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STUDY OF IR-SPECTROSCOPIC ANALYSIS OF OILS USED IN THE TEXTILE INDUSTRY

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Abstract

This article presents the composition, physical and chemical properties of textile industry machine oils and the results of their IR-spectroscopic analysis. Also, the basic technological and operational requirements for the oils used in the textile industry have been developed.

Keywords: *oil, IR-spectroscopy, breeding, process, analysis, requirements*

Introduction

The textile industry is one of the fastest growing industries, where high-speed equipment operation, sensitive materials, and the need to produce high-quality products require a special approach to lubricants. One of the main elements of the technological process is textile oils, which ensure the smooth operation of machines and the preservation of the quality of the processed fibers.

Lubricant chemical analysis is a process of testing lubricant properties, contaminants, and wear debris to assess the condition of the lubricant and the equipment it's used in. This analysis helps in identifying potential problems, preventing costly repairs, and ensuring optimal equipment performance.

Textile oils and lubricants are special compounds that are used in the textile industry to reduce friction, prevent equipment wear, and improve the quality of fiber and fabric processing.

Currently, various oils are used as the main lubricating materials. The main function of the oil is to create a stable lubricating film to minimize friction and prevent wear of the rubbing surfaces. Changes in the properties of the oil during its operation in the engine are called oil aging. Changes in the properties of the oil are divided into two groups – quantitative and qualitative. However, changes in both groups can ultimately affect the reliable operation of the engine (Majidov, 2000).

During the process of working with oil, it comes into direct contact with metal, is exposed to external air, temperature, pressure, and other factors. As a result of these effects, hydrocarbon decomposition, oxidation, polymerization, and condensation processes, charring (incomplete combustion), liquefaction with fuel, contamination with foreign substances, and oil hydration occur.

Oils containing contaminants cannot meet the requirements and must be replaced with new oils. Under the influence of oxygen in the air, the oil oxidizes and, falling into the crankcase, mixes with hot and contaminated oil. Acids are strong oxidizing agents and are the main cause of corrosion and rusting of the cylinder wall and piston rings. Acids also create an environment that reduces friction in bearings. Resins, on the contrary, form a sticky deposit on the piston and piston rings, sharply reducing their mobility.

Modern motor oils produced today consist of base oils and additives that improve their properties. As base oils, distillate and residual components of various hardness (hydrocarbons), their mixtures, hydrocarbon components obtained by hydrocracking and hydroisomerization, as well as synthetic products (high molecular weight hydrocarbons, polyalphaolefins, complex esters, etc.) are usually used. Many all-season oils are obtained by supplementing low-hardness base oils with macropolymer additives.

Motor oils must meet the following requirements:

- have good lubricating properties that ensure reliable engine lubrication in all operating modes;
- have optimal viscosity-temperature characteristics for trouble-free engine start-up;
- have sufficient antioxidant stability that prevents significant changes in chemical composition during operation;
- have good detergent properties that prevent the formation of varnish and hardened deposits on hot engine parts;
- have high anti-corrosion properties (at operating temperatures) for structural materials, especially non-ferrous metals and alloys;
- have reliable protective properties that prevent corrosion during storage.

Materials and methods

Of the study are motor oil and used motor oil used in the textile industry.

The work used modern physicochemical analysis methods, including IR spectroscopy and other standard analysis methods.

Lubricating oils: analysis according to ASTM D6443 and D4927Turnkey solution for analysis of additives in lubricating oils.

Almost all commercial oils contain chemical additives to enhance their performance for a particular application. The ASTM D6443 and ASTM D4927 international standard test methods are used to determine if the oils, additives, and additive packages meet specification. These methods employ wavelength dispersive X-ray spectroscopy (WD XRF) and mathematical matrix corrections procedures. XRF is an excellent method for multi-elemental analysis as it provides cost-effective, precise and accurate data and fast data acquisition. Individual calibrations can be used for months, avoiding time-consuming and costly recalibration. Especially for liquids, the sample preparation is simple and the analysis does not require highly skilled lab personnel.

Expertise Program for XRF analysis of additives in lubricating oil according to ASTM D6443 and D4927

This Expertise program delivers a complete methodology to establish norm compliance and covers all aspects from sample preparation to quality assurance. Customers can choose to request a quote for either one or both norms to be covered in the program.

