

This is achieved through introduction of special additives, first of all organic derivatives of sulphur and chlorine and compounds containing both of these elements, into the mineral body of oil.

Extreme-pressure additives react chemically with a heated friction surface of a metal part and form films of reaction products which prevent from adhesion and scoring. Properties of gear oils and their test methods are specified in GOST 23652-79. Properties of some types of lubricating oils are given in table 1.

Table 1 – Properties and areas of application of lubricating oils

Oil grade	Oil type	Viscosity / density ratio at 100 °C, mm ² /s	Ash content, %, not more	Temperature, °C		Application objects
				Pour	Flash	
MC-14	Motor	14	0.003	-30	200	Aviation technical equipment
M-8A		8	0,45	-25	200	Automotives
ДС-8		8	0.005	-25	190	Diesel engines
MC-6		6	0.005	-55	145	Reaction engines
Ц-11	Cylinder	9–13	0.03	+5	215	Steam machines
T ₂₂	Turbine	22–23	0.005	-15	180	Steam and gas turbines
K-12	Compressor	11–14	0.015	-25	216	Piston and rotary compressors
ТА _{II} -10	Gear	10	0.1	-37	95	Automotives
ТС _{II} -14		14–15	0.01	–	140	Trucks
И-5А	Industrial	4–5*	–	-25	120	Indoor machinery and equipment
И-20А		17–23*	0.15	-15	180	
И-100А		90–118*	0.45	-10	210	

* At 50 °C

Oils for industrial equipment (industrial oils) are designed mostly to decrease friction coefficient in movable joints of machine tools, presses, rolling mills, and other equipment. Besides that, they have to remove friction heat, protect friction joints from corrosion, clean contamination from friction surfaces etc.

The main characteristic of industrial oils is viscosity stability in operating conditions, which is especially important when lubricating hydraulic gears of precise machine tools. Combination of these properties is typical of refined petroleum oils and their mixtures without additives, which are used in mechanical engineering – general-purpose industrial oils (GOST 20799-88). However in recent years a tendency to use oils modified by additives, first of all antioxidant and anti-friction ones, in lubrication systems of industrial equipment appeared.

Electrical insulating oils and fluids are adjacent to lubricating oils of the above mentioned basic groups.

They are used not only as actuating media in electrical equipment (transformers, capacitors etc.), but also for lubrication of some types of equipment. Electrical insulating oils are, as a rule, ultrapure mineral oils and organosilicon or synthetic fluids of special purity.

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UDC 678.028

THE INFLUENCE OF RAW RUBBERS VULCANIZATION ON THEIR MECHANICAL PROPERTIES

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We know that vulcanization is a technologic process of converting raw rubber into rubber. Vulcanization induces changes in the following raw rubber parameters: strain under assigned elongation, hardness, strength (modulus of elasticity) at extension, relative elongation, residual deformation, elasticity as well as some operation parameters (freeze resistance, swelling capacity, gas permeability, etc.).

The number of transverse connections, formed on vulcanization, determines the extent of raw rubber cross-linking or the extent of vulcanization.

As the extent of cross-linking increases, the hardness of the product formed (vulcanizate) also elevates monotonously. The curve of vulcanizate extension strength versus the density of transverse connection passes through the maximum (Figure 1).

At the beginning the vulcanizate strength elevates as the number of strain-maintaining lattice chains increase. However, on attaining a certain degree of cross-linking the distances between the nodes become small enough to hinder chain orientation on extension. This causes local overtensions, and, consequently, a break in the chains at these sites.

Before vulcanization, the rubber mixture contains the following ingredients:

- 1) raw rubber base mixed with plasticizers whose content reaches 8–30 % of the base mass;
- 2) fillers representing high dispersion products that determine rubber mechanical properties (carbon black, zinc oxide, etc.) or serve to reduce its cost (chalk, talc, barite as well as crushed wastes of rubber production and old rubber goods);
- 3) dyes giving the required color to rubber goods and sometimes increasing rubber stability to aging on exposure to sunlight;
- 4) antioxidants slowing rubber ageing during oxidation;
- 5) vulcanizing agent contributing to cross-linking of raw rubber molecules during vulcanization.

The main vulcanizing agent for the majority of raw rubbers is sulphur forming cross linkages among macromolecules. The mechanical properties of the vulcanization product are significantly dependent on the sulphur amount. If the mass proportion of sulphur amounts to 0.5–5 %, the grating line frequency is low and the vulcanizate has high elasticity. A higher sulphur proportion enhances the hardness of rubber, and when the mass proportion of it is 30–50 %, a hard material, named ebonite, is produced.

Selenium, metal oxides and other substances are used as other vulcanizing agents. In particular, rubbers synthesized on the basis of dienes are vulcanized by organic peroxides (peroxide vulcanization), quinones (contain $>C=O$ group incorporating the system of conjugated double bonds), alkyl phenol formaldehyde resins, polyhalogene-containing compounds as well as by the action of ionizing radiation (radiation vulcanization) and ultraviolet rays (photovulcanization). Butadiene and butadiene-styrene rubbers can be vulcanized on heating up to 190–200 °C in the absence of vulcanizing agents (thermovulcanization).

Vulcanization resulting in formation of cross linked molecular lattice dramatically changes all the properties of the initial raw rubber converting it into a qualitatively new material with increased strength, modulus of elasticity, gas impermeability, heat – and freeze stability to the action of solvents. For example, its tensile strength elevates dozen times (from 1–1.5 MPa to 35 MPa) and the vulcanizate acquires durability.

The enhancement of rubber strength on vulcanization is explained by not only macromolecular cross-linking, physical adsorption and chemical interaction on the interface of raw rubber and the active filler but also by structurization of the high dispersion filler in a cross-linking framework. An additional factor of strengthening of synthetic rubbers is their polymerization according to double carbon bonds.

