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EXPERIMENTAL RESEARCH OF STRESS LOADING OF BEARING STRUCTURES IN HINGE JOINT LOGGING MACHINERY

The work is devoted to experimental research of loading bearing structures harvesters and forwarders. Strain studies conducted hinge joint loading of half-frames in the various operations of the technological cycle. Performed the validation of the developed mathematical models. Analyzed the interdependence arising from the work force factors. Recommendations to reduce the loading of load-bearing structures.

Introduction. Exploitation of domestic harvesters and forwarders has revealed a number drawbacks concerning reliability of their bearing structures. According to statistical data, alongwith weakening bearing structures there is about 15–20% of operational failures. Their mending at cutting area is inconvenient and requires transportation of machinery to specialised workshops that results in long-term idle hours, underfulfilment in planned performance of an enterprise and considerable economic losses.

In order to check adequacy of designed mathematical models to actual dynamic systems of forwarders and harvesters and to define dynamic loading of units in their bearing structure experimental research have been conducted.

Main part. Objects of experimental research were multioperational logging machines produced by production association "MTZ": forwarder MLPT -354 and harvester MLH-414.

Tests of forwarder MLPT-354 have been carried out during loading-unloading and transfer engineering operations. Fulfilling transport operations there have been registered: vertical and longitudinal horizontal speedups of centre of gravity of forwarder, vertical speedups of its rear axle, treveling time of forwarder along experimental stretch of road, values of deformation on facets of hinge in joint semi-frames. Beforehand for obtaining the values of irregularities of a microsurface profile of a forest road the leveling of experimental stretch of road (150 m) has been made.

Registration of vertical and horizontal speedups was measured by potentiometer pick-offs MP-95. Their installation on rear axle and the centre of gravity of empty vehicle is shown at Fig. 1

a *b* *c*

Fig. 1. Location of acceleration transducers on forwarder MLPT-354:
a – upright on the rear axle; *b*, *c* – upright and longwise in the centre of gravity of the vehicle

Deformation in units bearing structure has been registered by means of single-unit resistance strain gage and rectangular gage rosettes (Fig. 2).

Fig. 2. Location of rectangular gage rosette on side face of hinge joint in semi-frames

Acceleration transducers and piezoresistive sensors have been attached to 8-channel amplifier "Spider8". Crossing separate irregularities and traveling along experimental stretch of road the speed of forwarder was varying from 1 till 12 kph, mass of laded logs – from 0till 5,000 kg, length of logs – 4 and 6 m, height of block (0.1; 0.15; 0.25 m). After each change in quantity loaded logs alternate measurement of support reactions in front and rare axle of forwarder have been made in order to determine batch mass, its evenness within a loading platform and location of vehicle center of gravity. The measurements have been done by means scales UD-1 (Fig. 3).

a *b*

Fig. 3. Gauging of support reactions in front and rare axle of forwarder

Forwarder traffic have been implemented with locked and unlocked joint of semi-frames. Thus moments of arising peak figures of bend and torsion loading when crossing irregularities with the locked hinge by wheels of one ramp do not coincide. It is explained by various moments of frame in the longitudinal and lateral plain, and also by various instantaneous values of hardness of blocked joint and wheels of front and rare axles. It should be noted, that a rise in mass of transported logs slightly influences the value of a torsional moment arising in the joint. Maximum difference between empty and

fully loaded forwarder comprises not more than 1.3% at travelling speed of 3 kph and not more than 2.4% at speed of 12 kph (length of logs from 4 till 6 m). Values of torsional moment in the joint for an empty forwarder and while crossing blocks by the wheels of front and rare axle comprise 30.1 and 41.2 kNm correspondently.

Fig. 4 shows dependencies of change of bend moment in the joint obtained after processin of strain gauges data and determination of resistance an places of their installation.

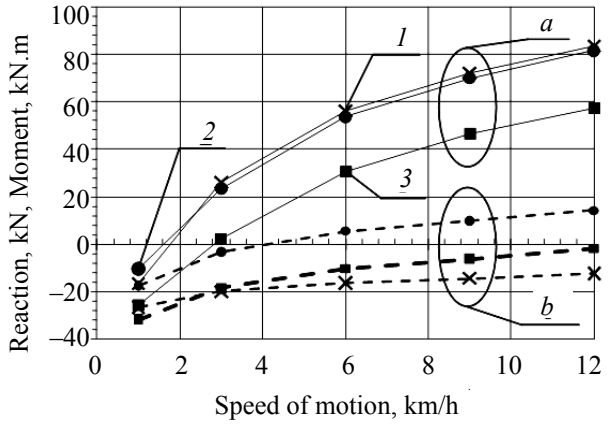

Fig. 4. Bend moments in hinge while crossing separate unevenness in 0.25m: *a* – front wheels, *b* – rare wheels; *1* – empty forwarder; *2*, *3* – forwarder fully loaded with logs of 4 and 6m

Hereinafter data for bending moments are given considering theoretically calculated static moments at various loading levels of a service platform by logs.

Along with an increase of a service platform loading there is some reduction of value of bending moments at crossing of blocks by rear axle wheels. It is explained by the extension of heel pattern of low-pressure tires with support surface and by the increase of their smoothing and absorptive ability.

Disconnection of joint block ease the frame from torsional moments arising in motion, and also reduces peak torques to 1.5%.

Stress loading tests of a forwarder traveling along the experimental stretch of forest road have been carried out at stable uniform motion modes. For a uniformity evaluation the acceleration transducer has been used. (It has been inslalled longwise in the centre of gravity of the vehicle (Fig. 1, *b)*.

Testing stress loading of the joint during loading-unloading data registration of vertical acceleration sensor of forwarder center of gravity has been made as well as vertical and horizontal accelerations where rotator of clamp hook was installed (Fig. 5).

