RESEARCH OF INFLUENCE OF CHANGE OF TEMPERATURE MODE ON ELASTIC-DISSIPATIVE PROPERTIES OF SUSPENSIONS

Mikhail Lyaschenko, Elena Cherkashina

Volgograd State Technical University
Auto-Tractor Faculty
Lenin Avenue 28, 400131, Volgograd, Russia
tel.: +7 (8442) 236948
e-mail: ts@vstu.ru, vilena400065@inbox.ru

Victor Buryakov, Ilia Lutin

Volgograd Engineering Company (VMC" VgTZ)
Dzerzhinskogo 1, 400006, Volgograd, Russia
tel.: +7 (8442) 746206, fax: +7 (8442) 746227
e-mail: skb@vmc-vgtz.com, skb@vmc-vgtz.com

Abstract

During the operation of the vehicle the friction in dissipative elements causes change of temperature mode. So there is a change in viscosity and volume of liquid. Also, change gas volume and pressure of elastic element. It has a significant impact on dissipative characteristic of suspensions as well as the elastic ones. The study of the rated model dedicated to the process of changing gas pressure and volume, as well as using as a working liquid oils with different densities and different viscosity changes depending on change of temperature mode. The rated model is presented basing on the elaboration, executed in Volgograd State Technical University in collaboration with Volgograd Engineering Company («VMC" VgTZ). Researchers based on change of pressure of gas in elastic element at constant volume; on change of volume of gas at constant pressure; on change of volume of liquid depending on used oil; on change of resistance of dissipative element at change of properties of liquid.

In the paper example results of experimental researches of hydromatic spring are presented. A comparison of resistance change of the shock-absorber at rise in temperature is worked out as well. Analysis of the obtained results indicates that essential influence has charting pressure.

Keywords: *dissipative element, elastic element, suspension, temperature mode, viscosity, volume, pressure*

The development and modernization of vehicles suspension received increasing attention in view of the fact that, in one hand, increasing the power of the transmission systems leads to a higher speed, but on the other hand, is constantly raising demands on the level vibroisolation driver, passengers and cargo, subject to modern standards.

It is not only comfort ride depends on perfect suspension system, but also the reliability, stability, durability, security and possibility. The optimum suspension characteristics can substantially increase the speed and efficiency of the vehicle.

The main problem was the construction of suspension by the controversial requirements of stability, controllability and comfort. So comfort means decrease of revolting influences from roughness of a basic surface. For increase of stability and controllability the constancy of contact of wheels with a basic surface at arrival on roughness and the suspension bracket should be whenever possible more rigid that there were no dangerous rolls and squatting in the body accelerations and decelerations. Therefore, the characteristics of passive suspensions are selected in terms of a compromise between these controversial requirements.

A promising direction on elimination of influence of the temperature mode is application of special grades of fluid with a greater range of working temperatures (with a high index of viscosity) and creation of spring systems with changing of its elastic-dissipative characteristics which would allow, manually or automatically, to arrange parameters of a suspension during moving of the vehicle.

However, one of the factors that hinder the establishment of the suspension with the best characteristics is the change of temperature, arising in the dissipative elements in the operation of the vehicle and has a significant impact both on the elastic as well as the dissipative characteristics of suspensions. So on the change of temperature affects not only the temperature of the environment, but also the duration and conditions of the vehicle (for example, at the time of starting at negative temperatures (in winter or in northern regions), elastic-dissipative characteristics of the suspension will be slightly different, than at positive temperatures, or after 30-50 minutes of operation, especially on the hard road).

Usually springs charge with gas at normal temperature (20^{o}C). At temperature, differs from the normal, changing the viscosity of the working fluid (as a consequence the resistance of the sock-absorber changes), its volume (which leads to a change of clearance), as well as changing the volume, and consequently the gas pressure in pneumatic chamber (which changes the elastic characteristics of the suspension).

