Nanosized Diamond-Containing Carbon for Motor Transport and Automobile Construction

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Abstract

High efficiency of the use of diamond-containing carbon additives in lubricants and rubber parts for engines and machines is demonstrated.

Lubricants play an important part in the production and maintenance of motor cars because they provide long-term performance of machinery. Their premature wear is due to the rise of dry friction under high specific load of the adjacent parts (welding effect) and limiting rotation rates. The use of nanosized diamond obtained by means of explosion prevents dry friction. The mean size of diamond particles is 4–5 nm, they have a rounded shape and specific surface S_{sp} = 360–400 m^2/g. The structure of a particle includes a diamond nucleus in a carbon shell. The powders of nanosized diamond are well compatible with hydrocarbon oil forming stable emulsions; they are manufactured by the FSTC "Altay" (Biysk, Russia) [1] under the trade name of UDAG. The first information about their use in lubricants [2] was published in 1990. The application experience accumulated during the subsequent years is described below.

The results of frictional tests carried out at A. A. Baikov Institute of Metallurgy and Materials Science, RAS (Moscow), with a friction machine equipped with five sequentially increasing loading steps SMTs-2 are shown in Fig. 1.

Friction was produced with a roller made of 6KhV2S steel (*HRC* > 60) over a shoe made of AL30 alloy. The I-50 oil with 1 % UDAG added was a lubricant. The results provide evidence of a substantial decrease in the friction coefficient (*f*), (at high load, a decrease by a factor of 5 was observed). As a consequence, oil temperature (T_{oil}) in the friction zone and wear (*J*) decreased. The limiting load (*P*) increased from 710 to >2100 N/cm^2. According to the data of Yamanashi University (Japan), the use of ISO-220 oil with 0.1 % UDAG in the tests according to the Sudzuki procedure (P = 370 N/cm^2) f decreases form 0.50 to 0.05. Tests in the Research Institute of Carbon Industry (Hungary) involving the motor oil SN-150 with 0.1 % UDAG showed that *f* decreases by a factor of 2, *P* increases from 1000 to 1200 N/mm^2, with the transmission oil

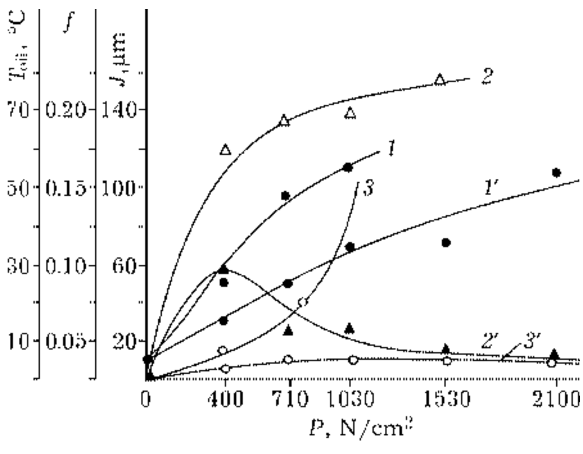

Fig. 1. Changes in oil temperature T_{oil} (*1*), friction coefficient *f* (*2*) and wear *J* (*3*) for pure oil and for oil with UDAG added (*1′–3′*, respectively) for different specific load *P*.

