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COMBINED LOADING OF THE SPECIMENS AND REALIZED EXPERIMENT

KOMBINOVANÉ ZATĚŽOVÁNÍ ZKUŠEBNÍCH VZORKŮ A PROVEDENÝ EXPERIMENT

Abstract

The rotary parts are characterized by concentration of certain part of the mass to the given volume and from dynamic point of view is this mass described by moment of inertia. This fact led the authors to an idea – to use the dynamic inertial effect of the mass for the testing of the material in high – cycle fatigue in torsion and for combination of torsion and axial tensile/compressive force. This idea became the basis for the design of the reconstruction of the testing machine. The reconstruction and experiment will be described in the following article.

Abstrakt

Rotující součástí se vyznačují soustředěním určité části hmoty do vymezeného objemu a z dynamického pohledu je tato hmota popsána hmotovým momentem setrvačnosti. Tento poznatek přivedl autory na myšlenku - využít dynamických setrvačných účinků hmoty pro zkoušky materiálů v oblasti vysokocyklové únavy v kroucení a pro kombinaci kroucení a osové tahové/tlakové síly. Tato myšlenka se stala základem při návrhu rekonstrukce zkušebního stroje. Rekonstrukce zkušebního stroje a experiment budou popsány v následujícím článku.

1 TESTING MACHINE RECONSTRUCTION

For materials testing in the field of high-cycle fatigue and strength criterion verification [3, 5] there was designed a new conception of the testing machine, more Fig. 1. The new conception changes loading characteristics of testing specimen out of deformation to the force.

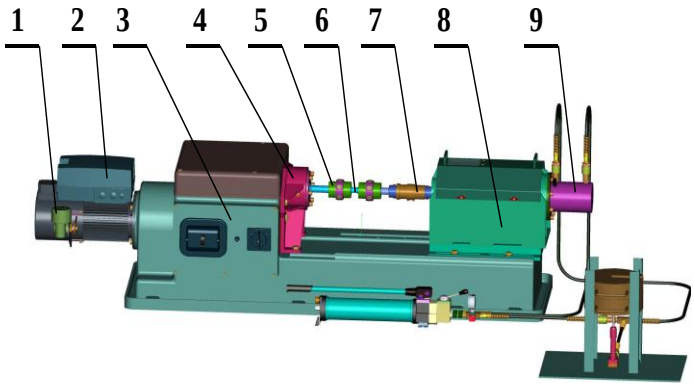

Fig. 1 New design of testing machine

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The new conception of the testing machine is applied for protection as utility patent under the name: “Equipment for cycle fatigue testing specimens by torsion moment”, utility patent number – number notation: 17226 (2007) and further under the name: “Equipment for combination load of testing specimens”, utility patent number – number notation: 17286 (2007).

2 EXPERIMENT – CYCLIC STRESS

Testing specimens made of steel 11523 smelt T18556, were loaded by cyclic torque. On Fig. 2 are shown measured points and drawn curves of Basquin’s approximation (1) and Fuxa’s approximation (2). The failure point in the static torsion was measured in the Department of Mechanics of Materials and its laboratory on a redesigned machine INOVA.