However, these activities do not completely eliminate the difficulties arising from the operation because, besides the changes already mentioned, a significant cooling causes thermal deformation, the violation of landings and change of physical-chemical properties of materials (plasticity, volume, linear dimensions, etc.), and increased heating, in turn, in connection with the reduction of viscosity working fluid below the permissible level, causes a dramatic increase in various types of leakage, increased friction parts and, consequently, increased heat, intense jamming and wear on working surfaces.

This leads to partial or complete loss of efficiency of suspension.

Therefore, to ensure reliability, safety and comfort of motion, among other things, it is necessary to apply:

- Advanced materials and coatings that reduce the impact of changes in temperature, friction at the contact surfaces (drawing layer surface-active substances with ftor, developed by a group of St. Petersburg scientists and awarded a silver medal and a diploma at the international exhibition «New inventions and technology,» in Switzerland, Geneva [5]).
- Working fluid practically does not change their parameters when changing the temperature or with variable parameters (such as magneto-rheological fluid (MRF), used in the suspension MAGNE RIDE installed in cars CADILLAC CATERA [1]).
- Improved design and sealing materials (the piston seal of polytetraftorethylene filled with bronze, applied to shock absorbers MONROE REFLEX, delivered on cars BMW 7 (E38), NISSAN PRIMERA (P10) [2]), etc.

All of this allows effectively reduce the impact of changes in temperature.

Figure 1 provided with basic scheme designed suspension wheel vehicle.

At creation of a new suspension updating of parameters depending on change of a temperature mode will occur as follows:

- To ensure a constant pressure in pneumatic chamber the system of change of volume is provides.
- To ensure the constant clearance the system of change of clearance is provides.
- To ensure the constant characteristics the shock-absorber of variable resistance is provides.
- Consider the possibility of using as a working fluid of hydraulic oil brand MGE-10A, as most often used for such systems, aviation grade oil VNIINP 50-1-4U, oil for automatic transmissions TNK brand ATF III and TSz-9gip (HM-5-9) with the best, compared to other oils, the characteristics.

To track changes in a suspension system of sensors, consisting of sensors of linear displacements, vertical acceleration, pressure and temperature sensors working fluid, which gives signals to the on-board information and control system, where the adjustment control signal to the executive bodies.

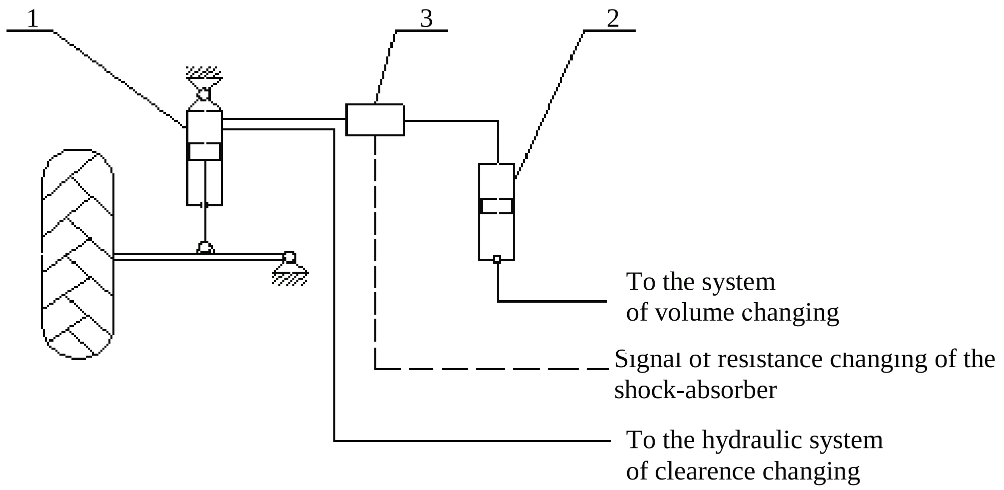

Fig. 1. Scheme of the wheel suspension of vehicle: 1 - spring hydraulic cylinder, 2 - spring pneumatic cylinders, 3 – shock-absorber control system

Changing the pressure of nitrogen in the spring pneumatic cylinders [3] in the working temperature range: from –50°C (when working in winter or in northern regions) to 100°C (the working temperature of the springs) is represented in Fig.2.

