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IMPROVING THE ABILITY OF MOTOR OILS TO THE EFFECTS OF HIGH TEMPERATURES

Zebo Alimova
(Professor) Tashkent State Transport University, Uzbekistan
Abduaziz Abdurazakov
(Associate Professor) Tashkent State Transport University, Uzbekistan

Annotation: *In modern internal combustion engines, lubricating oils are exposed to high-temperature zones where hydrocarbons and other oil components undergo thermo-oxidative degradation. This process leads to the formation of low-volatility, highly viscous, and poorly oil-soluble oxidation products, such as oxyacids, asphaltenes, and acidic resins. These compounds accumulate on critical engine parts, forming varnish deposits that impair piston ring mobility, reduce sealing efficiency, and contribute to wear and corrosion of cylinder walls. The consequences include decreased engine efficiency, reduced compression, and increased risk of component failure. Enhancing these properties is essential for extending engine life, reducing maintenance costs, and improving performance under extreme conditions.*

Keywords: *motor oil, high-temperature stability, varnish deposits, detergent–dispersant additives, antioxidants, engine lubrication.*

Studies indicate that oils containing optimized detergent–dispersant packages exhibit significantly reduced varnish formation and improved suspension of insoluble particles. Oils formulated with high-performance antioxidants maintain lower acid numbers and resist viscosity increases under prolonged high-temperature exposure. By maintaining the mobility of piston rings and preventing carbonaceous deposits, such oils contribute to better compression, higher efficiency, and reduced wear of cylinder components.

High-temperature degradation of motor oils is a critical factor affecting engine performance and reliability. The use of detergent–dispersant additives, antioxidants, and viscosity modifiers significantly improves oil stability, prevents varnish deposits, and maintains component mobility. By optimizing these formulations, it is possible to enhance engine efficiency, reduce wear, and extend service life under extreme operating conditions. Continued research into additive chemistry and base oil selection remains key to developing advanced motor oils capable of withstanding increasingly demanding engine environments.

Lacquer deposits are carbon-rich substances formed as deposits in the grooves under the piston rings, on the skirts and inner walls of the pistons.

The mechanisms by which motor oils resist high-temperature degradation involve both chemical and physical actions of additives. Detergents neutralize acidic by-products, while dispersants suspend insoluble residues, keeping them from adhering to metal surfaces. Antioxidants inhibit the radical chain reactions responsible for oil breakdown.

Further improvement can be achieved by:

- Optimizing additive concentrations for specific engine operating conditions.

- Developing multifunctional additives that combine dispersant, detergent, and antioxidant properties.
- Using synthetic or semi-synthetic base oils with superior thermal stability.

Advances in high-temperature oil formulation not only prevent varnish deposits but also enhance overall engine durability, reduce maintenance intervals, and improve fuel efficiency. Future research should focus on molecular-level understanding of oxidation and deposit formation, allowing targeted design of next-generation high-temperature resistant lubricants.

The greatest danger of varnish deposition is for piston rings. By filling the gaps formed by the piston rings and the grooves drilled in the pistons, it reduces the mobility of the rings. It is here that high-carbon compounds are formed, which are deposited in the grooves in the form of films. The deposition of varnish causes the piston rings to burn and the parts on which these deposits were formed to overheat. Combustion of piston rings, which causes a breakthrough of gases into the crankcase and a decrease in compression in the cylinders, and as a result – a drop in engine power.

The accumulation of carbonaceous deposits on cylinder walls, pistons, piston rings, valves, and other engine components occurs not only as a result of oxidative degradation of oil, but also due to thermal transformation of polycyclic hydrocarbons. Such deposits lead to increased engine oil consumption, accelerated wear, scoring of cylinder walls, piston ring breakage, and in severe cases, piston seizure.

The presence of sediments in the engine represents a significant hazard. Deposits can clog oil ducts, pipelines, and filters, disrupting normal lubrication. Blockages in the oil pump suction line or oil supply channels can lead to bearing liner melting, crankshaft journal damage, and even engine failure. When oil filters are obstructed, contaminated oil enters rubbing surfaces, accelerating wear and increasing the risk of piston ring burning.

Sediments also degrade the quality of freshly added oil and, over time, may condense and harden, making mechanical cleaning of parts extremely difficult. Engine operating conditions strongly influence deposit formation. Low-load and light-speed operation, frequent stops, prolonged idling, and insufficient operating temperatures favor sedimentation. Prolonged idling at low coolant temperatures exacerbates contamination of crankcase oil with products of incomplete combustion and fuel dilution. Maintaining coolant temperature around 70 °C during idling is recommended to reduce deposit formation.

Engine sediments are typically sticky, oily substances ranging from gray-brown to black, accumulating in the crankcase, valve housing, oil system, and filters. They are primarily water-in-oil emulsions contaminated with various impurities. The presence of water in crankcase oil is a major contributor to sediment formation. The composition and characteristics of these deposits vary depending on engine operating conditions and oil formulation.

Motor oils containing specialized additives are less prone to sediment formation than base oils. Additives enhance the suspension of insoluble particles, increase resistance to oxidation, and prevent adhesion of deposits to metal surfaces. Key preventive measures include the use of antioxidant and detergent–dispersant additives, which inhibit the formation of resinous and asphaltene deposits on hot engine surfaces. Detergents contain alkaline components that neutralize acids produced during fuel combustion, thereby reducing varnish and carbon deposits.

Modern developments include ash-free dispersant additives, such as succinimide derivatives, which differ in amino group content and the length and branching of aliphatic chains. Succinimides not only avoid forming abrasive particles but also demonstrate superior dispersing effectiveness compared to traditional ash-containing additives.

Alkylphenolic compounds are commonly employed as antioxidants, with ionic amine-type compounds and those containing sulfur, nitrogen, or phosphorus showing the highest effectiveness. Alkylsalicylates maintain solid particles in fine suspension, preventing deposition on metal surfaces and reducing varnish accumulation in the engine and oil pipelines. Sulfide compounds or phenol derivatives prevent oxidation of oil films on hot surfaces, while detergent-type SB-3 compounds effectively loosen and wash deposits, keeping insoluble substances suspended without agglomeration.

In summary, the combination of antioxidants, detergents, and dispersant additives significantly improves the high-temperature performance of engine oils. By preventing sediment formation, maintaining suspension of insoluble particles, and neutralizing acids, these additives enhance engine durability, reduce wear, and ensure reliable lubrication under severe operating conditions.

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