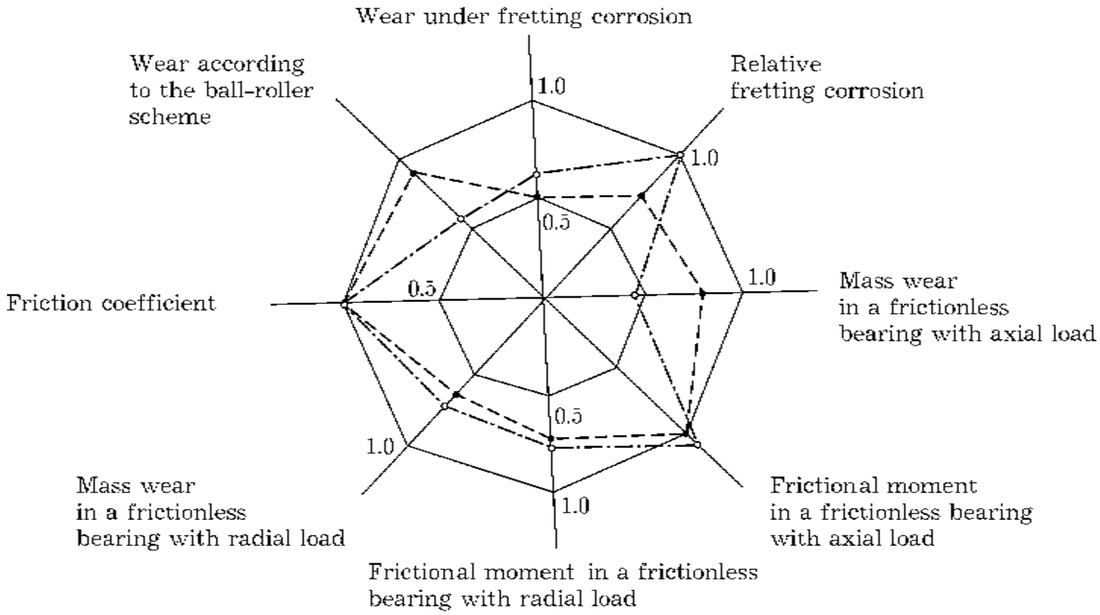

Fig. 2. Changes in the characteristics with the addition of UDAG into Litol-24 (*dot-and-dash line*) and a mixture of UDAG plus fluoroplastics (*broken line*).

Hykomol-K 80W90 the wear of the gear wheel decreased by 70–80 %.

The results of adding 0.1 % UDAG into the consistent lubricant Litol-24 are shown in the generalized diagram (Fig. 2). Accepting the results of tests with the initial oil basis to be unity (the external octahedron) and a two-fold decrease in the controllable characteristics to be 0.5 (the inner octahedron), one can see that almost all the characteristics are better than the initial ones though no substantial changes in f were detected. A positive effect with respect to separate characteristics enhances with the complex additive UDAG used together with the fluoroplastics.

The results characterizing the performance of different engines are presented in Table 1. In addition to a decrease in the consumption of combustive-lubricating materials and decrease in the wear of parts, an increase in engine power is observed. Tests also demonstrated the occurrence of the aftereffect which is connected with the insertion of diamond nanoparticles into the surface layer of interacting surfaces. The latter causes the conservation of the achieved effect after washing the engine and replacement of motor oil for the standard one. This result makes it promising to carry out running-in with the oil in which UDAG is added. Thus, for instance, a

TABLE 1

Results of engine tests with lubricants in which 0.1 % UDAG is added

Engine	Decrease in consumption, % of:		Increase, %, in:		Wear
	fuel	oil	compression	power	
VAZ-2101	6.0	–	12.0	4.4	Decreased within 180 motor hours
KAMAZ-4310	8.0	14.0	–	–	Decreased within 250 motor hours
Komatsu diesel SA6D-155-4A	2.0	–	–	–	Decreased by 40 % within 250 motor hours
Marine engine 6NFD48A-2U	5.6	–	–	–	Decreased by a factor of 2 within 2450 motor hours

Note. A dash means that the value was not determined.

TABLE 2

Results of tests of machinery with lubricants in which UDAG was added

Plant	Object	Lubricant	Duration of operation, months	Result
Kutaisi Automobile Plant(Georgia)	Coordinate milling machine (Japan, Germany, Switzerland)	Complete	6	Afterdribble of oil was eliminated, oil consumption decreased by a factor of 2–3, no wear was observed
Orsk Mechanical Plant	MSO32, 16K30, MK6736, 16K2OFZS machines	«	4	Heating of oil station decreased by 10–15 °C, no wear was observed
	Grinding machine "Lyandis"	«	12	Operation lifetime of bearings increased from 6 to 12 months, heating decreased.
Chemical Plant "Russia"	Variator VTs12-131-S3	«	6	No wear was observed.
	Compressor VP-20/8	Friction centre of the cross head housing	9	« «
	Press K-0044	Complete	4	« «
	Line 4L-513	«	7	No wear was observed (the former turnaround life was 2 months)

5-fold decrease in engine running-in time was achieved at the Zavolzhsk Motor Plant.

Automobile production involves machines, machinery and works for which lubrication with the UDAG additive gives a positive effect. The data of tests are presented in Table 2.

An automobile is equipped with various mechanical rubber goods (bushings, sealing cuffs) the wear of which affects the overhaul period. Their operation lifetime can be increased by adding UGAD into the rubber [1]. Manufacture and tests of a number of such

TABLE 3

Characteristics of mechanical rubber parts with UDAG added

Rubber grade, part	Relative change			
	Shore hardness	tear resistance, kg/cm	abradability, $cm^3/(kW \cdot h)$	residual deformation, %
7IRP-1315, reinforced bushing of silent block	1.08	1.09	0.24	0.97
7-2462, sealing cuff	1.03	1.00		0.50
7-51-5003, sealing of shock strut piston	1.00	1.05	0.75	0.42
7IRP-1100, sealing of shock absorber junction	1.07	1.06	0.85	0.69
7-4004, sealing of the steering shaft	1.02	1.10	0.65	0.90

parts at the Chapaev Cheboksary Plant (Table 3) showed a substantial decrease in their abradability and residual deformability with a definite increase in hardness and tear resistance.

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