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WASTE HIERARCHY CONCEPT IN RELATION WITH EUROPEAN AND WORLDWIDE USED LUBE OILS MANAGEMENT PRACTICES

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Abstract: *Benefits of waste lube oils management are well known. They impact the environment, the public health, and the economy. These aspects have different priorities of the same measures in managing this kind of waste. Consequently, different strategies for solving this problem have emerged in different parts of the world. This paper shows the data from literature management practices in various world regions related to waste hierarchy concept. It also shows insight into the situation in Serbia.*
Keywords: *waste lube oils management, stocks, environment, economy*

1. INTRODUCTION

Used lube oils is just a part of waste oil stream. From the environment and economy point of view it is the most important one. Other streams are: fuel tanks residues and sludge on the ships and on the land, contaminated fuels, emulsions, and water contaminated with different non biodegradable oil, waste food oils, etc.
Two major types of lube oils are: automotive and industrial lubricants. Industrial lube oils presents less than 30% of the collectable waste oils in EU. They are under better control, part of them can be re-used and recycling process can be done “on site” in some cases. Collecting of waste is much easier and with lower costs. It is a usual practices that supplier of lube oils are the collector of waste oils at the same time [1].
Automotive lube oils are mainly engine (motor or crankcase) oils and gear (transmission) oils.

Engine oils present the biggest single waste oil stream. It is also more specific and lower percentage of these used oils is recycled. Engine oils have shorter service interval (6-24 months) then gear ones (5-10 years) and the service fill is usually double. As a result more than 90% of the marketed automotive lubes are the engine oils [2,3].
Lube oils are mixtures of base stocks (oils) and additives. Most industrial oils contain no more than 5% additives whereas most motor oils contain up to 20–25% additives. Some of industrial lubes are pure base oils without additives [4].
Base oils are produced mainly from crude oil, even when they are synthetic ones. During the use, lube oils became dirty, but only additives are worn and the base oil remains almost same as new especially in the case of industrial oils. In the case of engine oils few percents of it could be (thermally) degraded. Contaminates of the combustion of fuel are present in used oil as well as heavy metals from depleted additives and wear. Thus, used (engine) oil is a hazardous waste [5].

The key difference in processing used oil to manufacture automotive oils, industrial oil and fuels is energy and processing severity. A more severe process is needed to produce

base oil for automotive use and this requires higher capital investment. Industrial oil processing is less severe.

2. WASTE HIERARCHY CONCEPT

Current EU waste policy is based on a concept known as the 'waste hierarchy', which classifies the different options for managing waste from 'best' to 'worst' from an environmental perspective: Prevention; re-use; recycling; recovery; and disposal [6].

Figure 1. Waste Hierarchy Concept [7]

Although the waste hierarchy should not be seen as a rigid rule, the aim of moving towards a recycling. In more general concept, the minimisation should be added between prevention and re-use but it can be treated as the part of prevention. It could be said that waste hierarchy in similar form is worldwide accepted. It is often called Resource Conservation Hierarchy [7].

Managing waste engine lube practice is extraordinary example of making compromises between different influences: technical and economy vs. environmental.
There is no big limitation from technical point of view but they exist. Engine oils are hard to re-use. Prevent the waste in the first place is possible to some extent. Recycling to meet all environment requirements is complex from technical side.
Economy is more difficult to go with this concept but fortunately it is not completely opposite. With some legislation assistant economy can be (and almost is) nearly equalized for all options in the concept. The biggest obstacles were interests of industries directly connected with the issue.

It is obvious then lube (oil) industry has not interest for extended oil drain intervals. It found its interest with more expensive synthetic oils which equalized smaller quantities of lubricants. But construction of engine was not ready for the possibilities of synthetic lubes. Low share of market for the synthetic oils was obvious till mid-90 in XX century. New ecological legislation gave the automakers difficult task to fitful them and they have lot of technical problems in 90's but after technical improvement in late '90s the pressure has moved on lubricant producers which has to adopt new formulations for the new requirements which also reduced the quantity of lubricant in vehicles. Oil industry, also, have no big interest in recycling waste engine oils. Virgin base oils are less expensive and recycled oils are not competitive with them. The quality of recycled base oils is much smaller problem, although is technically demanding one [8,9].

Legislation is important part of the waste oil management but can not solve the whole problem.
Same legislation often leads to different practice and results where EU is the best example.

3. PREVENTION AND MINIMISATION OF WASTE ENGINE OIL STREAM

Although possibilities exist and base for this option are very serious, it is not achieved as much as possible in this field. Theoretically, the quantity of waste engine oils per vehicle could be several times less, and the total quantity at least half of the one 20 years ago. But actually it was not happened. Over the period from 1995 to 2003 the total quantity of oil marketed/sold, in EU, decreased by 11% [6]. Since the number of cars raised from 230 million to 290 million (26%) [9], during that period the result is more significant.

