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Energy Management by Recycling of Vehicle Waste Oil in Pakistan

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Abstract : ***Pakistan has been suffering from an energy crisis for about half a decade now. The power crisis is proving to be unbearable, so importing huge amount of hydrocarbons from abroad to meet its energy needs. This study therefore focuses on the analysis of energy and environmental benefits for vehicle waste lubricant oil pertaining to its reuse by means of: (i) regain the heating value of used oils in a combustion process and (ii) recycling of waste oil to make fresh oil products. The waste oil samples were tested by ICP method and the test results were compared with standard requirements. It was found that the matter could effectively be solved by means of waste oil management practices together with collection centers, transports and processors by encouraging and financial help for the recycling industry. The importance and worth of this work concludes minor levels of hazardous elements when regained the heating value from the waste lubricating oil.***

Keywords: Waste lubricating oil, Recycling, Energy management.

1. Introduction

Automotive used oil is generated from the transport sectors when oil loses its effectiveness during operation because unserviceable due to degradation of additives made it toxic chemicals [Klaman-1983]. The waste oil was estimated worldwide that than 45% collected and remaining 55% was either misused [Environment Oils Ltd., 2000] or improperly disposed off by the end user severely increase problem of waste discharge into the environment[Leak,D 1998].

In Pakistan the total waste lubricating oil was estimated in the year 2005 to 2006 was around 100,000 tons each year that is being disposed off improperly [Durrani et al 2008]. Pakistan also offers immense business and investment opportunities in automobile and this sector presently, contributes 16% to the manufacturing sector which also is expected to increase 25% in the next 7 years and car ownership in Pakistan has risen by 40% per annum since [Economic Survey of Pakistan 2010-11]. Waste lubricant oil creates environmental pollution if not disposed off properly, there is a possibility that other substance that it may contain, enter natural cycles through the food chain via water, soil and air. In this way waste lubricant oil pose risk to human health and impede the growth of plants and their ability to take up water as some times waste lubricant oil contained hydrocarbons, heavy metals polychlorinated biphnyls (PBCs) and other halogen compounds[M.El-Fadal et al., 2001].

To convert the harmful wastes into harmless substance, it is necessary to make it beneficial for reuse, recycling keeps oil out of our groundwater supplies, thus protecting drinking water resources. This hazardous waste oil needs proper management to make it useful as value added product and minimize the quality of oil being improperly disposed off [Dang,G.S,2006] and to protect the environment from this hazard and conserve energy resources [Mitsch and Jorgensen, 2003.2004].Waste lubricant oil can be reprocessed, reclaimed and regenerated into base oil by solvent extraction process produce adequate same of lube oils and restores to its original quality for re-use as lubricant.[Durrani et al 2009, 10, 11,12].One gallon (3.8 kg) of used oil can be re-refined into 2.3 kg of lubricating oil. For comparison, a 42-gallon (150 kg) barrel of crude oil typically contains only 1/2 gallon (1.9 kg) of lubricant-quality base oil [Lin and Mendelssohn, 1998].Similarly can also be reprocessed into fuel that can be used in furnaces for heat, or in power plants to generate electricity for homes, schools and businesses [American Petroleum Institute, www.recycleoil.org; Pawlak, 2003). In fact, 1 liter of waste lubricating oil contains about 8000 kJ of energy when reprocessed as fuel, contains about 8000 kJ of energy, which is sufficient energy to light a 100 W bulb for 1 day or to operate a 1000 W electric heater for 2 h. Also, while 67 liters of crude oil are needed to obtain 1 liter of motor oil, only 1.6 liter of waste oil are required to produce the same amount of motor oil (EPA, 1996).