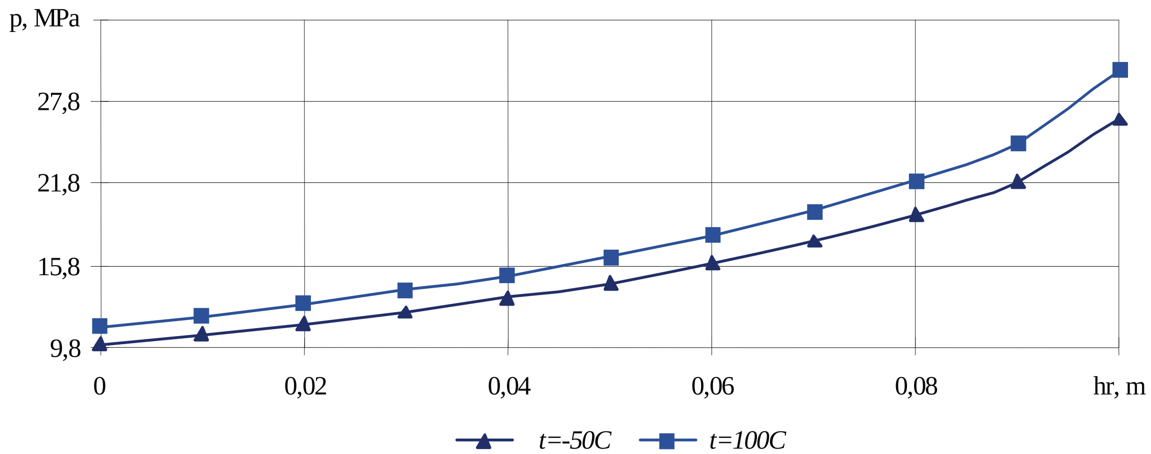

Fig. 2. Dependence of pressure of gas in the pneumochamber from temperature at change of a displacement of a rod (V=const)

The calculated dependences of loadings on a rod from the displacement of a rod are constructed (Fig.3) [3].

At change of the temperature from –50°C up to 100°C loading on rod change in all range of values.

At completely compressed spring pressure in the pneumatic chamber increases on 4 MPa, and loading on rod change approximately on 12 kN (from 88 up to 100 kN). As consequence, loading on an axis of a wheel, bearings and other units of a suspension bracket increase (For an example, the maximal supposed loading on bearing SHS-45 established in an eye of the body of a spring is

105 kN). To lower loading on these units it is necessary to increase volume of the pneumatic chamber, tracing pressure according to from gauges of temperature and pressure, submitting data from gauges on on-board information control system and forming correcting operating signal, that, bringing it into accord with pressure at 20°C, that corresponds to temperature of refuelling of a spring nitrogen. At change of charging pressure within limits of the ±0.1 MPa admission at 20°C, the effort to a rod changes on 3.5 kN.