Automakers achieve big improvements in better usage of engine (and gear) lubes during the last decade of XX century and in the first decade of the XXI. Long life oil drain intervals become very common. European car makers are extended drain intervals from average 7500 km (5000-10000 km) in 80's to 30000 km (20000 to 50000 km) nowadays. What's more, they reduced quantity of service fill for approx. 20% (from 5 to 4 liters). The transport vehicles have even more extension of the oil drain intervals (with similar service fill), typically from thirty thousand to 120 thousand km [10].
It gave conditions for 5 times less quantity of waste stream for the cars no older than 5 to 10 years theoretically but in the practice reduction was much smaller. However EU is obvious world leader in the minimisation of waste stream since there is no decrease in lube market in other regions of the world. North America has slow growth (less than 10%) in last decade [9] and Japan has a volume which has remained stable for the past decade [5,10]. On the other hand BRIC (Brazil, Russia, India, and China) has growth of 30% from 1998-2008 and now has ¼ of global consumption, same as Europe [6]. Europe is also leader in use of biolubricants, followed with Japan, even market share is still symbolic one, 2% in 1999, with estimates that would be 5% by 2010 [8]. Biolubricants would be the most important way for minimisation of waste oil (WO) as hazardous. Major obstacle for biolube growth is their higher prices.
The biggest improvement in the prevention can be achieved due the fact that almost 48% of total lube oils in 2006 are lost during use (evaporation, combustion) and through leakages [9]. It leaves plenty of room for improvement in minimisation of waste.

4. RECYCLING VS. INCLINATION (ENERGY RECOVERY)

Legislative framework for waste oils management at European level is:
Directive 75/439/EEC from 16. June 1975, followed by Directive 87/101/EEC from 22. December 1986 (amending Directive 75/439/EEC). Directive 2008/98/EC from 12/12/10 (as more general) repeals the Directives 75/439/EEC, 91/689/EEC and 2006/12/EC [8].
Serbian legislative is partly harmonized with the EU and is based on the "Zakon o upravljanju otpadom" ("Sl. glasnik RS", br. 36/2009 i 88/2010). Subordinate legislation is still in progress and should be completed in the next few years.

The directive 87/101/EEC gives regeneration priority over other disposal. However, some studies and practice itself shows different point of view and less rigid position about the priorities. "Combustion of used oils in cement kilns or in power plants under controlled conditions provides better, or at least, equivalent benefits in terms of crude oil and energy savings" [11]. The average WO collection rate reached about 70-75% in the E.U. and was stable during the period between 1994 and 2000. In 2003 collection rate was 81% [12,13].

Similar collection rate of about 75% had Canada. Japan and Brazil [14,15] virtually collect all used oil and are world leaders in this segment of WO management. In Serbia WO collection rate is only about 10%. The most of those 3000 tons was incinerated but percentage of recycled WO rising since end of the first decade of XXI century.

An average of 25% of the collectable WO (and 33% of the collected WO) would have entered a regeneration plant in the EU and two times more (50% and 67% respectively) of WO were energetically used in the E.U., in 1999. Uncollected WO (20-25% of collectable) is illegally burned or dumped in the environment; include sewage, where concentrations of 50 to 100 ppm of used oil can foul sewage treatment processes [16]. Waste oil management in USA shows different results with WO collection rate of 46.7% in 2000 and 47.9% in 2005 but with two-thirds of total collected WO recycled (32% of total waste generated where just 15,9% was incinerated) [13]. Problems are not just higher cost for WO recycle then for produce virgin base oils but also high investment cost for WO recovery plants. European WO regeneration industry is global leader and is constituted of about 28 plants; nearly 4000 people are employed in re-fining and in WO collection [9].

