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STUDY OF METHODS FOR DEVELOPING WASTE LUBRICANT RECOVERY

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Abstract: *The article provides analytical information on the study of methods of treatment of used engine oils. The issues of ecological safety of storage, processing and use of automobile waste are considered. The problems of ecological safety of application of lubricants are inseparable from utilization of OWS, which are currently one of the most common man-caused waste that negatively affects all objects of environment atmosphere, soil and water. It has been shown that water pollution by waste oil accounts for 20% of total techno-genic pollution, or 60% of petroleum product pollution. The study determined that obtaining oils with characteristics superior to the original properties of the product received for regeneration is possible in addition to various stages of OM treatment requiring the use of chemical regeneration methods associated with the use of complex equipment and high costs. An improved combined processing scheme for used motor, industrial, turbine and transformer oils is analysed,* *the scheme of which involves coagulation, atmospheric distillation, acid and adsorption purification stages followed by vacuum distillation and contact refining of the high-viscosity component.*

Keywords: *oil, energy, waste, source, fuel, recycling, techno-genic.*

INTRODUCTION. The rapid development of the global chemical and oil & gas industry has led to an increased demand for high quality fuels and oils for internal combustion engines. Deeper refining of raw materials and expansion of the product range is driving the modern petrochemical industry. As the demand for motor fuels and oils grows, so do the environmental requirements for vehicle waste. The environmental issues of automotive waste storage, recycling and use are very complex, and have a number of specific features for each type of waste. The number of vehicles in Uzbekistan is growing every year, and this figure currently stands at more than 3 million vehicles.

As a result, millions of tons of waste engine oil are generated in the country each year in the form of waste, which undoubtedly represents a significant threat to the environment. The problem of an increasing number of vehicles and waste oil from waste motor oil is an urgent issue in our country. In our time, mankind is experiencing a serious problem in the form of a dramatic increase in waste.

As cities continue to grow, so do the mountains of rubbish around them. Whereas in the past the disposal of used raw materials or rubbish consisted of taking the waste out of the city and setting up huge landfill sites, with the development of progress, recycling is becoming more and more relevant, making it possible not only to get rid of waste, but also to do so with maximum profit and benefit.

MATERIAL AND METHODS. Waste oil regeneration is an area that began more than 30 years ago and is still developing rapidly. Most waste oil regeneration installations simply remove mechanical impurities and water [1], which cannot always restore the original properties of the oil. Therefore, deeper oil regeneration is carried out using a vacuum, which in turn increases the cost of the regenerated oil.

The regeneration and disposal of waste engine oils is an important scientific and technical problem, as it is a man-made waste which has a very negative impact on environmental objects, i.e. atmosphere, soil and water. Water pollution by waste oil alone accounts for 20% of anthropogenic pollution, or 60% of the total pollution by petroleum products. At the same time, by developing their recycling processes, in particular processing of used engine oils instead of the usual waste collection, it is possible to obtain promising energy sources, the rational use of which will reduce the cost of petrochemical products in our country and ensure the growth of economy.

The most important problem is the collection of used engine oil. The probability of collecting: motor and industrial oils - up to 20-40%, transformer oils - 80-90% of waste. The global collection of used lubricants is around 15 million tons per year, most of which (70-90%) is incinerated as a fuel component. Many countries around the world still lack centralized collection of used lubricants. The figure is the highest in Europe, the collection of waste lubricants is approx. 57 per cent (up to 1.6 million tons annually), and their use as a fuel component is 60 per cent. [1]

It should be noted that solutions have also been proposed for the use of used engine oils with or without partial regeneration in a variety of technological processes. For example, work [2] shows the possibility of using used oils as a complex reagent-collector for flotation of coal sludge. The concept of application of composite compositions for temporary protection of agricultural machinery against corrosion using used engine oils as a base solvent and a polyfunctional additive has been developed [3]. Soap (hydrated calcium and lithium) and hydrocarbon lubricants have been produced on the basis of used engine oils by the author of [4].