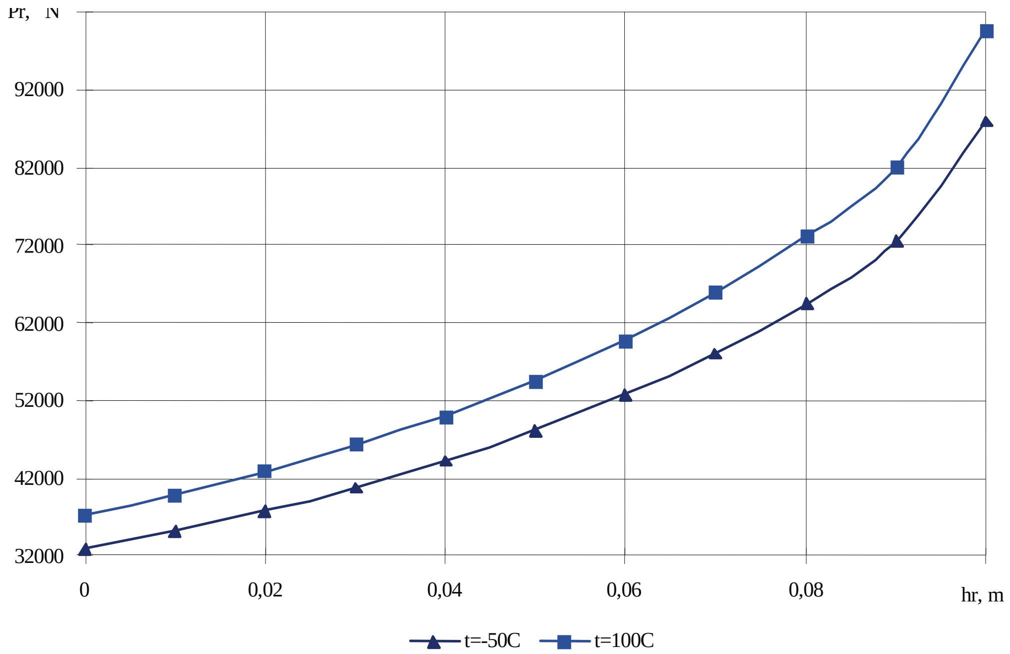

Fig. 3. Elastic characteristic of hydropneumatic spring at change of temperature (V=const)

On Fig. 4 change of volume of the pneumatic chamber depending on a displacement of a rod is presented.

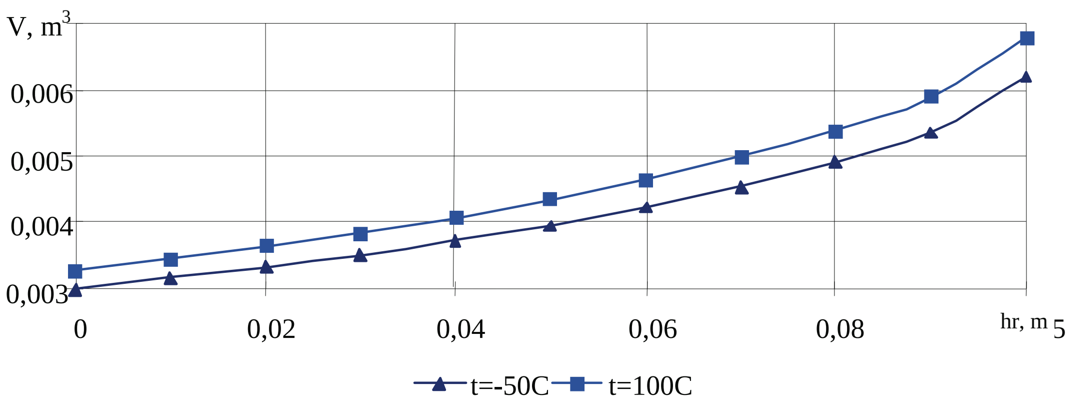

Fig. 4. Change of volume of gas in the pneumatic chamber at change of a displacement of a rod depending on change of temperature (p=const)

At change of temperature from –50°C up to 100°C for completely compressed spring the volume of the pneumatic chamber is necessary to change to 60.3 sm^3 (for an example, with the diameter of the piston equal to 65 mm, the required movement of the piston to 18 mm).

At change of a temperature mode the volume of a fluid (that leads to the change of clearance), and its viscosity (as consequence also changes resistance of the shock-absorber) change.

The hydraulic cylinder of a spring is the closed system and is informed with hydraulic system only at submission of an operating signal from on-board information control system for change of position of the hardware. Therefore change of temperature leads to moving of a rod due to change of volume of the working fluid which is being the hydraulic cylinder, and, as consequence, to change clearance. Change of volume of a fluid depends on factor of volumetric expansion.

