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Fatigue life estimation of screws under multiaxial loading using a local approach

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Abstract

The fatigue life estimation of screws usually applies a nominal approach on the basis of normal forces. For time-dependent, multiaxial loading of screws this method is not accurate enough; a related method has not been specified yet. In this regard, the current contribution discusses the incorporation of a local approach to predict durability. Therefore, Schneider's method is enhanced to generate an efficient procedure for calculating the fatigue-induced damage at the screws. The failure criterion is the technical relevant incipient crack length in the first load-bearing thread turn of the screw. By incorporating a submodelling technique, the presented method leads to damage values over the circumferential angle of the thread.

In order to validate the method, the computed damage values are compared with experimentally determined results. In the experiments, the incipient crack length in the thread of the screws is measured by an advanced technique using a rod-type strain gauge.

Keywords: life prediction, load histories, bolted joints, notches, strain gauging

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Nomenclature

σ_{ij}	components of stress tensor	$R_{p0.2}$	offset yield strength
ε_{ij}	components of strain tensor	R_m	tensile strength
$(\cdot)_{ij}$	components of linear transfer tensor	E	young's modulus
$F_{N(\cdot)}$	normal component of the section force	ν	Poisson's ratio
$F_{S(\cdot)}$	shear component of the section force	t_n	time point of the load spectrum
$M_{B(\cdot)}$	bending component of the section moment	D	damage
$M_{T(\cdot)}$	torsion component of the section moment	D_i	partial damage
$(\cdot)_{(\cdot),UL}$	unit load	D^*	fatigue life in terms of distance
$(\cdot)_{(\cdot),ini}$	initial force/moment	P_{SWT}	damage parameter (Smith, Wattson, Topper)
$(\cdot)_{(\cdot),VF}$	vertical wheel force	P_J	damage parameter (Vormwald)
$(\cdot)_{(\cdot),LF}$	lateral wheel force	L	distance of load spectrum
$(\cdot)_{(\cdot),BT}$	breaking torque	n_i	number of cycles per rainflow class
a_i, b_i	polynomial coefficients	N_{Ai}	number of cycles until incipient crack
φ	circumferential angle of the wheel	$\Delta\sigma_{eff}$	effective stress width
α	circumferential angle of the thread	$\Delta\varepsilon_{p,eff}$	effective plastic strain width
$\Delta\sigma_{relax}$	stress relaxation value	σ_{N+S}	stress induced by normal and shear force
A_g	uniform strain	σ_{N+B}	stress induced by normal force and bending moment

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