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New Grades of Russian Fluororubbers

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Abstract—Characteristics of Russian fluorrubbers and lattices are reported.

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Fluororubbers form a separate class of specialty fluoropolymers that possess specific features. Their chemical and physico-mechanical characteristics significantly exceed those of hydrocarbon and natural rubbers. Nowadays the fluororubbers are indispensable for production of rubber articles operating in the contact with oils, acids and other aggressive media at a high temperature.

The only Russian enterprise manufacturing fluororubbers is the Limited Liability Co "Polymer Plant of the Konstantinov Kirovo-Chepetsk Chemical Industrial Complex." Until 2006 only two types of fluororubbers were produced: SKF-26 and SKF-32. They are well known at Russian enterprises manufacturing cured goods of specialty applications and supplying the products to car-building plants. The fluororubbers are used for gaskets, oil-retaining rings, glands, and other parts of internal-combustion engines.

It should be noted however that alongside the high strength, low compression set, excellent chemical resistance and heat resistance the fluororubbers SKF-26 and SKF-32 are difficult for processing. Due to high viscosity and hardness the only processing method suitable for them is pressing.

In 2006 a complex modernization of equipment was carried out at the Kirovo-Chepetsk polymer plant that made it possible to put into production new kinds and grades of fluororubber developed in the central laboratory of the plant: SKF-26/3-8 (Elaftor of series 2000), SKF-264/3-9 (Elaftor of series 3000), SKF-264V/3-6 (Elaftor of series 7000). All the mentioned fluororubbers are manufactured as granules (see the figure) and sheets.

Fluororubbers of this series are of various Mooney viscosity:

Grade	(ML1+10)120°C
Elaftor 2031	30–35
Elaftor 2041	36–45
Elaftor 2051	46–55
Elaftor 2061	56–65
Elaftor 2071	66–75
Elaftor 2081	76–85

Fluororubbers Elaftor of series 3000 (Elaftor 3031, 3041, 3051, 3061, 3071, 3081) are copolymers of vinylidene fluoride, hexafluoropropylene, and tetrafluoroethylene containing 68 wt % of fluorine, density 1.87 g cm^{-3}, glass transition temperature –13°C, curing with bisphenol or amine.

This series also contains fluororubbers of a wide range of Mooney viscosity:

Grade	(ML1+10)120°C
Elaftor 3031	30–39
Elaftor 3041	40–49
Elaftor 3051	50–59
Elaftor 3061	60–69
Elaftor 3071	70–79
Elaftor 3081	80–89

Fig. 1. Fluororubber Elaftor 3000. *Fluororubbers Elaftor of series 2000* (Elaftor 2031, 2041, 2051, 2061, 2071, 2081) are copolymers of vinylidene fluoride and hexafluoropropylene containing 66 wt% of fluorine, density 1.83 g cm^{-3}, glass transition temperature –17°C, curing with bisphenol or amine.

Fluororubbers Elaftor of series 7000 (Elaftor 7031, 7041, 7051, 7061, 7071, 7081) are copolymers of vinylidene fluoride, hexafluoropropylene, tetrafluoroethylene, and a functionalized monomer containing 70 wt % of fluorine, density 1.91 g cm^{-3}, glass transition temperature –5°C, curing with peroxides.

The following grades of Elaftor of series 7000 are produced with various Mooney viscosity:

Grade	(ML1+10)120°C
Elaftor 7031	30–39
Elaftor 7041	40–49
Elaftor 7051	50–59
Elaftor 7061	60–69

The appearance on the Russian market of these new materials extended significantly the opportunities for the manufactureres of rubber goods providing a possibility to take into account in choosing the fluororubber both the technical characteristics of the rubber and the processing procedure. All new fluororubbers are capable to be processed by the common methods: extrusion, extrusion molding. Fluororubbers of low Mooney viscosity (30–40) can be processed by highly productive and low-waste modern technology, injection casting.