In Table 1 the index of volumetric expansion (β) and density at 20^{o}C (ρ20) for the considered fluids.

Tab. 1. The index of volumetric expansion (β) and density at 20^{o}C (ρ20) fluids

Type of fluid	MGE-10A GOST 38 01281-82	TSz-9gip (TM-5-9) TU 38.1011238-89	TNK ATF III GOST 17479.3-MG-32-V	VNIINP 50-1-4U TU 38.401-58-12-91
β	$8.2 \cdot 10^{-4}$	$7.2 \cdot 10^{-4}$	$7.7 \cdot 10^{-4}$	$5.8 \cdot 10^{-4}$
P_{20},kg/m^{3}	860	910	875	926

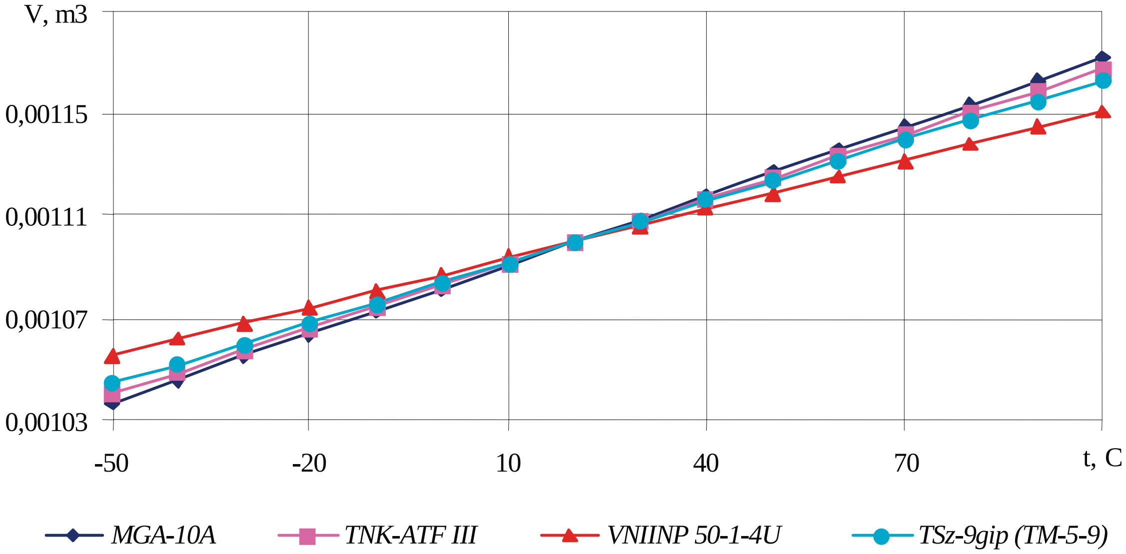

Fig. 5. Change of volume of a fluid depending on change of temperature

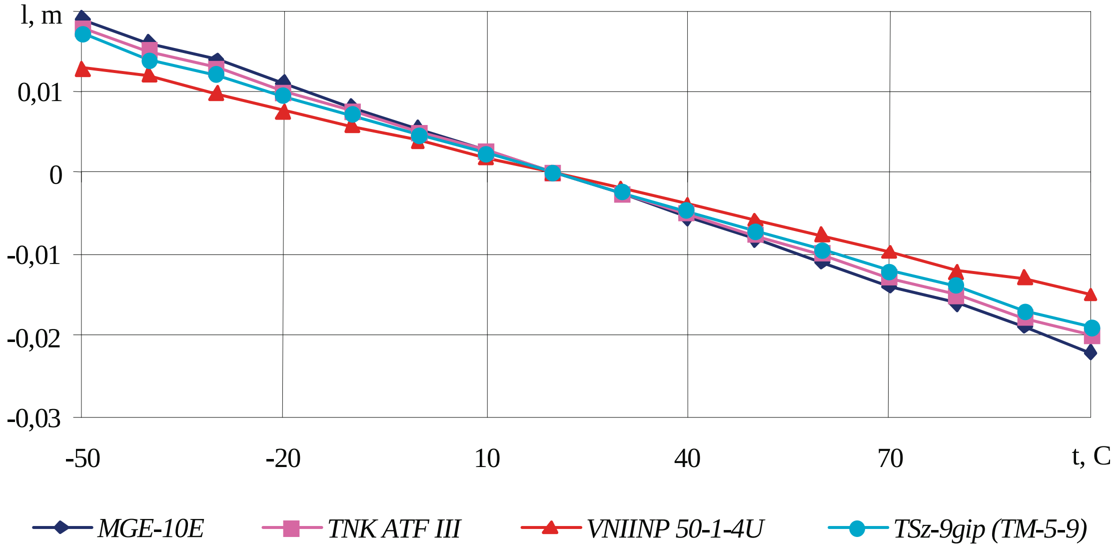

Fig. 6. The displacement of a rod of the hydraulic cylinder from nominal position depending on change of temperature

