Mineral Solid Lubricant Coatings
Nano-Material Based Anti-Friction Technology

Case 1. Car fleet

Table 1 shows results obtained for a municipality car fleet, consisting of 70 cars, both locally made and imported. Parameters of the car fleet were measured before and after the anti-friction treatment.

Table 1. Results of the anti-friction treatment. Car fleet of municipality consisted of 70 cars. Car fleet was observed for 2 years.

Parameter	**Initial state 1st year**	**After treatment 2nd year**
Distance run By the fleet	6 525 000 km	3 000 000 km
Number of capital engine repairs/year	**58**	**1**
Average distance run per one engine repair	**112 500 km**	**3 000 000 km**
Average fuel economy		**17 %**
Annual economy/ costs of car fleet		**12 %**

Before treatment, the capital repairs of car engines took place rather often, altogether there were **58 caital repairs** per year. After antifriction technologies were applied, the number of capital repairs diminished to **1**. Average car fleet economy of gasoline was 17 %. The general annual economic effect of the reduction of fuel consumption and number of repairs was equal to 12 % of the full operating costs of the car fleet. Additional costs savings are due to the economy of oil/grease and decrease of downtime of cars.

Case 2. Open-pit dump truck BELAZ-7519

According to the analysis of the open-pit autoservice group, a dump truck BELAZ-7519 worn out by ~70 % was analyzed. It was exploited on the same route, and it was easy to monitor fuel consumption rate. The truck was consuming **3 800 l/month more than standard** fuel consumption declared by the manufacturer. A decision was made to write it off. It was decided to try our new anti-friction technology for this truck.

Two months after anti-friction treatment, it was found out that the consumption of fuel for this truck was **700 l/month lesser than the standard** consumption (marked for a truck with this level of kilometers run and the worn-out level). Thus, the total fuel savings as a result of application of mineral solid lubricant were **4 500 l per month**. The decision to write it off was immediately canceled as the dump truck had a minimum fuel consumption in the open-pit truck fleet.

Applications in power generation equipment

Case 3. Kamchatka Geothermal Power Plant

Anti-friction technology was tested and exploited at a large industrial enterprise - manufacturer of power generation equipment "KTZ" (Joint Stock Company "Kaluga Turbine Works"). The company had produced power generation equipment for Kamchatka Geothermal Power Plant; however, friction pairs were easily oxidized in aggressive environment (hot vapour at 240 °C with H_2S and salts) and needed repair every 3 months. After application of mineral coatings to the friction pairs, the equipment worked for **10 years** without any problems and is still running. Service time increased **40 times**.

Tests of metal parts and units for **turbines and pumps** with mineral coatings have been made at KTZ during these 10 years. Efficiency and reliability were tested for **bearings** of **turbo generators**, **pumps** with water lubrication and **regulating and protecting units**. The products with mineral coatings showed high reliability. Wear decreased 5 times. The products work in most unfavourable conditions: in aggressive media, in conditions of limited aqueous lubrication, border friction and abrasive wear. The tests and prolonged exploitation showed substantial advantages of mineral coatings in reliability, service life, labour intensity and time of manufacturing.

Applications in gear boxes and bearings

Case 4. Tests of **gear box** of locomotives and wagons were performed. The mineral coating was applied to gears and compared to non-treated control gears. **One-time lubrication** was used.

Locomotive "TEM-1"(Russian manufactured)/ТЭМ1(diesel engine) was observed for 385 days;
Locomotive M62 (diesel engine) was observed for 411 days (53 600 km);
Electric train "EP-2"/ЭР2 was observed for 284 days (101 000 km);
Two cars of electric train "EP-1"/ЭР1 were observed for 358 days.

The gears with mineral coatings showed no signs of wear of teeth and demonstrated good performance in winter (under harsh environmental conditions). No galling and no defects were observed. Mineral layer of 0.1 mm thickness was present. Non-treated control gears had defects of 3-4 mm^2 area and 0.1 mm depth, the wear being enhanced in winter.

Later investigation of the teeth showed that micro-hardness of non-treated metal had a value of H50=556, whereas micro-hardness of the mineral layer attained a value of H50=758.

Case 5. Experience of work at conditions of **dry friction**: two **gear boxes** of an electric train had a mineral coating and were exploited **for a month without any oil**. Inspection of the surface showed that the teeth in one gear box had a mineral coating with a smooth surface; teeth in another gear reducer had a small number of defects. Oil was added, and gear boxes continued work.

Gear boxes of locomotives and wagons are some of the most intensively working units in trains. The customer benefits from economy of lubricating oil, economy of spare parts and economy of maintenance costs.

Case 6. Gear box of the drive of the roller conveyor at “Izhora Steel Works (Russia)”. Drive specifications: Power 0.5 kWt, Speed 505 RPM, Ratio 2.73. After treatment with mineral coating and wearing-in, **oil was completely removed**. The gear box worked for **15 months**. Usually it was used for 8-10 hours per day. For about 35 % of working time the gear was exploited at a maximum loading. Regular inspection showed absence of wear of the teeth.

Case 7. Bending machine BM-3 (Escher, Germany) had a two-stage **gear box**, 6 open tooth pairs and 11 **bearings**. General energy conversion efficiency was 0.622. After forming mineral coating on the surfaces of the friction pairs, energy consumption was reduced from 27.54 kWt to 19.78 kWt, i.e. by **28 %**. The energy conversion efficiency raised for a tooth gear - from 0.980 to 0.986, for a bearing - from 0.97 to 0.98, for a gear reducer - from 0.830 to 0.877.

Case 8. In food industry use of oil in gears should be reduced to a minimum because of the losses caused by a possible leakage of oil into the product. Mineral coatings were applied to a **worn gear box** and **bearings** at a milk-producing plant in Nizhny Novgorod area (Russia). After formation of the coating, small amount of grease was used instead of standard quantities of oil. Inspection after 4.5 months of exploitation showed: the gear did not need any maintenance work; noise of the gear with the mineral coating was lower compared to the untreated gears of the same type; temperature of the gear working without liquid oil was lower than that of the gears working at the standard oil lubrication conditions.

Application in mining industry

Case 9. Ball mill

Ball mill MShR 4,5*5.0 is designed to crush ore lumps and consists of the following parts: drum (bowl) on two supporting slider bearings, tooth gearwheel of the drum, gearshaft on spherical bearings 3680, box-coupling, electric engine drive on two slider bearings. Lubrication is provided by forced-feed lubrication system with an oil reservoir of 250 l.

Inspection of the ball mill revealed several defects: tooth gearwheel and gearshaft were worn (30 % of the thickness of tooth); all teeth of the tooth gearwheel had wear cavities of 30-40 mm width. During inspection initial parameters of the ball mill (current of idle running, slowing time after switching off) were measured.

Antifriction technologies were applied to the bearings and gears of the ball mill. Furthermore, dispersion of mineral powder was added to the lubricating oil reservoir.

After formation of mineral coatings the following results were observed:

- current of idle running diminished from **140 A** to **85 A** (friction losses by 39 % less);
- slowing time after switching off increased from **7-10 sec** to **35-45 sec** (3 measurements were performed).

After additional running-in work, the ball mill was exploited as usual.

After 2.5 months, additional antifriction treatment of spherical bearings and tooth gearwheel was done. Running-in was performed for 1 hour in the routine working regime. After switching off the average slowing time was **195 sec**. After 48 hours of work the measurements were repeated, and the slowing time already equaled **315 sec**. All these facts speak for **significantly diminished friction**.

The wear cavities were found to be filled by the mineral material, and practically only traces of cavities were seen. No additional treatment of the slider bearings was needed!