Whereas the Russian users already know the new grades of fluororubbers SKF-26/3-8 and SKF-264/3-9 and approve their wide technical opportunities, the fluororubber SKF-264V (Elaftor of series 7000) has not yet appeared on the domestic market. We predict that this product will be required by oil, natural gas, and car-building industry. It is characterized by enhanced stability against aromatic hydrocarbons, steam, acids, oils containing additives, and against modern fuels, in particular, gasoline that in some countries contains alcohols and ethers added to increase the octane number of the gasoline and the combustion efficiency.

The properties of fluororubber SKF-264V and its vulcanizates are presented in Table 1 in comparison with its Dupont analog, fluororubber Viton GF.

Cured rubber SKF-264V possesses high strength. Compared with its analog Viton GF the fluororubber SKF-264V shows higher resistance to accumulation of compression set at high temperature and requires shorter duration of postvulcanization to reach the optimum quality; the new rubbers should undergo the postvulcanization for 15 h against 24 h for the analog. This results in energy gain and increased equipment productivity.

Fluororubber SKF-264V is also produced in the form of concentrated latex (aqueous dispersion) with the fluorine content in the polymer 70 wt %, latex Elaftor 7000. The operating temperature range of the coatings made of the latex is from –35 to +200°C. The application of this latex is environmentally friendly. The rubber coatings were traditionally prepared by the use of rubber solutions containing the curing system components, applying the solution on the surface to be protected, and curing the coating. The use of rubber solutions in organic solvents was restricted due to the toxic properties of the latter. The preparation of coatings based on the aqueous rubber latex of the concentration no less than 60% is an alternative to the solution procedure.

The physico-mechanical properties of coatings based on the latex SKF-264V depending on the cure time are reported in Table 2.

Table 1. Characteristics of fluororubber SKF-264V and its vulcanizates in comparison with the characteristics of its Dupont analog

Parameter	Fluororubber	
	SKF-264B/5	Viton GF
Mooney viscosity (MB 1+10)120°C	55	61
Glass transition temperature, °C	–4.9	–5
Fluorine content, %	70.8	70.4
Properties after the I stage of curing (10 min, 180 °C in press)		
Modulus at 100% elongation, MPa	3.6	3.1
Tensile strength, MPa	13.0	12.3
Elongation at break, %	260	360
Properties after the II stage of postvulcanization (15 h, 230 °C, in air oven)		
Modulus at 100% elongation, MPa	4.5	4.3
Tensile strength, MPa	18.2	18.3
Elongation at break, %	250	300
Compression set (25%, 200°C, 24 h), %	20	35
Properties after the II stage of postvulcanization (24 h, 230 °C, in air oven)		
Modulus at 100% elongation, MPa	4 5	4.8
Tensile strength, MPa	18.5	21.5
Elongation at break, %	250	290
Compression set (25%, 200°C, 24 h), %	20	30
Compression set (25%, 200°C, 70 h), %	30	46
Shore A hardness	74	72
Swell in methanol (168 h, 230°C), wt %	3.6	3.8
Properties after the ageing for 70 h at 200°C		
Modulus at 100% elongation, MPa	4.5	4.8
Tensile strength, MPa	19.0	20.0
Elongation at break, %	240	280
Properties after the ageing for 70 h at 275°C		
Modulus at 100% elongation, MPa	4.2	4.1
Tensile strength, MPa	10.5	9.9
Elongation at break, %	260	250

Table 2. Characteristics of coatings obtained from concentrated latex SKF-264V depending on vulcanization time at room temperature in comparison with the properties of coatings from the latex of Solvay Solexis Co

Parameter	Latex SKF-264V			Latex Tecnoflon TN		
	Curing time, days			Curing time, days		
	4	6	8	4	6	8
Tensile strength, MPa	7.6	10.7	12.8		6.7	7.7
Elongation at break, %	560	425	275		750	570

For comparison analogous characteristics are given of the coatings obtained from the latex Tecnoflon TN of Solvay Solexis Co based on a three-component rubber containing 68% of fluorine.

As seen, the coatings of latex SKF-264V compared to Tecnoflon TN are cured faster and possess higher strength.

CONCLUSION

The necessity to increase the range of Russian fluororubbers was overdue. The implementation of new fluororubbers into the Russian industry will both meet the growing requirements of the users and introduce new competitive goods and processes.