Thus, comparing the displacement of the rod depending on the fluid (MGE-10A, TNK ATF III, TSz-9gip (TM-5-9) and VNIINP 50-1-4U), we can see that the smallest change in clearance (0028 m) with increasing temperature from –50°C to 100°C will use as a working fluid the aviation oil VNIINP 50-1-4U.

Let's consider the change of the damping characteristics of the shock-absorber due to change of viscosity of fluid at change of temperature [4].

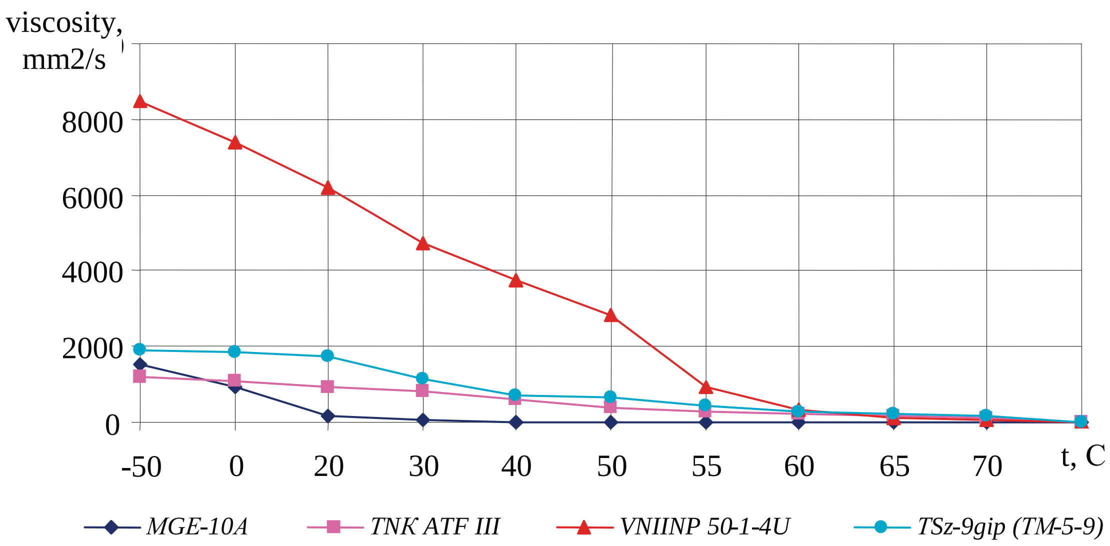

Fig. 7. Change of viscosity of fluid depending on change of temperature

By results of the calculation made by a technique, developed at Volgograd Engineering Company "VMC"VgTz", we shall construct dependence of resistance of the shock-absorber on speed of a rod at use of various fluids.

