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Regeneration of Used Lube Oil by using Solvent Extraction Method

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Abstract: *Regenerated or recycle of oil is economical process and reduce the environmental pollution produce from the used lube oil. Regenerated of used oil with solvent extraction shows the yield up to 90 % which is more than the oil regenerated from the different acid. In the solvent extraction we need separate column for solvent recovery. The major benefit of solvent extraction process gives higher yield and high quality product compares with acid treatment process and also reduce the sludge generation problem that produce by acid method. That will be reduce the degree and nature of contamination, environmental/health risks associated with disposal. With help of Activated charcoal/alumina or silica gel can removes the color and various impurities presents in the recycled used oil by using different acids. The major drawback to the acid/clay method is difficulty of removal of clay sludge. MEK are 62%, 68% and 72% at feed to solvent ration 1:2, 1:4 and 1:6 settling time 24 hr., extraction 30-40 mins at temperature of 35-45 OC. As per analysis the optimum feed to solvent ration will be 1:4 in which yield of oil and its properties are satisfactory for further use of oil. As per analysis with MEK solvent regenerated oil gives highest yield or recovery of lube oil from waste oil. As per analysis the optimum feed to solvent ration will be 1:4 in which yield of oil and its properties are satisfactory for further use of oil. Solvent extraction process cost reducing, less sludge producing and high yield process. All there solvents have better yield and high recoverability by simple distillation process. By experimental analysis it's clear that the solvent extraction process for regeneration of lube oil is easy, simple, cost effective and low sludge producing. Additionally use of alumina or silica gel are beneficial for removal of impurities and color from regenerated oil.*

Keywords: Used Lube Oil Regeneration, Solvent Extraction, MEK, Silica or Alumina Gel

I. INTRODUCTION

The lubricating oil acts as a lubricating medium for various automobile parts such as engines and gearboxes. The primary function of lubricating oil is to reduce friction and to provide a heat transfer medium. It also inhibits corrosion and carries away the metal wear parts. The lubricating oil itself doesn't undergo any changes after use but it gets dirty due the addition of combustion products, degraded additives, water and other dust particles during its time inside the engine. The dirt added to the lubricating oil can be obviated and the oil can be restored to its original state. At present the used oil is disposed by pouring into ground, water bodies or used as fuel leading to serious environmental problems. The refining of used oil can produce a valuable resource which is wasted and turn increases the need to drill for more crude oil. The crude oil contains more impurities than used oil and production of lubricating oil from crude oil is much costlier than refining of used oil. In automobiles lubricating oils are changed for every 5000 kilometers. During the time of oil inside the engine properties of the lubricating oil such as viscosity, specific gravity, flash point, pour point , gets reduced due to the continuous addition of heat. The additive gets degraded and form of sludge along with metal wear parts. Water goes into the oil as a result of combustion and finally oil becomes unfit for use in engines and needs replacement. Additives are added in sequential process and the properties of final lubricating oil determine. The properties are then compared with the standards provided by the Society of Automotive Engineers (SAE) to determine reliability of using re-refined oils in automobile engines. With the large amount of engine oils used disposal of lubricating oils has now become a major problem. Dirt's and metal parts worn out from the surfaces are deposited into the lubricating oils. With increased time of uses lubricating oil loses its lubricating properties as a result of over-

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reduction of desired properties. Typically lubricants contain 90 % base oil and less than 10 % additives. Waste lubricating oil is generated from transport sectors when loses its effectiveness during operation because it degrades after a time of use becomes contaminated and creates a serious pollution problem. When it is burnt as a low grade fuel it causes air pollution. Re-refining of waste oil elimination of pollution.

1.1 Function of Oil

1. Lubricant, i.e. form a fluid film between highly loaded moving parts.
2. Act as a coolant to remove frictional heat generated both within and outside of machine.
3. Receive and carry away and contaminants arising from internal and external sources.
4. Act as a hydraulic medium in many applications.
5. Protect against wear of highly loaded parts, when the fluid film is very thin.
6. Protect against rust and corrosion of precision parts made of various metals.
7. Resist aeration and foaming which can cause malfunctions.

1.2 Sources of Lube Oil Contamination

1. The breakdown of the additives and their subsequent reaction.
2. Soot and lead from engine blowby.
3. Dirt and dust metal particles from engine wear.
4. Residual gasoline or diesel fuels from incomplete combustion.
5. Water from combustion and blowby vapors.
6. Water from rain water and Salt water ingress.
7. Boiler Industry and Oil Furnaces.