Included:

- Suit of calibration standards for D4927 and/or D6443 including validation sample;
- P-1 or P-2 cups and assembly tool and pre-cut Mylar foils, sufficient for calibration and validation;
- Setup of optimized application setup and calibration for accurate analysis of the range of elements in concentration ranges as given in the table above;
- Setup of methodology validation and calibration maintenance procedure;
- Advice on sample preparation best practices and workflow optimization;
- User training and documentation.

Results and Discussion

Textile oils are not simple lubricants, but important tools that affect the performance of equipment, product quality and economic efficiency of the enterprise. Choosing the right oil, taking into account technological requirements, the type of material being processed and the characteristics of the equipment, significantly extends the service life of machines and increases the competitiveness of the finished product.

The main functions of textile oils are: to reduce friction between equipment parts and the materials being processed; to prevent sticking of moving parts of machines; to reduce static electricity in the processing of synthetic fibers; to maintain the quality of the fibers – smoothness, softness, brightness; to protect equipment from rust; to increase the technological convenience of spinning, weaving, knitting and final processing processes.

The composition of motor oil mainly consists of two components (Pentin, 2003):

1. Base oil (70–90%). Mineral (derived from petroleum) – produced by boiling direct petroleum and then separating the alkanes. This product consists of up to 90% branched saturated hydrocarbons. It is characterized by high dispersion of paraffins (non-uniformity of molecular chain masses). The lubricant is thermally unstable and does not retain its viscosity indicators during operation. Synthetic – a product of petrochemical synthesis. Ethylene is used as a raw material, from which a certain molecular mass and a long-chain polymer base are obtained by catalytic polymerization. Synthetic oil can also be obtained by hydrocracking mineral oils. It does not lose its properties during its service life (Abishek, 2024).

Semi-synthetic – a mixture of mineral (70–75%) and synthetic oil (up to 30%).

2. The proportion of modifiers in motor oil is about 10%. Ready-made "add-on packages" consist of a set of various components and are used to increase the necessary parameters of the lubricant: Antioxidant – slows down the wear of the oil; Forms a protective film against friction and adhesion; Detergent – prevents residue formation; Dispersant – keeps pollution in suspension; Antifoaming – reduces foaming; Viscosity modifiers – provide stability at different temperatures; Anti-corrosion – protects metal from rust. The general composition of lubricating oils is given in the table below.

Table 1. *Composition of lubricating motor fluids*

Components	Percentage amount
Basic base (saturated paraffins, polyalkylnaphthalenes, polyalphaolefins, linear alkylbenzenes, as well as complex ethers)	~90%
Additives package (sticky stabilizers, protective and antioxidant additives	Up to 10%

The strict technological and operational requirements for oils used in the textile industry include:

1. Low viscosity – so that they spread evenly throughout the material and do not weigh it down.

2. Easy washability – the ability to remove the oil from the fiber without damaging the fabric.

3. Chemical stability – resistance to oxidation and decomposition. 4. Odorless and non-toxic – safety for workers and the end user.

5. Colorless and non-staining – especially important for light fabrics.

6. Antistatic properties – especially relevant when working with synthetic materials.

Table 2. *Main properties of lubricant*

Property	Description
Viscosity	Determines the oil's fluidity; measured by SAE (e.g., 5W-40).
Ignition temperature	The temperature at which oil vapors ignite (usually 200–250 °C).