At the moment, three methods of recycling are the most popular. The first is recycling using separate waste collection. This method is most widely used in developed countries - USA, Western Europe, Japan. Another method used to dispose of waste is incineration in an incineration plant. This method is the most expensive and poses a serious threat to the environment, and it is the need to minimize the hazardous, toxic impact on the environment of incinerating waste that drives up the price of this method of waste disposal.

Equipment required for construction of a modern waste incineration plant with minimal environmental impact is also very expensive - on average it costs from three billion rubles and more. In order to clean the toxins from the combustion products about two hundred fifty tons of high quality lime costing more than forty thousand rubles per ton is used in a single month, also activated carbon and modifiers need to be used.

This adds up to a waste disposal price of over one thousand rubles per ton at such a plant. In order for people to be able to pay these rates, municipalities have to subsidize their waste collection and recycling services. Waste management through separate recycling is therefore the most promising at the moment. Waste is now disposed of by incineration in incineration plants.

Used lubricant is any oil derived from crude oil or synthetic oil, used and contaminated by physical or chemical impurities as a result of such use. In other words, used oil is exactly what its name implies, i.e. it is any used petroleum-based lubricant or synthetic oil. In normal use, impurities such as dirt, metal particles, water or chemicals may mix in such a way that over time the lubricant cannot be used as intended.

Main trends of OSM utilization. Environmental safety problems of lubricant application are inseparable from recycling of WAS, which are currently one of the most common techno-genic waste, negatively affecting all environmental objects - atmosphere, soil and water. Only water pollution by waste oil accounts for 20% of the total techno-genic pollution, or 60% of oil product pollution. Here the main directions of solving the problem are considered and the most important technological processes for all types of OWW are described.

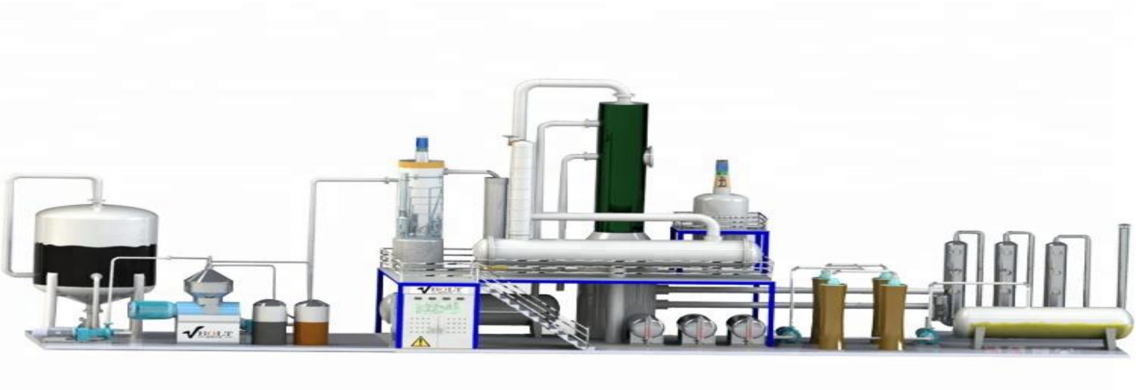

Fig.1. Recycled Plastic & Plastic Waste to Oil Market - Waste Oil to Base Oil Equipment

The necessity of recycling of WGW is not in doubt nowadays, because its burial and destruction (mainly by incineration) causes even greater environmental problems than WGW themselves and at considerable cost does not allow reuse of valuable secondary raw materials, which is not economically profitable. At the same time, it is very important that the recycling processes themselves do not pose a significant threat to the biosphere. As already noted, the most rational direction in solving today's environmental problems seems to be the practical implementation of the concept of pollution prevention, since the enormous cost of eliminating the resulting pollution and the inability to foresee and eliminate all its consequences fully justify the development of new, safer technologies and the creation of fundamentally new equipment.

As in the mainstream industries, in the recycling industry a growing number of specialists are arguing in favor of abandoning traditional methods of pollution control by installing cleaning equipment at the end of the process chain. The task of solving environmental problems in the production process, based on fundamentally new technological solutions, is being put forward. The ideal embodiment of this idea is the creation of industrial plants with minimal emissions.