II. LITERATURE REVIEWS

In June 2013, by the experimental analysis Undone J.D and Bakare O.A, prove that the three acids use effectively activated and remove the slug from the used Lubricating oil and return the oil to it quality form. Clay samples possess high adsorption properties which enabled the removal of impurities and the black color from the lubricating oil. From results obtained Sulphuric acid yields 90 % while Nitric acid yield 70 % to 80 %. Nitric acid can used in place of Sulphuric acid and proved to yield about 75% and cost less to obtain used oil. This process reduce degree and nature of contamination, environmental and health risks associated with disposal. As per analysis of different tests flash point, cloud point, pour point, viscosity index, Sulphur content and water content. [1].

Methyl Ethyl Ketone (MEK) is a selective aromatic solvent employed in the solvent extraction process. Oil fraction obtained by distillation is mixed by agitation with MEK in the ratio 2:1. The lubricating oil and solvent mixture is allowed to settle in separation flask for four hours. Aromatic content and degraded additives present in lubricating oil fraction settle at bottom and lubricating oil fraction and solvent mixture layer forms at top. Bottom layer is similar to residue obtained in distillation and the top layer of lubricating oil and solvent mixture is subjected to atmospheric distillation. Atmospheric distillation is carried out at a temperature of $80^{O}C$ which is the boiling point of MEK. MEK vapor produced is condensed and again used as a solvent by blending with the fresh solvent. Lubricating oil produced at this stage similar to that of base lubricating oil. [2]. **As per experimental study solvent extraction process can** be used to recover quality base oil with 94 % yield from used lubricating oil. Yield is higher than thin film distillation/clay treatment (70 - 80 %)and Some modifications of thin film claimed 90-95 % oil recovery but these processes are expensive and require skilled operations. Solvent extraction of used oil can be carried out at ambient temperature with cheap and low boiling point solvent MEK. Sludge from process can mix with asphalt without any problem. Solvent extraction process better than traditional acid/clay treatment which produces acidic sludge. Due to low boiling point and low cost MEK preferred over 1-butanol.[4].

In March 2015, Experimental studied by Merai Yash P proved that Methyl Ethyl Ketone (MEK) is a selective aromatic solvent employed in solvent extraction process. Oil is heated to 130 ^{O}C in a closed vessel to boil off emulsified water and some of the fuel diluents. Lubricating oil and solvent mixture is allowed to settle in separator tank. Lubricating oil fraction will settle at the bottom and the lubricating oil fraction and solvent mixture layer forms at the

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top. Solvent mixture is again subjected to atmospheric distillation. The atmospheric distillation is carried out at temperature of around 80 ^{O}C which is boiling point of MEK. MEK vapor produced condensed and again use as solvent. [5].

Solvent extraction process for recycling of used lubricating engine oil. Three solvents: 1-butanol, 2-propanol and mixtures of 1-butanol-ethanol considered. Solvent used to segregate impurities in form of sludge at different extraction factors considered. Performances of solvents determination by Percent Sludge Removal (PSR) and Percent Oil Loss (POL). POL decreased with extraction temperature and increase in SOR can improve reduction in POL. Butanol least POL at extraction temperature 45^{O}C at follow by propanol and mixture of butanol and ethanol. Maximum PSR at butanol as solvent at extraction temperature 45 ^{O}C and50 ^{O}C PSR 11.4 and 11.9 respectively at SOR 6:1 and contact time of 30 minutes. POL continued to drop between SOR 2:1 and 2.8:1. The optimum PSR and POL obtained at solvent to oil (SOR) ratio 3:1. extraction temperature 45 ^{O}C with contact time 30 Min. The increase in amount of PSR was gradual at solvent to oil ratio (SOR). [7]

Re-refining of waste lubricating oil by solvent extraction is one of potential techniques. Advantages of solvent extraction technique practically offers from environmental and economic points. Selection of composite solvent and technique to upgrade used lubricant oil into base oil. Composite solvent 2-propanol, 1-butanol and butanone two alcohols that make binary system is effective. Performance of composite solvent in the extraction process for recovering waste lubricating oil. Using composite solvent 25% 2-propanol, 37% 1-butanol and 38% butanone by a solvent to oil ratio of 6:1.Excellent oil recovery by extraction obtained using solvent to oil ratio 6:1 are ash reduction and 68% oil recovery and removal sludge from the waste oils. [8]