The new lubricating base oil consists of heavy end distillate of crude oil, boiling range of 325–600 ◦C. It contains approximately 44% of straight and branch chain alkanes (primary C18 through C34, 29% of cycloalkanes, 22% of aromatics, 4.2% of total aromatics and 3.2% of total naphthalene). Major additive classes (10–20 vol%) include corrosion and rust inhibitors, antioxidants, emulsifiers,

detergents and dispersants, viscosity and color stabilizers, and anti-wear additives. The additives usually contain calcium, zinc, magnesium, molybdenum, phosphorus, sulfur and bromine compounds [Pawlak, 2003]. The waste lubricant oil handling and disposal of is an extensive source of environment degradation and ecological damage country's environment and these waste lubricants are: engine waste lubricants, transmission, brake fluids, hydraulic fluids, compressor oils, heat transfer fluids, synthetic oils, refrigeration oils, so special handling of waste lubricant oil requires a typical household hazardous waste such as paints, varnishes, pesticides, and many cleaning products.

1.1 Waste Oil specification

Waste lubricating oil that has a flash point less than 38 ˚C, dilution of contaminated used oil that contains PCBs or organic halogen compounds in excess of the maximum allowable concentrations prescribed in Table 1

Table 1.Used oil property and constituent limits.

Property/constituent	Maximum allowable level, ppm
Arsenic	5.0
Cadmium	2.0
Chromium	10.0
Lead	100.0
Sulfur	Variable, mostly 1.0%
Polychlorinated biphenyls (PCBs)a	Variable, mostly 2.0
Totalorganic halogensas chlorineb	1000 or 4000
Flash point	38 ◦C

a "Polychlorinated biphenyls" or "PCBs" means chlorobiphenyls that have the molecular formula C12H10−nCln in which "n" is greater than 2.

b "Organic halogen compound" means an organic chemical compound in which one or more halogen elements are incorporated. (ATSDR, 1997; Magiera et al., 2003).

Pakistan Environmental Protection Act [1997] and three state of USA (California Massachusetts, and Rhode Island) have classified waste lubricant oil as a hazardous waste [Pawlak et al., 2010] as it contains a high concentration of heavy metals and poses a serious risk to human health and impede the growth of plants and . Each state has adapted the federal EPA used oil management rules in Title 40 of the Code of Federal Regulations (CFR), part 279 and additional state used oil management requirements [Padma et al., 2004]. The combustion conditions in most cement kilns can provide the safe incineration conditions for PCBs at a temperature exceeding 1200 ◦C and the residence time of 4 sec. Under federal regulations, used oil or fuel produced from used oil exceeding the limits set by US EPA can be burned for energy recovery only in industrial and utility boilers, industrial furnaces, hazard waste incinerators, and used oil-fired space heaters that meet specified provisions [CFR, section 279.11].

This paper will discuss how to regain the heating value of waste lubricant oil and the waste lubricant oil samples tests and results compare with standards requirements using the ICP-AES technique.

2. Oil Samples collection and analysis

Waste lubricating oil samples collected around 25 locations that includes vehicle maintenance garages gasoline and petrol pumps. These samples were analyzed in petroleum refinery laboratory, Institute of Petroleum and Natural Gas Engineering, Mehran University of Engineering and Technology, Jamshoro, Pakistan and Hydrocarbon Development Institute of Pakistan to find out the concentrations of the contaminants. Since the vehicle maintenance garages are the largest generation area of waste lubricant oil, so the majority waste lubricant oil samples were collected from these locations.

2.1 Waste Lubricant Oil Analysis Results

Waste lubricant oil samples analysis results are listed in Table 2. The contaminants in waste lubricating oil have been compared to the contaminants in the virgin lubricant oil. The only metal zinc was revealed in significant amount in the virgin lubricating oil that is because of additive. In waste lubricating oil Barium, chromium, cadmium and lead appear in higher concentrations due to its use in the engine. In table.1 no remarkable differences found in sulfur contents among the various oil types. No sufficient quantities of arsenic and beryllium were present in the virgin oils or waste lubricant oil for reliable measurement. For all samples minimum limit of the analytical equipment was set 5ppm but no PCBs were detected.