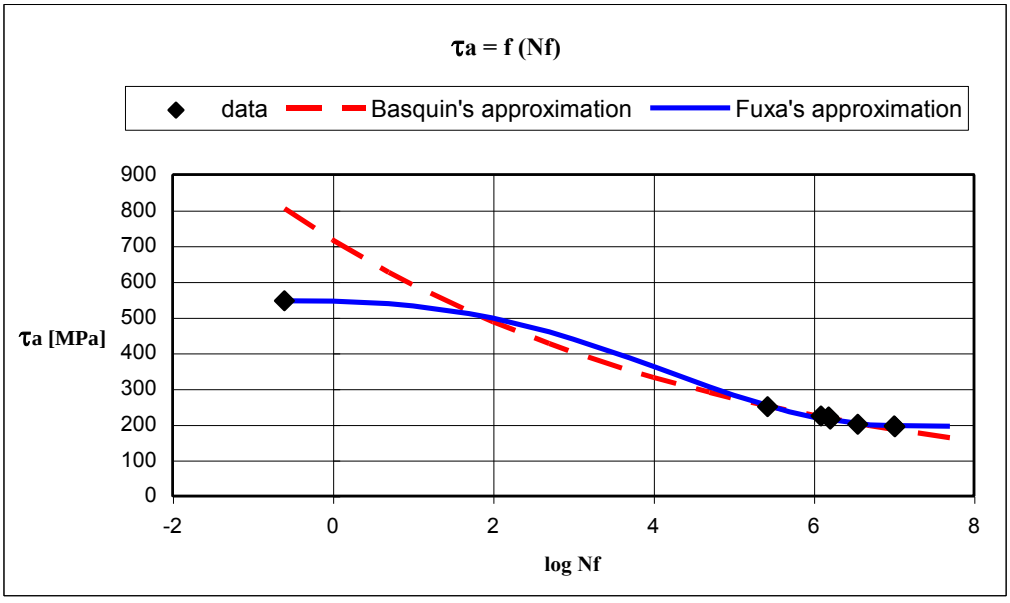

Fig. 2 W – curve and its approximation

Basquin’s approximation:

$$\tau_a = \tau_f' \cdot \left(2N_f\right)^b, \tag{1}$$

Fuxa‘s approximation [2, 3]:

$$\tau_{aF} = \left(\tau_f + \tau_C\right)/2 + \left(\tau_f - \tau_C\right)/2 \cdot \cos\left\{\pi \cdot \left[\log\left(4 \cdot N_f\right)/\log\left(4 \cdot N_C\right)\right]^{a_1}\right\}, \tag{2}$$

for N_f in interval [*1/4; N_C*] a τ_{aF} in interval [τ_f ; τ_C].

3 EXPERIMENT – CYCLIC TORQUE AND TENSION

Testing specimens made of steel 11523 smelt T18556, were loaded by the cyclic torque and axial tension force. Tests were made the way that every single set of the testing specimens was loaded by different constant value of an axial tension stress (σ_t). For the tensional stress there was for each series chosen an initial amplitude of shear stress, by which the specimen was loaded up to the crack occurrence. The amplitude was gradually declined up to the value, which the specimen endured for 10^7 cycles. Overall there were accomplished four series of experiments. Test results were elaborated by means of conjugated strength criteria (3) [2, 4] and shown on Fig. 3.

$$\tau_{aF2} = \left(\tau_f{}^* + \tau_C{}^*\right)/2 + \left(\tau_f{}^* - \tau_C{}^*\right)/2 \cdot \cos\left\{ \pi \cdot \left[\log\left(4 \cdot N_f\right)/\log\left(4 \cdot N_C\right)\right]^{a_1} \right\}, \quad (3)$$

$$\tau_f{}^* = 1/\sqrt{3} \cdot \left((\sqrt{3} \cdot \tau_f)^2 - 2 \cdot \sqrt{3} \cdot \tau_f \cdot B_O \cdot \sigma_t / 3 + \sigma_t{}^2 \cdot B_O{}^2 / 9 - \sigma_t{}^2\right)^{1/2}, \quad (4)$$

(4) is static strength condition while $N_f = 1/4$, where constant B_O [2, 4] is equal:

$$B_O = 3 \cdot \left(\sqrt{3} \cdot \tau_f / \sigma_f - 1\right), \quad (5)$$

$\tau_C{}^* = \tau_C / 2 \cdot \left\{ 1 + \cos\left[\pi \cdot \left(\sigma_t / \sigma_f\right)^B\right] \right\}$ is strength condition for ($N_f = N_C$). (6)

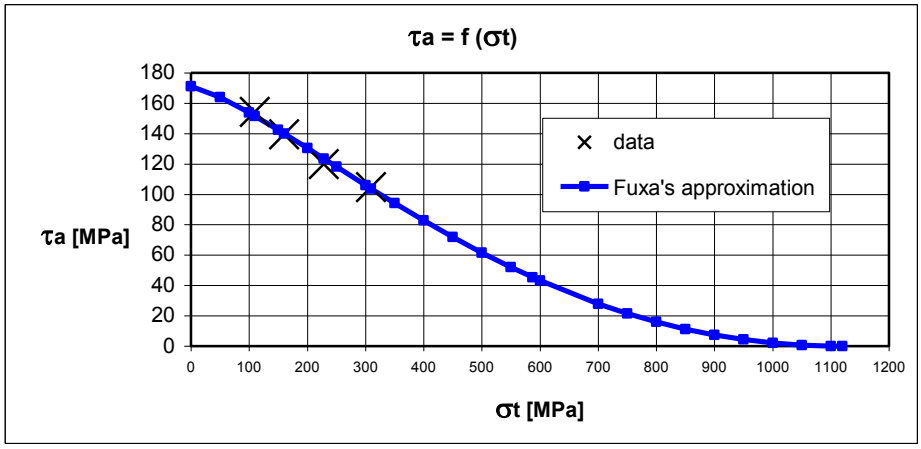

Fig. 3 Influence of mean value tension stress for crack initialization

On Fig. 4 are shown experimental results obtained by localization of stress amplitudes within limits N = 10^7 cycles, for four different values of an axial tension stress. Results of the experiments (along with fatigue limit curve Fig. 3) are smooth by earlier described Fuxa's approximation for the appropriate number of cycles.