Waste lubricating oil collected from different service stations and local vehicles repair workshops/ garages. Collected oil mixed in single container. After settling, oil sample (Woil) mixed with solvent (Wsol) in a conical flask. Collected oil dehydrated at 200^{O}C under vacuum pressure (600mmHg), cold and then mixed with a composite solvent (2-propanol, 1-butanol and butanone) of different proportion at various solvent oil ratios and mixture stirred for 15 minutes. Sedimentation is a process where particles or system of particles under the action of gravity settles out from suspension fluid. Tubes filled with solvent (25% 2-propanol, 37% 1-butanol and 38% butanone) used the solvent oil ratio 6:1 proportions. Agitated in inverted tubes 30 times to promote flocculation by velocity gradients. Height of settling measured every 30 seconds from the front scale that almost finished within 30 minutes time. Sedimentation take place at 1cm in 30 minutes time. Optimum solvent mixture 25% 2-propanol, 35% 1-butanol and 40% butanone suitable solvent composition use with Iraqi waste lubricating oil recovery 80% [8]

Solvent used and mixing ratio applied for different runs shown significant effects on yield of recovered oil. A Maximum yield of 72% obtained for Rubia Tir 7400 using 2-Propanol solvent and mixing ratio of 6:1, whereas minimum recovery yield of 55% was obtained using n-Butanol and 4:1 mixing ratio. For Quartz 20W-50 a maximum yield of 73.4 obtained using 2-Propanol solvent and mixing ratio of 6:1 whereas minimum recovery yield of 50 % obtained using n Butanol and 4:1 mixing ratio. [9].

For design batch process for re-refining of used lubricating oils using composite solvent technique. Composite solvent includes 1-Butanol, 2-propanol and Methyl Ethyl ketone ratio of 2:1:1. Composite solvent observed to have more advantages over traditional singular acidic, basic and alcoholic solvents. Solvent to oil ratio taken is 3:1 which is the optimum ratio considering cost and other factors. Process found to be cost effective and efficient with a recovery of 75.6% with 95% solvent recovery. Comparison of various solvents done with composite solvent and recovery of oil obtain. Batch process for composite solvent extraction designed and cost estimation carried out. [10].

III. EXPERIMENTAL ANALYSIS

3.1 Regeneration of Used Oil by using Solvent Extraction

A. Raw Materials

1. Used Lube Oil
2. MEK (Methyl Ethyl Ketone – B.P 79.9 ^{O}C.)
3. Activated Charcoal/Alumina or Silica Gel

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B. Equipment's

1. Separating Funnel
2. Simple Distillation Apparatus
3. Filter Cloth
4. Magnetic Stirrer with hot plate
5. Measuring Cylinder
6. Thermometers
7. Beakers
8. Conical Flask

3.2 Steps for Recovery or Regeneration of Lube Oil

1. **Filtration:** Take 1L used lubricating Oil and Filter it by using filter cloth to remove impurities such as sand, metal chips, micro impurities that contaminated lube oil.
2. **Dehydration of Used Lube Oil:** Pre-treatment of the oil involved removal of solid particles by gravity settling. Used lube oil heated at 120-140 ^{O}C and atmospheric pressure for 1 hour to remove residual free and emulsified water.
3. **Choice of Solvent:** The choice was due to the difficulties in recovery of this solvent again that results in great lose in solvent which leads to high cost. The MEK low boiling point and low cost and the solvent was of analytical grade. The dehydrated oil was subjected to solvent extraction at 35-45 ^{O}C and atmospheric pressure.
4. **Mixing:** Take solvent to Used Lube Oil ratio 2:1, 4:1, 6:1 and mixed it in used lube oil by continuous stirring up to 30 min. The extraction of dehydrated oil by MEK, 1-Butanol and 2-Propanol solvent to oil ratio lower than 6:1 leads to dissolution of some contaminants forming material which was considered to be undesirable.
5. **Extraction:** Take mixture of oil and solvent in the separating funnel and allowed to settle for 24 hrs. After settling shows the two separate phases one containing oil-solvent phase md another containing impurities or sludge. Sludge removed from bottom of separating funnel and after that oil-solvent phase removed.
6. **Effect of Settling Time:** Amount of sludge removal increases by increasing settling time. Rate of settling was maximum during initial 12 hours. However it continued up to 24 hours. Impurities aggregate and form sludge which sediments out.
7. **Separation of Oil from Solvent by Distillation:** The solvent was as the MEK can recovered by distillation B.P. 80 ^{O}C. Solvent removed from the top of distillation column which is condensed in condenser and can be recycle for extraction. Oil to be recover from the bottom of distillation column. Similarly butanol and propanol can be separated at their B.P.
8. **Removal of Color and Impurities:** With the help of Alumina/silica gel/activated charcoal some impurities and color can be removed from the regenerated oil. Calculate the yield of oil and also calculating the various properties of oil like density, Specific gravity and Viscosity of Oil.