Since the generation of waste in industrial production cannot be avoided, as it is impossible to avoid thermodynamically determined losses of substance and energy and to fully process raw materials into the desired products, the creation of such enterprises involves a system of technological processes that ensure the integrated use of raw materials and energy, where by-products and waste from one process are raw materials or reagents of another. Integrated recycling of raw materials involves capturing, separating and recycling all wastes into finished products or relatively environmentally sound substances suitable for safe disposal.

Integrated use of raw materials - the most complete, economically and environmentally justified use of all the useful components contained in the raw materials as well as in the production waste; this assumes the maximum output at each processing stage, which increases production efficiency and reduces waste generation.

The current term "waste-free or environmentally friendly technology" is therefore unlikely to be successful. Any technology is inherently and objectively opposed to the biosphere and therefore cannot but pose a threat to it (to a greater or lesser extent). The most appropriate term seems to be "low-waste technology" - a method of production in which the harmful environmental impact does not exceed the level permitted by sanitary and hygienic standards, where, for technical, economic, organizational or other reasons, some raw materials and materials are transferred to unused waste and sent for long-term storage or disposal.

The most important condition for the organization of low-waste production is the existence of a system for the neutralization of unused waste, especially toxic waste. In doing so, the impact of waste on the environment must not exceed the maximum permissible concentrations.

The following ways of creating low-waste technology are outlined:

1) Integrated processing of raw materials;

2) Development of fundamentally new processes and schemes for obtaining known products;

3) Design of drain less and closed loop water systems;

4) industrial waste recovery;

5) Development and creation of territorial-industrial complexes with a closed structure of material flows of raw materials and waste.

To sum up, mineral recycling, like any techno-genic system, cannot be a solution to environmental problems, because it requires the expenditure of energy and matter, the production and use of which in turn leads to pollution and degradation of the environment. The energy expended cannot be recycled; by disposing of one kind of waste, we create other kinds of waste, sometimes even more hazardous, and create new ecological problems. The solution, we repeat, lies only in the spiritual realm.

Let's move on to a specific consideration of the problem. Ecologically safe use of OSM implies their recycling with obtaining marketable products for various purposes (fuels, oils, lubricants, coolants, preservative materials, etc.).

The analysis of the current states of the question shows the fact that the problem isn't solved in theory as well as in practice. The exceptions are only some processing processes and directions and uses. However, there is an undoubted tendency to low-waste recycling of OSM around the world due to the growing number of environmental problems. In today's technical literature, different terms are used when considering OSM quality recovery cleaning, regeneration, recycling. It is therefore important to clearly distinguish the purpose and application of these processes.

By cleaning we mean continuous or periodic cleaning of the running lubricant in the operating equipment, which is carried out by means of settling tanks, filters, centrifuges and absorbers. This cleaning process does not always result in a product of the same quality as fresh lubricant. This is often not even required by the operating conditions. Such measures not only contribute to rational recycling of condensate, but also to increasing the lubricant's service life. Cleaning of running oils without draining the equipment is only possible with circulating lubrication systems for a number of motor, industrial and turbine oils and virtually all transformer oils.

The term "regeneration" refers to restoring the quality of used lubricant to that of fresh lubricant. It is used in relation to the cleaning of lubricants (mainly those containing no additives) which have previously been drained from equipment. In this process, the properties of the waste products are fully restored and they can be used again for their intended purpose. For regeneration, more complex physical and chemical processes such as coagulation, sulphuric acid and adsorption purification are used. Regeneration is often carried out on site when the lubricant is consumed.

In the case of recycling mixtures of different waste petroleum oils (PO) collected centrally from industrial plants, the term 'recycling' is used. These raw materials can be used to produce base oils of different compositions and purposes. Recycling is only feasible at large, specialized facilities and involves a combination of processes - vacuum distillation, extraction, hydro-treating and some other physical and chemical methods. OM lubricants are a major part of the solution to the problem. The industry of cleaning and regenerating used synthetic oils is also beginning to develop. A considerable number of experimental works are known to recycle waste greases, but their practical use is hampered by a number of factors.

The most important problem is the disposal of environmentally safe waste lubricants based on synthetic oils and natural fats. Western European countries are leading the way in recycling OSM and have developed a highly developed recycling industry.