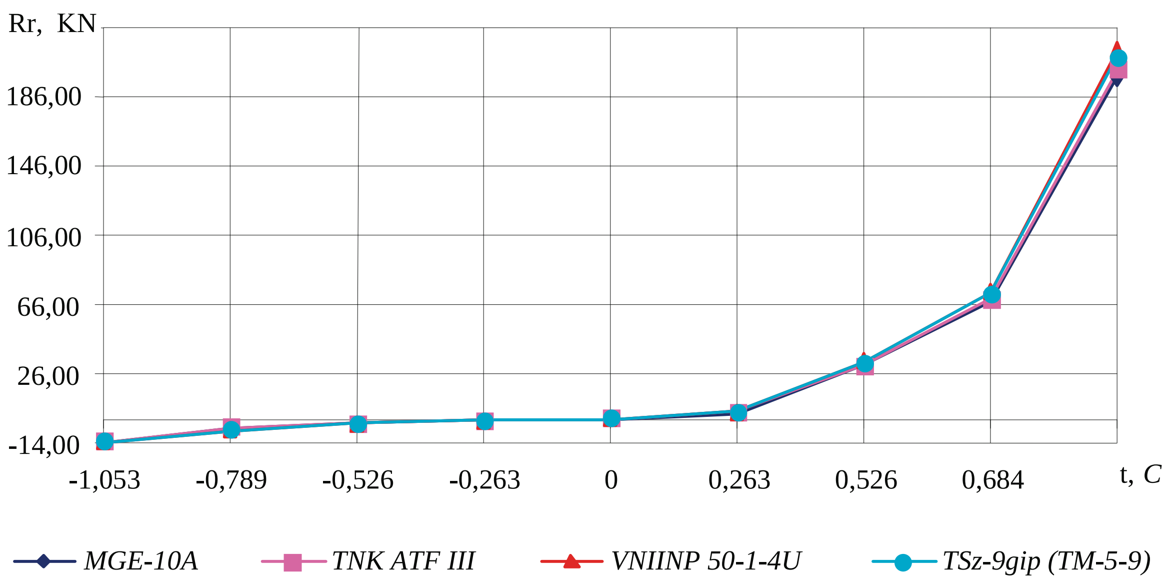

Fig. 8. Dissipative characteristic of the shock-absorber at 20°C at use as a working fluid MGE-10A, TNK ATF III, TSz-9gip (TM-5-9) and VNIINP 50-1-4U

Owing to reduction of viscosity of a working fluid at rise of temperature from –50°C up to 100°C decreases also resistance of the shock-absorber.

Tab. 2. Change of resistance of the shock-absorber at rise in temperature

	MGE-10A GOST 38 01281-82	TSz-9gip (TM-5-9) TU 38.1011238-89	TNK ATF III GOST 17479.3-MG-32-V	VNIINP 50-1-4У ТУ 38.401-58-12-91
v, m/s	P, kN	P, kN	P, kN	P, kN
-1.053	1.47348	1.324	1.43718	1.29624
-0.789	0.61985	0.55697	0.60458	0.54529
-0.526	0.18366	0.16503	0.17913	0.16156
-0.263	0.02296	0.02062	0.02239	0.02019
0	0	0	0	0
0.263	-0.46327	-0.41627	-0.45185	-0.40754
0.526	-3.70611	-3.33013	-3.6148	-3.2603
0.684	-8.14947	-7.32272	-7.9487	-7.16918
2.105	-23.7529	-21.3432	-23.1677	-20.8957

Comparing the change of resistance with increasing temperature from -50^{0}C to 100^{0}C for MGE-10A, TNK ATF III, TSz-9gip (TM-5-9) and VNIINP 50-1-4U, we could argue that the minimal impact of the change in temperature occurs when used as the working fluid VNIINP 50-1-4U. Thus, as a working fluid in the hydronewmatic spring should use fluids with higher viscosity and high viscosity index (over 140).

Conclusion

Changing the properties of fluid does not have such an impact on the changing characteristics of the suspension than the change in elastic parameters. Analyzing the obtained results (Table 2) it can be argued that the use of different fluids is not a substantial difference in the change of resistance of shock-absorber. While the change of charging pressure in the admission gives essential change of loadings on a rod.

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