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EXPERIMENTAL RESEARCH OF WITHDRAWAL OF OIL REMAINS FROM THE USED "KOLLAN" OIL FILTERS

Yury Holik, Elena Ganoshenko

Poltava National Technical Yuriy Kondratiuk University
24, Pervomajskij Avenue, Poltava, 36011, Ukraine
golik38@in.ua, elena.ganoshenko@gmail.com

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Adstract. This article provides the results of research of withdrawal of oil remains as a valuable resource from the filter elements of used oil filters in order to reuse them. The possibility of effective utilization (recycling) of the used filter paper with reduced capacity of ambient air is also considered in the research.

Key words: Utilization (recycling), used oil filter, waste.

Introduction. Every year the amount of waste accumulated in proving grounds and landfills increases in Ukraine, which in its turn influences the state of the environment in cities and towns and has great impact on the nation health. Recent research has shown that a great amount of pollution and waste from manufacturing and transportation have a significant part in this phenomenon. The annual amount of industrial waste in Ukraine is approximately 200 million tons. Attention must be drawn to industrial and municipal solid waste as it is a potential raw material component. To generate the same amount of resources from natural sources such as minerals and fossils it is necessary to use much more financial, energy and human resources.

Identifying the problem. Many countries direct their efforts to environmental protection by developing and installing effective modern techniques to reuse and recycle industrial waste as valuable resource components. Motor transport waste is not an exception. Technologies for the utilization and recycling of car tires, batteries and motor oils have gained a great deal of interest and development from the point of view of environmental protection and resource saving activities.

A special niche has been acquired by waste car oil filters (WCOF) as the industrial waste of the 3rd class of danger – waste which according to the Ukrainian Standards Act demands definite utilization as it contains certain recyclable waste including car oil.

Article objectives formation. The objective of this article is experimental research of the withdrawal of oil remains from the filter paper of KOLAN type used car oil filters by previous flushing with detergent.

Presenting the main material. The development and research of processes and technologies for the utilization of the used equipment from motor vehicles and some of its elements are studied in many scientific works [1–8]. Furthermore, there is patented research concerning the development of methods and ways of improving technologies and utilization systems particularly in used oil filters especially with the possibility of their recycling. The studies and works by K. V. Shmidt, I. Bohtska, S. Levandovsky [9, 10], should be noted as they provide shredding of filters with either their successive combustion or cutting with washing in special solvents.

The way offered by Y. I. Babenko and V. I. Vlasov denotes cutting of filter body into a cowl and a base with further separation from inner elements of oil filter with the help of magnets [11].

G. A. Koltunov offers more thorough research of the recycling process in the used oil filters (WCOF). The special filter body is fastened with its cover which makes the process of filter sectioning and separation easier and creates a possibility of further usage of waste elements. They are sorted by suitability for their intended usage and then transferred to hydraulic and/or mechanical processing. The technical specifications control is perpetrated in such a way so that it would be possible to transfer suitable parts to assemble new oil filters and recycle and utilize unsuitable parts [12].

The most dangerous element is the filter paper of the used oil filter which doesn't just contain waste oil

but cannot be reused or utilized by any known method without harmful impact on the environment. It also cannot be transported to landfills for solid industrial waste. In most cases thermal waste disposal is used for its utilization in special furnaces and installations. Thermal disposal process is accompanied by formation of large amounts of pollutant substances, such as soot, solid unidentifiable particles, phenol formaldehyde resins, volatile organic compounds, etc. That is why from an engineering point of view as well as the concerns about the effective resource and energy conservation, it is advisable to prior separate the scavenge oil from filter paper in order to have significant ecological effect and reduce the impact on the environment.

In this regard, one of the most effective methods, which quickly allows the elimination of the negative impact from incineration of the used oil filter paper, is its preliminary processing (washing) with detergents. One necessary condition of using this method is assessment of the efficiency in withdrawal of the oil remains and also the use of effective but dangerous detergent.

For the experimental research of flushing withdrawal of the used filter paper from oil remains the following washing solutions and detergents were chosen (Table 1).