Values of static, torsion and bending moments acting on the hinge of forwarder MLPT-354 are dependent on log mass being lifted, level of service platform loading (0–5,000 kg) and the length of loaded logs (Fig. 7).

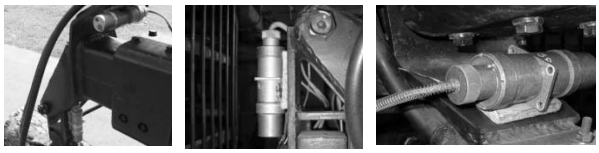

Fig. 5. Locations of acceleration sensors MP-95 on the forwarder manipulator

Log mass used in testing was determined by preliminary weighting at their suspension 2 the sensor of force gauging U9B (Fig. 6).

Fig 6. Sensor of force gauging U9B

A significant shift of dependences (Fig. 7) lengthwise axis abscissas is explained by a console location of a gravity centref of a forwarder energetic unit that results in arising of static moment of bend 14–18 kN·m. Nonlinear reduction of torsion moment in the joint has ben caused by a rise of restoring torque in process module and a rise of its wheels stiffness.

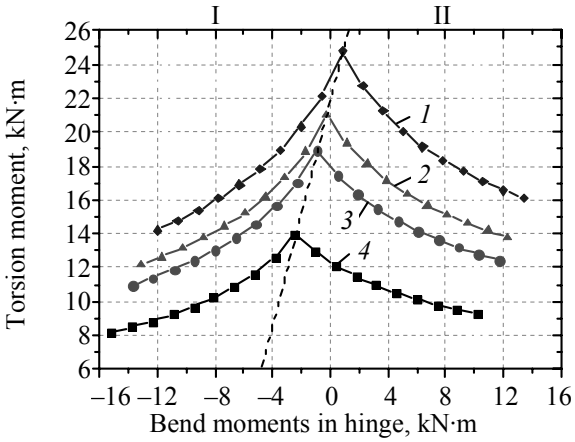

Fig. 7. Stress loading of the joint in loading-unloading at handling radius 5.3 m and uniform log lifting

Forwarder MLPT-354 and harvester MLH-414 are produced on the basis of the unitized forest chassis, therefore it is important to research stress loading of a harvester in its work cycle.

Harvester stress loading tests have been done in actual conditions of its exploitation in GLHU "Uzdensky forestry".

On bearing structure of harvester there have been installed two rectangular strain-gauge rosettes (Fig. 8).

On harvester head the potentiometric pickup of accelerations MP-95 has been fixed. It changed its space orientation depending on transport or engineering head location.

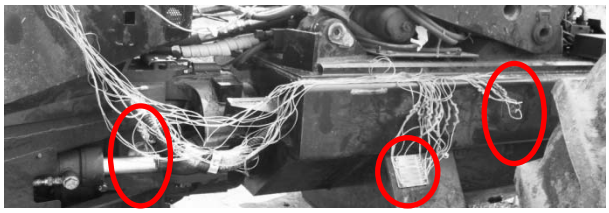

Fig. 8. Location of strain-gauge rosettes on the frame of harvester MLH-414

Working at large handling radius operators often fold semi-frames at an angle 15–30°, that considerably increases sustainability of a harvester. However it also results in rise 8–11 kN of torsion moment in lateral plate of working part of joint . Change of torsion moment in longitudinal plain does not exceed 2%.

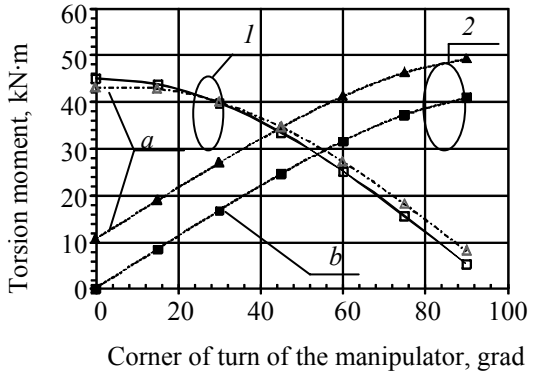

Fig. 9. Dependencies of torsion moments changes in longitudinal and lateral plains of joint: *a* – fold of semi-frames at 15°; *b* – at coaxial locating of semi-frames in longitudinal (*1*) and lateral (*2*) plains

At turning of an empty manipulator at handling radius of 9.3 m at the angle 90° torsion moments in longitudinal and lateral plains of the joint varies, as it is shown at Fig. 9.

Further theoretical studies proved stress loading to be affected by value of hardness of a block mechanism of semi-frames.

Conclusion. Experimental researches have proved high hinge joint loading in semi-frames of harvesters and forwarders.

It is has been determined that value of torsion moment in forwarder joint at overcoming of unevenness by rare wheels tends to diminish with an increase of transported load mass to 5 t.

Thus larger reduction of bend loads with 4 metre logs has been caused by a shift 0.45 m in the location of gravity centre of loaded bunch. During loading-unloading operations a rise in mass of loaded bunch to 5 t. leads to a reduction of torsion moments by 2–4 kNm, and their value at uniform lifting of logs with mass of 457 kg at handling radius 5.3 m doesn't exceed 14.5 kNm.

Stress loading tests of harvester MLH-414 have shown that loading of hinge joint semi-frames is greatly depends on operator's skills when fulfilling tree preload. At empty manipulator turning at the angle to 90° and handling radius 9.3 m, torsion moment in longitudinal plain will be reduced by 38 kN·m, and in lateral plain – increased to 41 kN·m. Folding of semi-frames towards manipulator operation results in an increase of torsion moment in lateral plane by 8–11 kN.

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