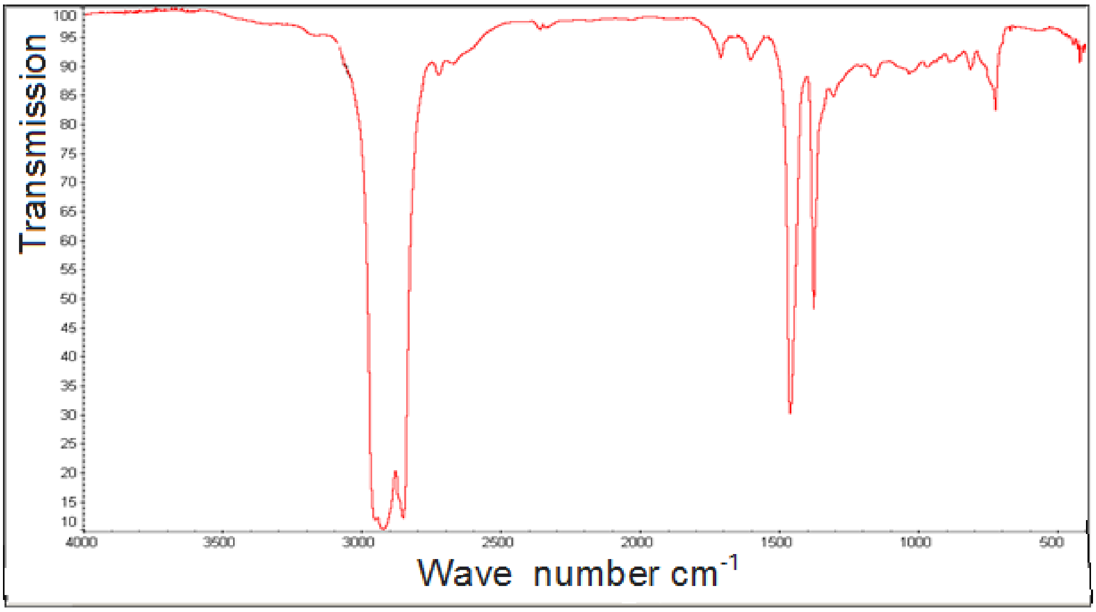
Property	Description
Solidification temperature	The temperature at which the oil loses its mobility (down to –50 °C for synthetic oils).
Alkalinity number	Indicates the acid-neutralizing ability (6–12 mg KOH/g).
Acidity number	Indicates the amount of acids in the oil; increases as the oil ages.
Sulphated ash content	Indicates the amount of solid residue left after combustion (0.5–1.5%).
Evaporation rate	Mass loss at high temperatures; the lower the better.

Among the various methods for studying the structure of organic and inorganic compounds, infrared spectroscopy (IRS), which is based on the absorption, reflection, and scattering of infrared radiation energy as it passes through a substance, occupies an important place (Tarasevich, 2012).

IR spectroscopy is based on the absorption of infrared radiation by oil molecules at certain frequencies, which correspond to the vibrations of chemical bonds. By comparing the spectra of motor oil and used oil, it is possible to determine the following: the degree of oxidation, the presence of decomposition products (organic metal compounds), the presence of water, fuel, and solid particles.

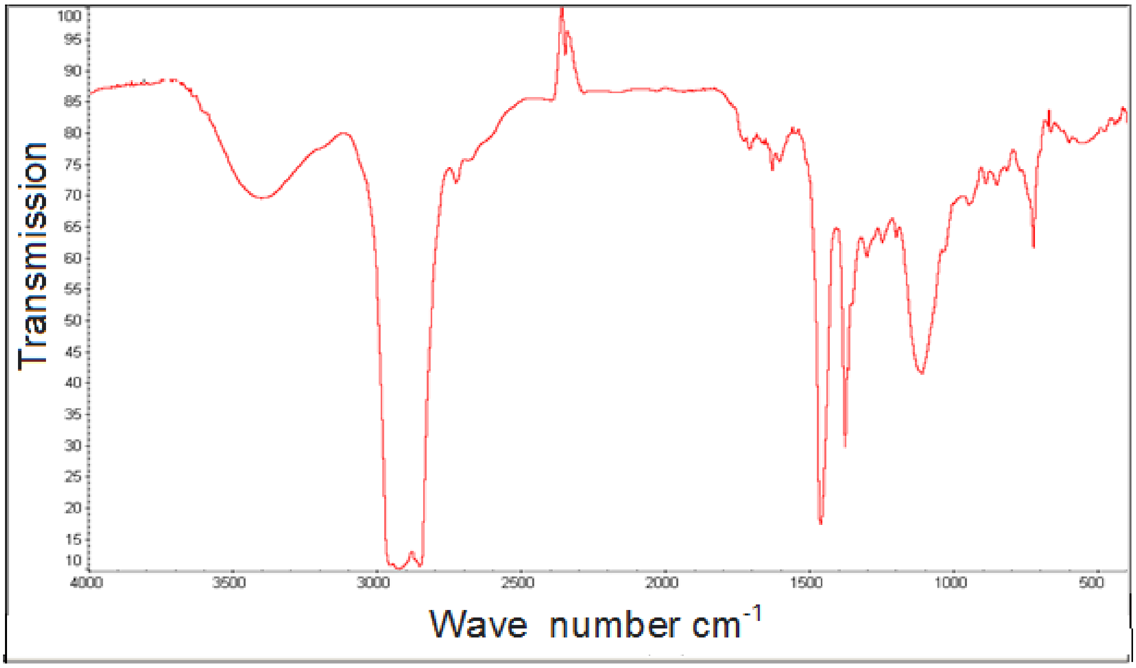
In the course of work, the composition of the oil was determined by IR spectra in the laboratory of the Center for Advanced Technologies of the Republic of Uzbekistan using equipment manufactured by Shimadzu (Japan).