Table 1

No.	Composition of washing detergent	Chemical formula	Common name
	Baking soda	$NaHCO_3$ – acid salt of carbonic acid and sodium is fine crystalline white powder. Laundry detergent is a washing solution, which consists of three main components: substances, which control water hardness; sodium – dodecyl-benzol-sulfonate as a surfactant and bleach that is a powdery mixture with dry white components and added colored enzymes.	Baking soda, sodium bicarbonate. Laundry detergent
	Sodium carbonate and Hydrogen peroxide (sol. 35 %)	Na_2CO_3 – the water-soluble sodium salt of carbonic acid, colorless powder. H_2O_2 – hydrogen peroxide, binary compound of hydrogen and oxygen, colorless liquid.	Sodium carbonate, washing soda. Hydrogen peroxide
	Sodium percarbonate	$Na_2CO_3 \cdot 1{,}5\ H_2O_2$ – an adduct of sodium carbonate and hydrogen peroxide (a perhydrate). It is a colorless, crystalline, hygroscopic and water-soluble powder.	Oxygen bleach.

Research results. The experimental research of flushing the oil filter paper in different thermal conditions and using different solutions of washing detergents shows various kinds of results. The difference between the weight of the non-processed filter paper and its weight after the flushing, i.e. the effectiveness of the withdrawal of the used oil remains was used as the criteria of effective cleaning of the used oil.

The scheme of experimental stand (Fig. 1), is offered to reduce the impact on the environment and eliminate the amount of polluting substances, which are coming to the environment.

In Figure 1 "Test unit of oil products withdrawal from oiled filter paper of waste car oil filters consists of a tank for flushing the filter paper": 1. a guard; 2. a grid; 3. a mixer; 4. an electric motor; 5. a receiving pocket for waste oil; 6. a tank for preparing hot water; 7. a heater; 8. a tank for oil products storage; 9. a collection of used washing detergent; 10. a pump; 11. a centrifuge.

Fifteen filter elements of the used oil filter were taken for washing and processing by flushing with sodium and laundry detergent and then boiled. They were weighed before and after processing. Different solutions of washing detergent (25–75 gr) were used as well as different timing for the boiling process (5–30 minutes).

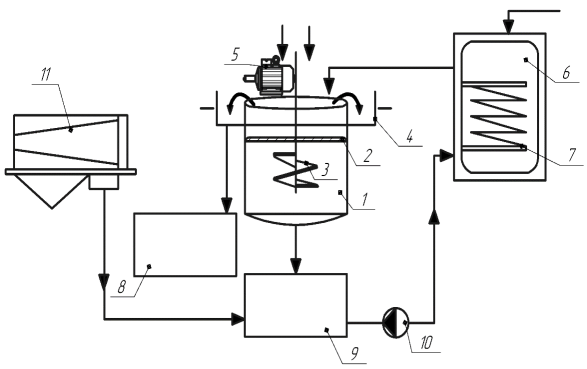

Fig. 1. Test unit of oil products withdrawal from oiled filter paper of waste car oil filters

Table 2

Results after flushing with sodium and laundry detergent with boiling process

No. of filter	Weight before washing m_1, gr	Weight after washing m_2, gr	Efficiency of filter material cleaning E, %
001	101	87	14
002	92	58	37
003	100	55	45
004	52	30	42
005	56	34	39
006	58	53	9
007	56	36	36
008	56	42	25
009	52	27	48
010	54	34	37
011	54	32	41
012	50	38	24
019	44	26	41
020	68	43	37
022	52	29	44

Efficiency of cleaning filter material was calculated by classical formula:

$$E = \frac{m_1 - m_2}{m_1} \cdot 100\ \%$$

where, m_1 – weight of the used filter paper before washing, gr; m_2 – weight of the used filter paper after washing, gr.

After boiling in such a way, the used oil is separated from the filter element quite well: the filter paper loses from 9 to 48 % of its weight.

The next method is processing of the used filter material with solution of sodium carbonate Na_2CO_3 and hydrogen peroxide (35 %) and water heated to 60–70 °C for dilution. Filter material is drowned into the heated solution and a great amount of oxygen is released. The "oil cap" rises as the used oil separates.

Oil becomes gelatinous and can be captured at the surface of the solution. The process of floatation (the bubbles of gas or the drops of oil stick to badly damped particles and raise them to the surface) of oil products on the solution surface happens because of the gas bubbles released during the reaction $2H_2O_2 \rightarrow 2H_2O+O_2\uparrow$. Foam is formed which collects the waste oil products. After their selection and sedimentation the solution is divided into 2 phases:

– Liquid (translucent);
– Suspension (dark-brown, oily, gelatinous).

The filter paper was dried and weighed after washing. The results are shown in Table 3.