Table 2 :Average analytical results of waste oil samples

Contaminant	Gasoline engine oil	Diesel engine oil	Virgin engine oil	Fuel oil
Arsenic (ppm)1	--	--	--	--
Barium (ppm)	2.72	3.37	<1.00	<1.00
Beryllium (ppm)	<0.02	<0.02	<0.02	<0.02
Cadmium (ppm)	<1.50	2.33	<0.25	<0.25
Chromium (ppm)	3.18	3.90	<2.00	<2.00
Lead (ppm)	47.22	57.01	<20.00	<10.00
Flash point (0F)	>200	>200	>200	>200
Sulfur (% w/w)	0.35	0.24	0.36	0.12
PCBs (ppm)	< 5	<5	<5	<5
Total halogens ppm)	<348	<233	<300	<200
Total organic halogens (ppm)	<300	<216	<292	<200

1. Due to analytical difficulties and accuracy determining, arsenic concentrations are not reported.

In this case two oil samples were selected and analysis result shows that individual sample exceeded the other constituent standard was lead and for HWMR limit oil samples exceeded 100ppm but not the 200ppm APCR limit. The limit found would be considered in compliance, so waste lubricant oil would not be banned from being burned. Contaminants in the individual samples ranged as follows: barium<1.0 ppm to 6.9 ppm; chromium <2.0 ppm to 6.8 ppm; cadmium<0.25 ppm to 6.6 ppm;; lead<20 ppm to 146 ppm;; halogens <200 ppm to 877 ppm.

3. Materials and Methods

Waste lubricant oil samples collected were diluted with xylene followed by nitric acid (HNO_3) extraction to determine low levels of several elements like igneous rocks, sedimentary rocks, and sediments, must be dissolved and digested as inductively coupled plasma-atomic emission spectrometry (ICP-AES) requires a sample to be in solution. ICP provides low detection limits, measuring at very low (ultra trace) concentration, utilizes an inductively coupled plasma source to de-solvate, atomize, and excite or ionize the sample. Oil samples were digested with xylene and nitric acid using hot block digestion because the block digestion systems is best option to accommodate large sample numbers under controlled conditions. The standard method 6010 (U.S.SW-846, 1986) was used prepared samples in a nitric acid matrix, as specified in method. The instrument performance was evaluated by detection limit (DL) for the metals. The results of method reported level (MRL) values are (ppm): arsenic 0.49, cadmium 0.5, chromium 0.05, lead 0.31. During the analysis, several QC checks were performed to ensure that the ICP spectrometer was operating properly.

4. Results and discussion

In Pakistan, management of waste lubricant oil is important because it is generated in large quantities. The data collected from the dealers of the used oil divulged that 95 %of oil changes occur either in repair shops/garages and 5% in service stations. Generated oil disposed off 5% land fill, 10% goes in sewers and 25% used in sub-standard re-fining and grease making and 60% burns in sugar mills, cement factories, furnaces and low pressure boilers etc shown in figure 1.

