STRESS-STRAIN STATE AND DAMAGED VOLUME IN CONTACT AREA OF CAR TIRE–ASPHALT CONCRETE SYSTEM UNDER VARIOUS LOADS

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Computer finite-elements models for describing the 3D stress-strain state of an active system “car tire–asphalt concrete” have great practical importance for road and tire industry. Also important challenge for road services and tires manufacturers is the assessment of volume damageability and wear of the tire tread and the asphalt pavement, which work in conditions of contact, mechanical and sliding fatigue. Today, there are many works dedicated to analytical and FEM simulation of the “car tire–asphalt concrete” separate system components. However, the problem of estimating 3D stress-strain state and the state of the volumetric damageability in contact interactions of asphalt and multicomponent tire with rib pattern is still not fully investigated.

In this investigate simultaneous contact interactions of the full multielement system “car tire–asphalt concrete”, loaded by the various tire inner pressure P_S (from 0.65 to 0.85 MPa) and radial load F_H (from 6 to 10 kN) on rim were modelled using finite-element method [1,2]. The main goal of this work is determine and analyze 3D stress-strain state of the whole system and the state of volumetric damageability by maximum stress intensity $\sigma_{\text{int}}^{\max}$ and damaged volume V_{int} in contact interaction area of tire and asphalt concrete, where maximum stresses occur: 1) asphalt concrete, 2) tire tread and 3) rubber under radial ply [2]. Calculation of damaged volume V_{int} is based on the model of deformable solid mechanics [3]. According to this model damaged volume V_{int} is the volume where acting stresses σ_{int} are greater than limiting stress $\sigma_{\text{int}}^{(\text{lim})}$. Allowable limit stress by stress intensity $\sigma_{\text{int}}^{(\text{lim})}$ for friction fatigue in contact zone of tire and asphalt is 0.5 MPa and for others rubber parts of tire is 1 MPa which work in conditions of mechanical fatigue.

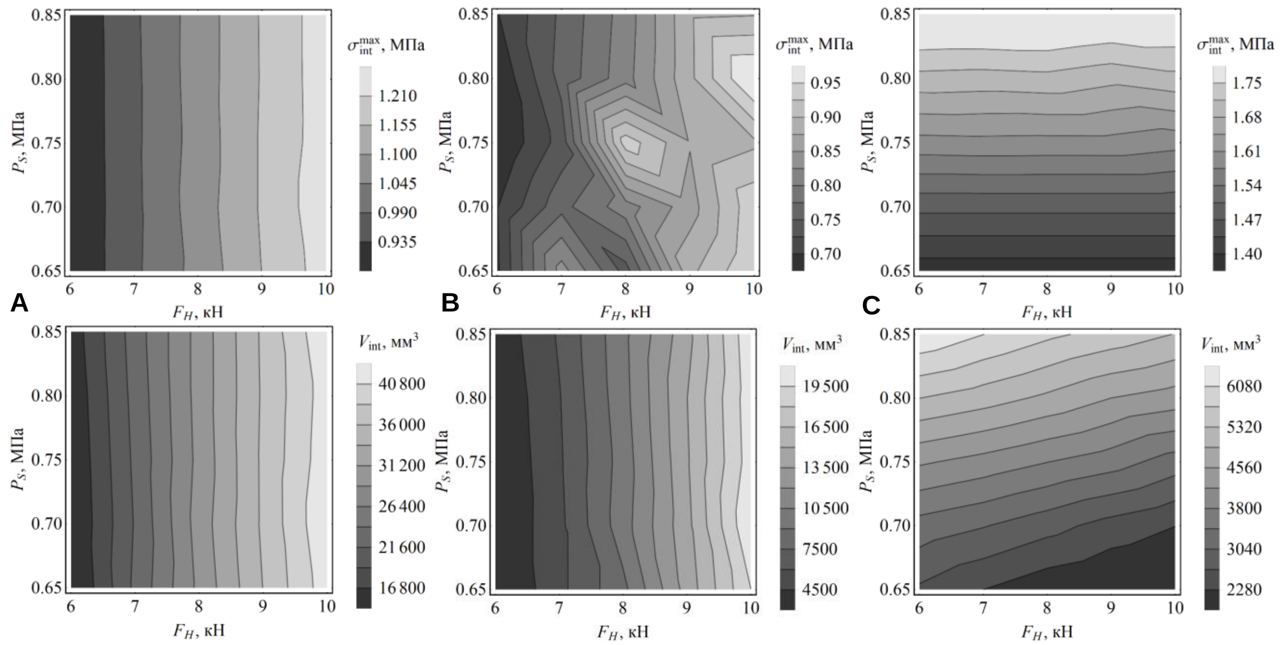

Fig. 1. Values of $\sigma_{\text{int}}^{\max}$ (top) and V_{int} (bottom) by F_H and P_S in tread (A), asphalt (B) and rubber under radial ply (C)

Values of $\sigma_{\text{int}}^{\max}$ and V_{int} in tire tread (fig. 1-a) increased to 1.4 and 2.7–3 times when the F_H is increased from 6 to 10 kN and increased slightly when P_S is increased from 0.65 to 0.85 MPa.

Values of $\sigma_{\text{int}}^{\max}$ in asphalt (fig. 1-b) increased to 1.28¬1.46 times when the F_H is increased and $\sigma_{\text{int}}^{\max}$ changed nonlinearly to 3–27% without an explicit dependency with local minimum and maximum when the P_S is increased. At the same time V_{int} increased to 6–7.5 times when F_H is increased and V_{int} increased to 3–27% when P_S is increased. At this case system stress-strain analysis by V_{in} is easier than by $\sigma_{\text{int}}^{\max}$ and allows to smooth features of FEM calculations.

Values of $\sigma_{\text{int}}^{\max}$ in rubber under radial ply (fig 1-c) changed slightly when F_H is increased, however, V_{in} decreased to 17–34%. At the same time $\sigma_{\text{int}}^{\max}$ and V_{int} in rubber under radial ply increased to 1.3 and 2.4–3.1 times when P_S is increased. This case shown us much more influence P_S on system stress-strain state at analysis by V_{int} than by $\sigma_{\text{int}}^{\max}$

[1] S. S. Sherbakov, G. V. Gribovskiy, Stress-strain state of multicomponent «rim–tire–asphalt-concrete» system for different values of radial load on the rim and internal pressure in the tire, International Scientific and Technical Collection Theoretical and Applied Mechanics 34, 307 – 313 (2019).
[2] G. V. Gribovskii, Damageability in contact area of tire and asphalt concrete under various loads, 62nd scientific conference for young students of physics and natural sciences Open Readings 2019, Vilnius University, 311 (2019).
[3] L.A. Sosnovskiy, S.S. Sherbakov, Mechanothermodynamics (Springer, 2016).