Table 3

The results after washing with solution of sodium carbonate Na_2CO_3 and hydrogen peroxide (35 %)

No. of filter	Weigh before washing m_1, gr	Weigh after washing m_2, gr	Efficiency of filter material cleaning E, %
023	48	30	37,5
024	52	33	36,5
025	56	42	25
026	53	52	2
033	51	30	41
034	52	31	40
035	55	38	31
036	56	38	32
037	53	30	43
038	56	35	37,5

The research has shown the efficiency of washing filter paper with sufficient withdrawal of oil waste products. In addition, after the reaction with oxygen release, there are no impurities in the liquid, which are typical for the solution of the previous research. These are phosphates, surfactants, etc., which are characteristic for washing detergents.

The next method supposes using a washing detergent with Sodium bicarbonate. The filter paper of the used oil filters is washed using a floatation method resulting in the process of quick disintegration of hydrogen peroxide while adding it to the solution heated to 70 °C. The release of active oxygen occurs because it is a highly effective floatation agent. It brings up all the remained oil products to the surface of the solution as an "oil cap". In this case the following phases are preserved: washed used filter element – used washing detergent – oil product.

The filter paper was weighed after washing and drying and the results are shown in Table 4.

Table 4

The results after washing with detergent and sodium percarbonate

No. of filter	Weight before washing m_1, gr	Weight after washing m_2, gr	Efficiency of filter material cleaning E, %
027	52	34	35,6
028	50	29	42
029	63	30	52,4
030	54	32	41
031	64	41	36
032	53	30	43
039	51	28	45
044	53	28	47
051	62	30	51,6
052	61	28	54

As a result of the first experiment of washing filter paper there is the surfactant in the solution, which is oil emulsion with high content of oil products. It is hard to delaminate and difficult to utilize.

Processing of filter paper with the solution of Sodium percarbonate Na_2CO_3 and Hydrogen peroxide (sol. 35 %) and water heated to 60–70 °C for dilution has shown better results with higher efficiency of cleaning filter material. However, using such components is not very safe as the reaction is rather quick which prevents it from being controlled.

On the basis of experimental research, the most perspective peroxide compound for resolving the set problem turned out to be Sodium percarbonate $Na_2CO_3 \cdot 1{,}5\ H_2O_2$. This chemical compound is the safest and the most convenient substance containing hydrogen peroxide. In addition, the research of the used solution has taken place, which is formed as the result of physical and chemical cleaning of the used filter element. The content of oil product is 31 mgr/l.

The coordinate system, that demonstrates all three methods of the used oil filters processing, was chosen to summarize and present the results of the research. The time of washing the filter paper τ, min. was chosen as the output data. The results show the efficiency of cleaning filter material E, %.

As a result of processing data, the graph shows the comparison of the efficiency of washing solutions, which are presented in Fig. 2.

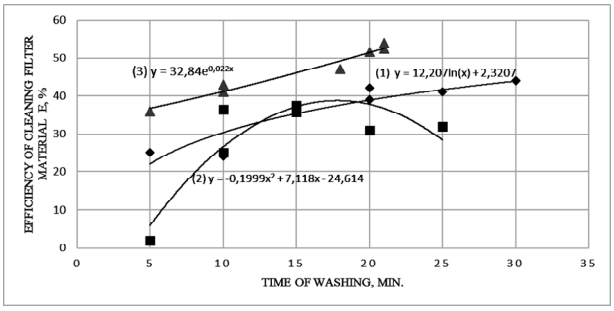

Fig. 2. Comparison of washing detergent efficiency (1) – Laundry detergent + baking soda (logarithmic); (2) – Hydrogen peroxide + Sodium carbonate (polynomial line); (3) – Sodium percarbonate (Exponential)

Filter elements of the used oil car filters preparation was conveyed for thermal utilization under the conditions of studying the process of filter paper burning after assertion, boiling and washing. It was done to experimentally define quantitative and qualitative structure of combustion products under different conditions of possible receiving of thermal energy.

Conclusion. Experimental studies have shown that the offered eco-friendly detergent, which does not contain surfactants, based on soda ash and peroxide, effectively withdraws oil remains from KOLAN type filter paper of the used car filters owing to creating the effect of flotation of the polluter on the solution surface. Generated waste car oil can be recycled or used in construction or road sectors. Concerning waste detergent, after processing it can be reused in reversible water system.

Therefore, preparation of reutilization using the above mentioned method of filtering elements of the used car oil filters enables the removal of valuable resource components and decreases their environmental damage.

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