head. Fatigue failures in bolts in fluctuating tension commonly occur at this last location or in the first thread under the nut. The design of the joint is very important; the fatigue strength finally depends on the real path of the loads through the connection, and the fluctuation in stresses of the fatigue sensitive regions. The thread in a bolt acts as a notch and therefore a high stress concentration is caused at the root of the thread. At two locations of the thread the stress concentration can be even higher, i.e. at the runout of the thread and where the thread of the nut first engages the thread of the bolt. In addition, the head-shank transition is also a stress concentration. There are, therefore, basically three locations in a bolt with nut axially loaded, where a fatigue crack can initiate in a bolt with nut axially loaded. These locations are: head-shank transition, run out of thread, thread at nut. In standard bolts the radius at the bolt-head shank transition is large enough to prevent fatigue cracks at this point. Normally, if fatigue cracks occur, they will be located at the first engagement of the threads of the bolt and nut. This is due to the load transfer from nut to bolt.

It is evident that the fatigue strength of a bolt is largely influenced by the stress concentration at the root of first thread of the bolt which carries most of the load. The distribution of the load between the engaging threads has