Figure 1. *IR spectroscopic image of textile oil*



Analysis of the data presented in the figure shows that the main absorption lines are located at approximately 2850, 2925 cm⁻¹ and 3000–3100 cm⁻¹. According to the characteristic frequency table, these vibrations correspond to the following: the valence vibration lines of the CH_2 group, characteristic of aliphatic hydrocarbons; the C=C bond vibrations of aromatic rings. The strong peak at approximately 700 cm⁻¹ indicates the presence of four carbon atoms in the aliphatic chains. Thus, the main composition of the studied oil consists of saturated hydrocarbons and benzene class compounds. The IR-spectrum of the oil used for the comparative analysis was also obtained (Fig. 2), which made it possible to determine the changes in the composition – oxidation processes, accumulation of substances formed during wear and decomposition of additives.

Figure 2. *IR spectroscopic appearance of used textile oil*



Analysis of the presented data shows that a broad peak around 3400–3450 cm^{-1} corresponds to the vibrations of the –OH (hydroxyl) group. This indicates that moisture or water was added to the oil during operation. Peaks around 1700–1750 cm^{-1} are characteristic of –C=O (carbonyl) groups, indicating the formation of aldehydes or ketones as a result of oil oxidation. Peaks in the range of 1100–1150 cm^{-1} belong to –S=O (sulfoxide or sulfate) groups, indicating the accumulation of metals or oil additives (detergent, antioxidant). A change in the ratio of the CH_2 and CH_3 vibration peaks around 2850–2950 cm^{-1} may indicate the presence of fuel residues or organic substances in the oil. Additional peaks in the range of 600–800 cm^{-1} may originate from mineral particles or metal oxides. Peaks around 3000–3100 cm^{-1} and 1600 cm^{-1} are characteristic of aromatic C–H and C=C vibrations, indicating benzene-like substances or heavy hydrocarbons accumulated in used oils.

The analysis shows that infrared spectroscopy is an effective and rapid tool for determining the composition and condition of both new and used motor oils. By comparing the spectra, it is possible to identify characteristic changes associated with oxidation, the accumulation of additives, the presence of moisture and friction products.

This allows an objective assessment of the suitability of oils for reuse in the textile industry. After cleaning and regeneration, used motor oils can be used as lubricants for mechanisms in the textile industry, anti-corrosion coatings, anti-dust compositions and auxiliary technical means. The use of regenerated oils reduces the cost of purchasing new lubricants, reduces the volume of industrial waste and reduces the impact on the environment.

Conclusion

An analysis of a sample of motor oil was performed using the Fourier transform infrared spectroscopy (FTIR) method, and characteristic spectra were obtained, including absorption lines characteristic of hydrocarbon oils and additives. The IR spectroscopy method allowed us to confirm the type of oil and determine its chemical composition without damaging the sample. The use of IR spectral analysis in combination with oil regeneration processes is an economically viable and environmentally sound solution that ensures the uninterrupted operation of textile enterprises.

References

Majidov A.Kh., Sharipov K. A. Osnovy ochistki masel. Tashkent, Science. 2000. – 140 p.
Pentin Yu. A., Vilkov L. V. Fizicheskie metody issledovaniya v khimii. –M.: Mir, 2003. –683 p.
Tarasevich B. N. IR spectrum osnovnykh klasov organicheskikh soedineniy. Reference material. – Moscow, 2012. – 55 p.
Abhishek Kumar, Avinish Kumar. Performance Characterization of Lubricants. CRC Press, Boca Raton FL USA-2024.

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