A number of technological processes continue to improve, mainly due to the increasing legal requirements for the environmental properties of commercial products and for the protection of the natural environment. At the same time, since the beginning of the 1990s there has been a practical absence of new technology developments in the world - primarily in WM recycling, which is probably explained by the achieved stabilization of the techno-sphere in this area, i.e. the practical impossibility of creating fundamentally new schemes without radical upheavals or fundamentally new discoveries in fundamental science.

Some development of refining technologies is observed mainly for the purpose of decontamination of environmentally hazardous OSM components. The following oxidation products accumulate during the use of petroleum-based engine oils: asphalt-resin compounds, fouling, varnish deposits and then. To prevent these harmful compounds from precipitating, detergent-dispersant additives are added to the oils to keep the oxidation products in a colloidal (suspended) state.

A significant reduction in the performance of engine oils occurs when the additives have reached the end of their service life. During this period, oxidation products begin to accumulate and precipitate in various engine components, thereby causing increased engine wear. This condition indicates that the engine oil must be changed as a matter of urgency.

Due to its inherent viscosity, such oil adheres to everything from sand to birds' feathers. Used engine oil is insoluble, chemically stable and can contain toxic chemical compounds and heavy metals. Under natural conditions, oil takes a long time to decompose. Without the addition of additional contaminants in the form of soil and airborne dust, water, fuels, detergents and fluids of non-petroleum origin to the used oil, it can be used after cleaning and reconditioning in medium-powered internal combustion engines at moderate loads, in hydraulic systems of machines, in gearboxes and transmissions of tractors and vehicles at moderate loads, in chassis of crawler tractors as well as in preservation of machinery.

Modern technology makes it possible to obtain a volume of lubricating oil from one liter of waste oil that would take several tens of liters of crude oil to produce in direct production. The process of recovering used engine oil in the modern sense involves removing colloidal substances, acids, bituminous deposits, mechanical particles and chemical sludge from it, removing gases, water condensate, giving the recovered product its original color and odor. Oxidation products accumulate in oils during their use, contaminants and other impurities that drastically reduce the quality of oils.

Oils, which contain pollutants are unable to meet the requirements placed on them requirements and must be replaced by fresh oils. Used oils used oils are collected and regenerated in order to preserve the valuable raw materials, which is economically advantageous. The adsorbents used are substances of natural origin (bleaching clays and hyaluronic acid) produced from nature (bleaching clays, bauxites, natural zeolites) and artificially (silica gel) are used as adsorbents. The adsorbents are manufactured artificially (silica gel, aluminum oxide, alum-inosilicate compounds.

In the used oil filtration process, there is very little cleaning effect due to the presence of multifunctional additives which contain a detergent component. The oxide compounds, which are in a colloidal fine state under the influence of the additives, have to be somewhat increased in volume with the help of coagulants, then the oil becomes filterable. Studies have shown that optimal coagulation is achieved when monoethanolamide is used. The ultimate goal of regeneration is to obtain oils with characteristics superior to the original product that came in for regeneration.

This is possible, but in addition to the above-mentioned OM treatment steps, this requires chemical methods of regeneration, which involve the use of complex equipment and high costs. In reality, the purified OM have sufficient reserve of performance properties, providing use in less loaded units and assemblies of machines. Thus, all of the above shows that the quality of fuel and lubricants has a significant impact on the technical condition of machinery. Cleaning of operating oils and regeneration of waste oils. In terms of production and use, petroleum oils lead the way amongst lubricants. Production of petroleum oils continues to increase, which in turn contributes to an increase in waste oils.

All industrialized and most developing countries increasingly collect, treat, recover and recycle waste oils, which are estimated to account for about 50% of their fresh product consumption, with waste oils accounting for about 30% of all oil waste. On-site oil refining is one of the most cost-effective ways of using recycled resources and allows selection of the processes and process regimes most appropriate for the oil in question and its ageing products. Some experts believe that the ageing of the oil itself, especially with additives, has little effect on the service life of the oil.