The main parameter of vulcanization is the process duration since cross-linking and structurization in rubber mixture proceed along with destruction processes (molecular rupture) under the action of oxygen and high temperature.

Depending on the properties of the rubber mixture the process of vulcanization is subdivided into 4 stages (Figure 2).

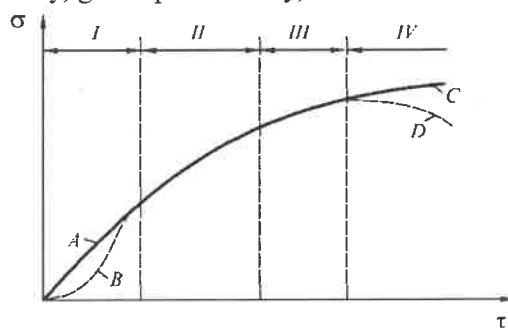


Figure 2 – Dependence of specimen strain (σ) at specified elongation on vulcanization time (τ). Vulcanization stages: I – scorching; II – undervulcanization; III – optimum cure; IV – overcuring; A – mixture with rapid stiffening; B – mixture with slow stiffening; C – mixture with elevated modulus; D – mixture with vulcanization reverse

loose the capacity of fluidity due to irreversible changes in fluidity and plasticity.

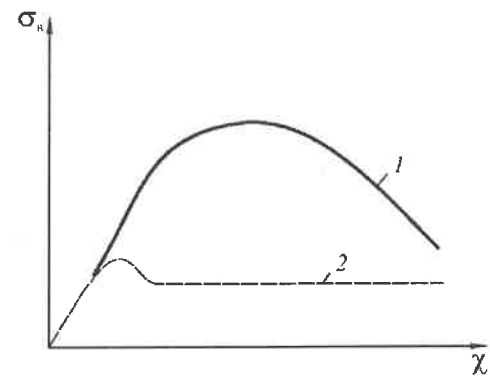


Figure 1 – Tensile strength dependence σ_b during extension on the extent of vulcanization (P) of natural (1) and butadiene-styrene (2) rubber

2 Undervulcanization is accompanied by increased strains at a low rate due to the plastic strain still being high.

3 Optimum cure is characterized by the best combination of physical-mechanical rubber parameters, in particular maximum tensile strength resistance to ageing. The period of time III is named vulcanization plateau. However, not all vulcanizate properties have the highest parameters at stage III. Thus, the durability and crack resistance under multiple deformations reach maximum values at lower extents of cross-linking. After the optimum, the elasticity, plastic deformation and dynamic losses become maximal.

4 Overcuring is the stage at which the elasticity modulus of the rubber mixture still becomes even higher. For the majority of NRR and synthetic isoprene rubber, the extent of cross-linking, and consequently, the modulus decrease (the so-called vulcanization reverse).

The ability of rubber mixtures for vulcanizing determines specific features of their processing into goods. The vulcanization process is carried out with equipment intended for production of the corresponding products at a temperature of 140–180 °C. To obtain sheet articles, non-vulcanized textile-or fiber-reinforced plates are milled first followed by their vulcanization in heated presses.

Tubes, cores and profiles are produced by extrusion (injection) of rubber mixtures, which is followed by vulcanization in special pots. Presses with heating are used for vulcanization in molds under pressure. Thin-walled good are produced by special treatment by aqueous latex solutions coated on the surface of the mold by immersion into solution. The choice of technologic process for processing of rubber mixtures is considerably dependent on the design and purpose of mechanic rubber goods.

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УДК 629.016

ВЛИЯНИЕ ДОПУСКАЕМОГО ОТКЛОНЕНИЯ СКОРОСТИ ОТ ЗАДАННОГО ЗНАЧЕНИЯ НА ТОРМОЗНОЙ ПУТЬ ВАГОНА ПРИ ИСПЫТАНИЯХ

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Безопасность движения поездов напрямую зависит от эффективности тормозов входящих в него единиц подвижного состава. При испытаниях новых вагонов проверяется длина тормозного пути на соответствие нормативным значениям. Согласно ГОСТ 33597–2015 [1] тормозной путь определяют для заданных скоростей движения от 40 км/ч до конструкционной с интервалом не более 20 км/ч. При этом допускаемое отклонение скорости непосредственно перед торможением от заданной не должно превышать $\pm 5\%$. Полученные при ходовых тормозных испытаниях значения тормозного пути одиночных вагонов с фактических скоростей движения пересчитывают на тормозной путь с заданной скорости и нулевой уклон (горизонтальный участок) из условия равенства тормозных сил, действующих на вагон в процессе торможения. Далее тормозной путь приводят к минимально допустимому давлению в тормозном цилиндре и к максимально допустимой массе (тары или брутто), а затем пересчитывают на тормозной путь вагона в составе поезда, который сравнивают с нормативными значениями, приведенными в [2, 3].

В настоящее время разработано и в МТК-524 проходит согласование Изменения № 1 к ГОСТ 33597–2015. Опасаясь, что при пересчете тормозного пути с фактической скорости на заданную скорость в случаях выполнения торможений с нижних допускаемых пределов скоростей, особенно конструкционных, будут получены неадекватные результаты, разработчики Изменения предложили более половины торможений в этой серии опытов выполнять со скоростей, превышающих конструкционную.

Тормозные пути грузовых и пассажирских вагонов определяют методом бросания. Сущность этого метода заключается в том, что при достижении заданной скорости от сцепы, состоящего из ведущего локомотива, вагона-лаборатории и испытываемого вагона, последний принудительно от-