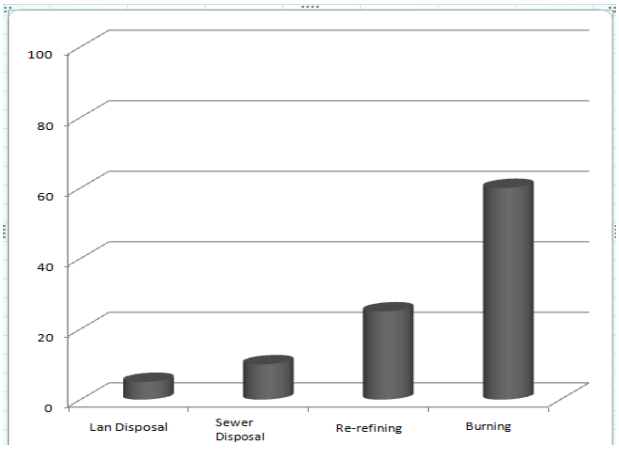

Figure 01. Sisposal of vehicle waste oil in Pakistan

When comparing the test results shown in table 2 oil samples were analyzed for total metal content and halogens with the regulatory limit shown in table 1. The results show that almost all the samples have better regulatory limit like as cadmium around <1.5 ppm in gasoline waste lubricant oil and 2.33 ppm in waste diesel lubricant oil, where as regulatory limit 2.0 ppm. The excellent condition found with chromium 3.18 in gasoline waste lubricant oil and 3.90 in diesel waste lubricant oil that is lower the regulatory limit of 10ppm. As far as lead is concerned that found much lower than the regulatory limit, this is due to the change of unleaded gasoline standard in 1996. The lead concentrations determined in samples collected shown in Table 2 are much lower than those reported in earlier studies (in the 1980s and 1990s) in Table 3 [Vermont Agency, 1996] due to the change of unleaded gasoline standard in 1996. Lead blended with gasoline from early 1920s, where as EPA started work in 1973 to reduce lead emission.

Lead has been blended with gasoline since the early 1920s.The EPA began working to reduce lead emission in 1973, gradually to one tenth of a gram per gallon by 1986. The average lead content in gasoline in 1973 was 2–3 g per gallon, or about 200,000 tonnes of lead per year [ATSDR, 1997].

The corrosivity, ignitability, toxicity and reactivity are the hazardous characteristics of waste lubricant oil that render waste oil hazardous, so waste oil should not exhibit it. Table 2 shows that waste lubricant oil contain polychlorinated biphenyls (PCBs) at a concentration at or below 5 parts per million (ppm) and also halogens (e.g., compounds containing chlorine, bromine, and fluorine) below 1000 ppm. Used oil containing more than 1000 ppm halogens is presumed to be mixed with halogenated hazardous wastes and must be managed as such, unless the generator of the waste can demonstrate otherwise [Vermont Agency of

Natural Resources, 1996]. Table 3 shows the distinct decrease in barium, chromium, lead and halogens content for used engine oils for the last two decades.

In Pakistan, until now, no proper waste lubricant oil collection management system available and no government policy exist for collection and public awareness for its environment impacts. Oil collection system is purely carried out by private parties. Collectors collect the waste lubricant oil from the repair garages, workshops, commercial fleet operators, shade trees mechanics, service stations and quick lube centers and sale to the middle man, who further sales to end user. People involved in collection of waste lubrication oil mostly suffer from gastro-intestinal upsets, irritation of skin and eyes. Pakistan is not manufacturing standard lubricant oil from the waste lubricant oil, only at small scale sub-standard oil is produced mostly used in two wheelers and three wheelers two stroke autos and water pumps.

Table 3 : Concentration of potential hazardous heavy metals, total halogens in used oils burned as a fuel in the 1980s and 1990s in the United States [Vermont Agency,1996].

Analyte	Mean concentration (ppm) in the 1980s	Concentration range (ppm) in the 1990s	Virgin fuel oil (ppm)
Arsenic	20	Not analyzed	0.06
Barium	137	1–7	13
Cadmium	4.0	0.3–7	1.0
Chromium	38	2–7	4.1
Lead	555	20–146	4.1
Zinc	707	570–2370	2.0
Halogens	5500	100–440	5.7–7.8

5. Conclusions

The main objective of the study was energy and environmental requirements of waste lubricant oil that deal the heating value in the combustion process and re-refining of waste lubricant. The results show that almost all the samples have better regulatory limit. In Pakistan approximately 60% of this amount is burned and 25% is re-refined and 15% lost to the environment. The proper waste oil collection would make the 15% useable. The oil collection and oil lost to the environment in Pakistan is shown graphically in Figure 1. It shows that Pakistan is not more advance in the area of recycling and reused as recycling would have two to three times a great processing capacity.

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