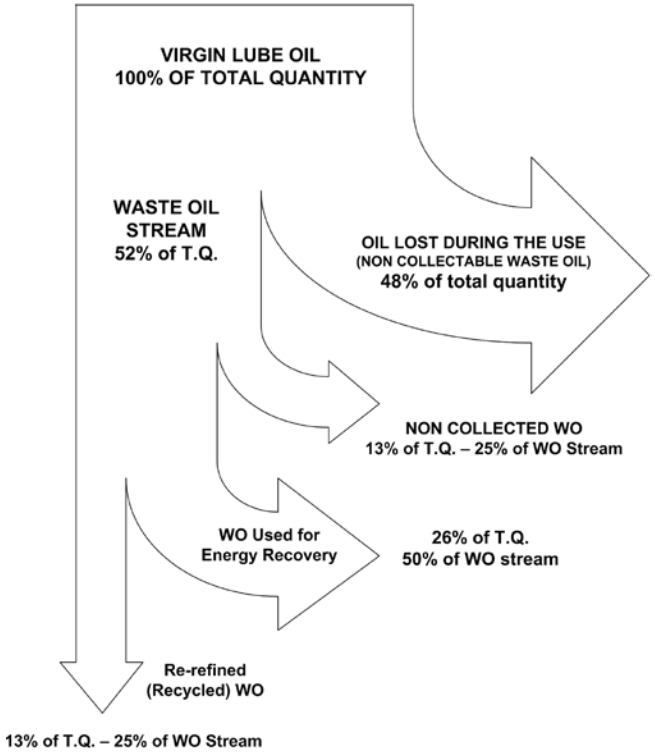

Figure 2. Distribution of lube oil in EU

Figure 2 shows the ways for improvements:

1) Main losses in the cycle are the waste during the use. Inappropriate handling, storage and operating procedures, is the leading problem that has to be solved by waste management in near future [16]. It is also important to make more rigorously standards and approvals for the lube oils in the terms of seals for lube oils and their better implementation.

Education of lube oil users is very important part of the process and not just regulations.

2) Collection rate could be higher as stated above. WO from 'Do-It-Yourself' (DIY) oil changes are less likely to be collected so the risk of improper disposal is higher [17]. Main issue in WO collection is its high costs.

3) The acceptance of re-refined oils in the marketplace is improving. It is significant for recycle rate which stagnate in many regions.

In Serbia a few companies have the plants. The first company with licence for WO recycling was "Ekosekund" d.o.o. Beograd, followed by "Delta" Company from Kladovo and Remol from Merošina (Niš) in process. Destilation or thin film evaporation are the main treatments. "Delta" Kladovo is the biggest recent investment in WO recycling (about 2 million euros) in Serbia. Greater significance is in fact that facility also processes other waste streams as: fuel tanks residues and sludge on the ships, contaminated fuels, emulsions and water contaminated with different non biodegradable oils. Oil Refinery Belgrade has old re-refining plant (from 1978.) with capacity of 22,000 tons per year which is about half of the used quantity in the country. Plant uses process of solvent extraction with propane and treatment with hydrogen. This is still the most advanced plant in the Serbia but unfortunately doesn't work continuous from economical reasons.
Although regeneration of used/waste oil can produce base oils of adequate quality, very severe and energy consuming re-refining processing needs to be employed to accomplish this. Quality of refined used oil is shown in the table 1 [17]. It is clear that recycled oil is comparable quality with fresh lube oil but it cannot be used for all purposes or even same for the top tier products.

Table 1. Results of tests using the various refining methods [17]

Parameter	Fresh lube oil	Used lube oil	Distillation /clay treatment	Acid / clay treatment	Acid treatment method	Activated charcoal / clay treatment
Water content v/v	< 0.20	13.70	0.66	0.40	0.60	0.47
Specific at gravity at 60°F	0.90	0.91	0.86	0.88	0.86	0.86
KV at 100°F (Cs)	82.20	61.60	84.10	82.00	84.20	80.20
Viscosity Index	92.80	21.10	85.80	88.90	84.40	86.80
Flash point °C	188.00	120.00	168.00	182.00	170.00	178.00
Pour point	-9.00	-35.00	-16.00	-11.00	-15.00	-13.00
Sulphur content	-	0.80	0.05	0.04	0.04	0.04
Iron (ppm)	-	22.50	10.30	2.60	10.50	9.50

The major disadvantage of the above conventional technologies, shown in the Table 1, is incomplete removal of heavy metals from waste oils.

European Petroleum Industry Association (Europia) believes that the re-refining processes should include, as a minimum, (a) thin film evaporation/vacuum distillation, plus either (b) severe hydrogenation/hydro cracking, or (c) solvent extraction, (a combination of both would be preferable) and hydro finishing as a finishing step [5]. It might be a point of view from the interests of the association; however, it is more or less confirmed in several other studies [9].
Practice shows, at least, that the controlled combustion is more economical method. From 2000 to 2004 price of WO increased by 120% to 80€ per ton in Germany [10] and exceed

100$ per ton in United States and used oil transport with re-refining operational cost are over 200$ per ton [15-17].

5. CONCLUSION

Waste oil management practice is fairly in line with waste hierarchy concept in EU but also worldwide. Main differences are in efficiency. Lot of improvements could be done. It is opinion that the easies one is the most important one. It gives opportunity for waste oil management system to make improvement with optimal resources usage. Stimulating of recycling and environmental restrictions on used oil combustion has given good results in EU and elsewhere. In all, recent worldwide activities relating to used oil management shows that the subject continues to be a controversial issue with many varied opinions.

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