The main problem is the ingress of foreign contaminants, the removal of which by mechanical cleaning is the most effective way of restoring quality. The cleaned oil is re-used for its intended purpose. This applies mainly to industrial, hydraulic, turbine and transformer oils, less often to motor oils, although this is the largest group of oils by volume of production. Among modern cleaning and regeneration methods, physical methods - settling, centrifugation, filtration and vacuum drying - predominate.

More sophisticated physical and chemical methods are also possible (in case of severe contamination or deep ageing of oils). Analysis of the state of OM regeneration in Russia and other CIS countries shows the predominance of mainly obsolete processes and imperfect technology. The oils produced in these processes. As a rule, they are of low quality. On the other hand, very efficient stationary and mobile units have been developed in recent years and their application is based mainly on physical cleaning methods.

The most effective equipment for physical cleaning and regeneration methods is produced by Alfa-Laval (Sweden), which is represented in 126 countries, by West German companies Westfalia and Montanus. With an annual consumption of 10 tons of oil, it is assumed that the capital investment in on-site cleaning and regeneration will pay for itself in full. This also applies to large lubrication systems with tank volumes of more than 0.75 m^3. However, cleaning and regeneration are not always possible for small consumers of lubricants. For smaller countries, centralized regeneration is most economical.

It must be kept in mind that for individual types of lubricants the values of the CTO collection resources vary greatly. For example, for motor oils they may be 20-40% and for transformer oils 80-90%. In most countries, collection of waste petroleum oils separately by grade is recognized as the most appropriate way to ensure more qualified recovery and recycling to produce high quality products with less waste.

On the other hand, according to EU requirements and legislation in many European countries, used oils are liquid or semi-fluid products consisting wholly or partly of petroleum or synthetic oils, oil residues from tanks; emulsions and mixtures of water and oil with at least 4% oil content, oil spills (from overflows, accidents, etc.) or with excessive storage time.

The terms liquid or semi-liquid imply the absence of crude oil, fuel oil and grease. The concepts fully and partially regulate the content of components in a mixture (petroleum and synthetic) from 100% to less than 20 mln-1, theoretically up to 1 mln-1. Among synthetic oils only hydrocarbons (mainly PAO), esters and ethers that do not complicate recycling are allowed in the blends to be collected. PAHs which are incompatible with petroleum oils are collected separately.

RESULTS AND DISCUSSION. This approach to solving the problem involves the use of flexible technologies that allow such mixtures to be recycled. The global collection of OM is about 15 million tons/year (less than 50% of fresh production), with the vast majority (70-90%) used as fuel. There is still a lack of centralized collection and disposal on a national scale in most countries, so the static data is very inconsistent.

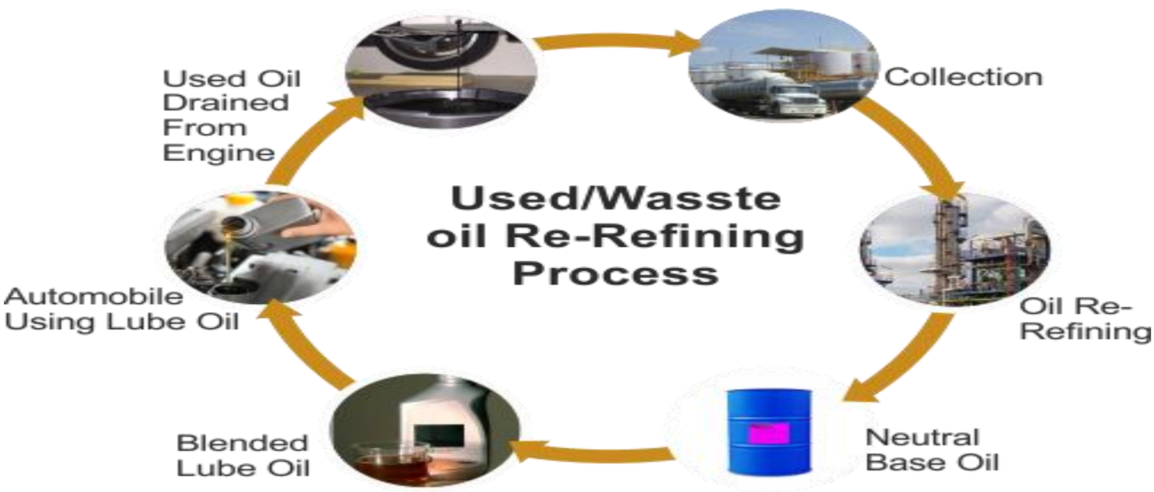

Fig. 2. Used and waste oil collection

In Europe, the figures are much higher. On collection is about 57% (1.6 million tons/year), use as fuel is 60%. There are currently three main areas in which WM is disposed of:

- recycling of blends with minor additions of synthetic oils and lubricants to produce base components;
- regeneration of OM separately by grades to produce products for the respective purpose. In this case the removal of ageing products and impurities is ensured without destroying and separating the additives, the missing amount of which is introduced in the final stage of the preparation of commercial oils;
- processing of OM mixtures or purification of individual products for the purpose of obtaining boiler, furnace fuel.

Secondary recycling. The largest volume of recycling is carried out in mixtures of WM, collected centrally at industrial enterprises. The main challenge here is the organization of raw material collection, which makes the published statistics sometimes very incomplete and even contradictory. Globally, the total share of recycled base oils apparently does not exceed 5% of fresh oils consumption, with Western European countries taking the lead. It is estimated that about 45% of the total consumption of petroleum oils in the European Union (1990-1995) is consumed or burned out in the process. About 2.8 million tons/year remain as OM, of which only 50-57% is centrally collected. Thus, even in Western Europe, some 1.2÷1.4 million tons/year of oil may either be illegally burned or simply released into the environment.

Of the 1.6 million tons of waste oil collected in Western Europe, more than 50% is used as fuel or "destroyed", with the rest going to recycling. The output of the latter is estimated to be around 470,000 tons, i.e. no more than 7% of the total oil demand. However, in the light of European legislation and the growing demand for environmentally friendly lubricants, this figure is expected to rise considerably in the near future. A large proportion of waste oils are engine oils containing mainly paraffin, naphthenic and aromatic hydrocarbons, additives, ageing products and metals. Among the latter the most important is lead which gets into oils as a result of the use of lead ant-knockers in fuels.

As a consequence of restricting the use of tetra-alkyl lead, lead content in waste oils has dropped from 1% in the late 1970s to 0.1% by the present day. However, lead content in waste oils on the order of 1000 ppm is already causing environmental problems. The bulk of the waste oil collected is incinerated or dumped on the ground. Only a small proportion is recycled, mainly for recycling (recycling) into fresh products. Among the various industrial recycling processes there are groups according to the main cleaning method: sulphuric acid, adsorption, hydro-treatment, extraction, thin film evaporation, ultrafiltration. The combined PROP process using the chemical method of OM demetallisation should be considered separately. Sulphur acid processes are at the forefront of the world in terms of the number of installations and the volume of raw materials processed. While the global volume of WM recycling exceeds 1.5 million t/year, sulphuric acid treatment accounts for 1.2 - 1.3 million t/year. There is a wide variety of sulphuric acid processes, among which the main ones are:

- acid-contact cleaning;
- Acid contact cleaning combined with atmospheric-vacuum cleaning distillation;
- the process of the French Institute of Petroleum (IFP);
- Matthys/Garap (France) process;
- processes with a heat treatment stage for raw materials;
- process by Meinken (Germany).

CONCLUSION. Thus, as the additive content in the oils increases, the consumption of acid and sorbents in acid-treatment increases. As a result, the amount of waste that is difficult to dispose of and environmentally hazardous increases. Moreover, sulphuric acid purification does not ensure removal of PA and highly toxic chlorine compounds from used oil. Modern environmentally compatible oils (vegetable and synthetic oils) cannot be processed by this scheme as sulphuric acid degrades them, increasing the yield of acidic tar in particular. In the CIS, sulphuric acid refining is hardly used at present.

In Germany a number of refineries use an improved combined scheme to process waste motor, industrial, turbine and transformer oils. The scheme implies the use of coagulation, atmospheric distillation, acid and adsorption purification stages, followed by vacuum distillation and contact refining of the high-viscosity component. According to experts, the design of new similar production facilities must take into account the increasing contamination of OM with surfactants while increasing the water content, which causes additional energy costs.

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