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MULTIAXIAL HIGH-CYCLE FATIGUE ANALYSIS OF ROLLING CONTACT PHENOMENON

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The phenomenon of rolling contact fatigue was analysed using multi-axial high-cycle fatigue criteria. In this kind of contact, cyclic compressive and shear effects are out of phase. The criteria can be grouped into hypotheses based on: stress tensor invariants, mean value of stresses, critical plane, energetic approach and empirical results. In this paper, fatigue effort was estimated by four different hypotheses suggested recently in literature [1 - 4]: Crossland (1956) criterion [1] based on stress tensor invariants, Dang Van (1973) [1 - 3] and Papadopoulos 2 (2001) [6] criteria based on critical plane, Papadopoulos 1 (1997) [4, 5] criterion based on mean value of shear stresses. A detailed comparison of values of fatigue equivalent stresses proposed by above criteria for simple loading forms (bending, torsion, bending with in-phase torsion and bending with out-of-phase torsion) was made.

The problems of free rolling (frictionless) and tractive rolling contact between a crane wheel and rail were solved using the finite element method (ANSYS®), first in 2D. For tests, the plane strain assumption was made in the solutions and the element mesh in the models was irregular with strong concentration of the grid in the contact area. The structural 2D solid 8-node elements PLANE82, 2D surface to surface 3-node contact elements CONTA172 and 2D target segments TARGE169 were used in the calculations.

Maximal equivalent fatigue stresses for free rolling contact and C60E material for investigated criteria were presented in Fig.1. The Crossland and both Papadopoulos hypotheses based on different approaches gave similar results. It allows to conclude, that the most adequate fatigue effort estimator is somewhere inside the indicated range.

The calculations show, that the original form of the Dang Van criterion is not useful for application to rolling contact fatigue for hard materials (see Fig. 1). For such

materials (for example C60E) this hypothesis overestimates influence of compressive hydrostatic stresses on the equivalent fatigue measure. Similar, critical remarks commenting this criterion recently appeared also in papers [3, 4]. Their authors proposed neglecting hydrostatic effects in the Dang Van criterion (see Fig.1).

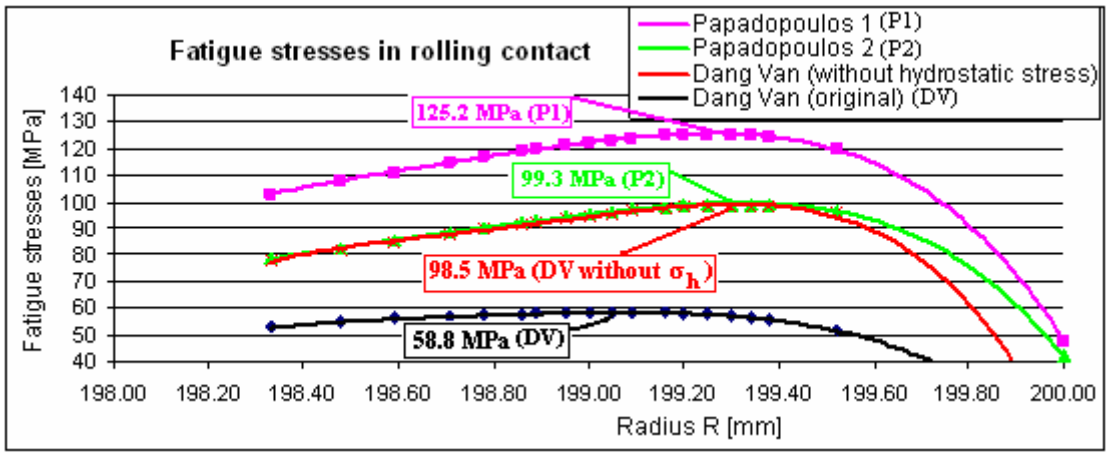

Fig. 1: Example of maximal fatigue equivalent stresses for free rolling contact (material C60E, radius of rolling element R=200 mm)

The phase difference between shear and compressive stresses, occurring in the rolling contact phenomenon, did not appear in the Papadopoulos 1 criterion. It led to excessive increase (on advantage of safety) of the value of equivalent fatigue stress (see exemplary results in Fig. 1). Hence, the investigations show that in case of rolling contact the most reasonable is using the Papadopoulos 2 or Crossland hypotheses.

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