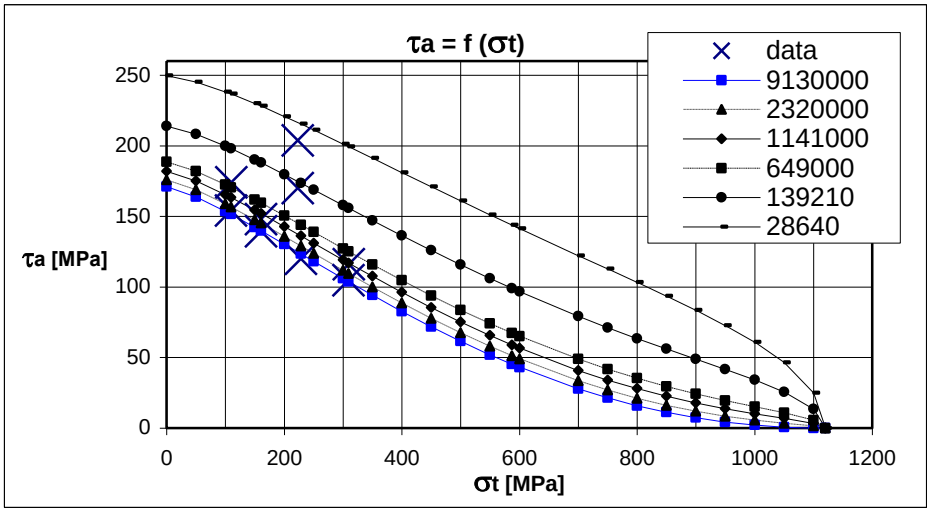

Fig. 4 Fuxa's approximation for the combined loading

On Fig. 5 are shown three phases of the crack development at the described cyclical loading.

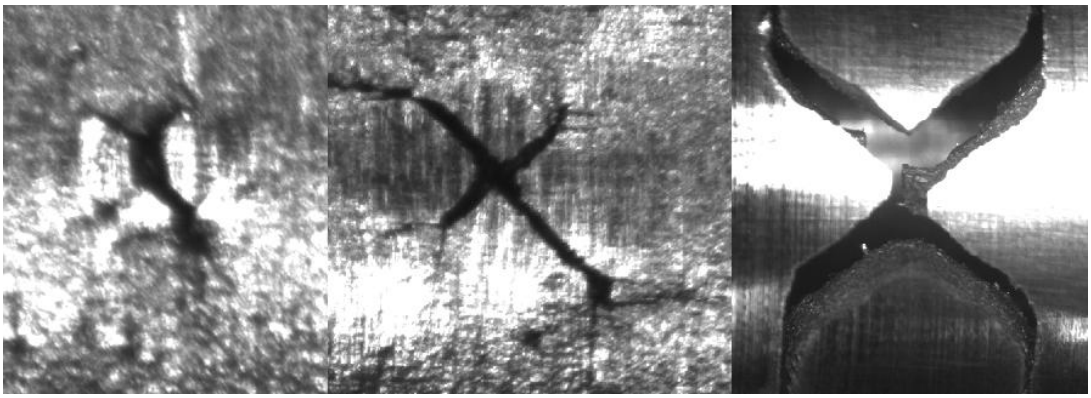

Fig. 5 Three phases of the crack development at the combined loading

4 ACKNOWLEDGEMENT

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5 CONCLUSIONS

The article introduced reconstructed torsion fatigue testing machine, appropriate for constant assessment of fatigue strength criteria. There is also possible to load the testing specimens by combination of time-variable torque and constant tension / press axial force.

In the article there were described results of experiments, executed in the conditions of cycled torsion and torsion in combination with axial tension force. In the first case the results are used for W-curve description with Basquin's and Fuxa's approximation, in the second case are the results of experiments used for expression of strength criteria (6). From Fig. 2, 3 and 4 is visible good match of proposed approximations obtained by experimental data.

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