3.3 Experimental Process for Solvent Extraction Using MEK

1. Used lubricating engine oil (W) collected from motor vehicle service stations.
2. Pre-treatment of oil to removal of solid particles by filter cloth or gravity settling.
3. The oil heated at 120-140 ^{O}C and atmospheric pressure for 1 hour to remove residual free and emulsified water.
4. Transfer sample in beaker and wait 1-2 hrs. for settling of solid particles at bottom.
5. Take 200 ml oil sample from beaker and mixed with 400 ml MEK (solvent to oil ratio 1:2) and mixed it in used lube oil by continuous stirring up to 30-40 min maintain a constant temperature at 35- 45 ^{O}C.
6. Transfer the mixture in separating funnel and allowed to stand for 24 hours.
7. The extract phase and wet sludge will be form.
8. The same procedure carried out for used lube oil to solvent to ratio 1:4 and 1:6.
9. Remove sludge from bottom and then extract phase from separating funnel.

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10. Transfer the mixture of oil and solvent (Extract Phase) in distillation column where maintain constant temperature of 80 ^{O}C for recovery of solvent MEK. (B.P. 79.9 ^{O}C)
11. Take regenerated 1:1.5 ratio of oil and Alumina/silica gel/activated charcoal some impurities and color can be removed from the regenerated oil.

IV. RESULTS AND DISCUSSION

4.1 Analysis of Various Properties of Regenerated Lube oil

1. **Density of Oil:** Density of a substance is equal to the mass of a substance divided by the volume of the substance. The temperature at which the density is been measured must be known for density changes as temperature changes.

   Density = Mass of oil / Volume of oil
2. **Specific Gravity:** Specific gravity is the ratio of the density of the material to density of the equal volume of water. Specific gravity can be calculated by using specific gravity bottle.
3. **Viscosity:** A decrease in the viscosity of engine oil indicates that the oil is contaminated. Lubrication oils are identified by the Society of Automotive Engineers (SAE) number. The greater or higher the SAE viscosity number and the heavier or more viscous the lubricating oil. Viscosity is defined as the force acting on a unit area where the velocity gradient is equal at a given density of the fluid. Viscosity is strongly depending on the temperature. As the temperature increase viscosity decrease. Viscosity can calculated using viscometer.
4. **% Yield of Regenerated Used Oil:** Yield of oil that produce from the used oil is depends on the value or amount of used oil feed. Yield of oil can be calculated by using amount of oil produce from the used lube oil and total amount of oil and sludge produce after dehydration of the both sludge and oil. With dehydration water removal from the oil and sludge.
5. **% Yield of oil:** % Yield of oil = [Weight of Oil Produce / Total Weight (Sludge + Oil Produce)] * 100
   % Yield (Recovery) by using feed to Solvent ratio 1:2= 62
   % Yield (Recovery) by using feed to Solvent ratio 1:4= 68
   % Yield (Recovery) by using feed to Solvent ratio 1:6= 72

4.2 Properties of Fresh and Used Oil

Sr. No.	Properties	Fresh Oil (4T-20W40)	Used Lube Oil
01	Density (Kg/m^3)	950	860
02	Viscosity @ 40 ^{O}C(cP)	58	32
03	Specific Gravity	0.95	0.860

Table: Properties of Fresh and Used Oil

% Yield of Regenerated Oil

Oil Feed to Solvent	% Yield (Recovery) with MEK	Density (Kg/m^3)	Viscosity @40^{o}C(cp)
1:2	60-62	870	48
1:4	65-68	850	52
1:6	70-72	830	56

Table: % Yield of Regenerated Oil

4.3 Need of Waste Oil Recycling

1. Improper used oil disposal is simply a waste of a valuable resource.
2. Every gallon of used motor oil not recovered results in the need to drill for more oil.
3. Most of the crude petroleum produced special hydrocarbon chains for motor oil.
4. Lube base oil can be recovered and 'regenerated' to the quality equal to original form.
5. Certain types of waste oils and lubricants can be reprocessed for their direct reuse.
6. Use of waste oils after treatment can be as lube base stock comparable to refined oil.
7. For minimization of pollution and protect environment.

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8. Protection of human health and animal from used oil pollution.
9. Recycling can complete 50% need of lube oil.
10. 10.With the recycling process can reduce the cost of lube oil.

4.4 Environmental Pollution

1. The contaminants in waste oil have adverse environmental and health impacts.
2. The presence of degraded additives and contaminants more toxic and harmful to health.
3. By-products of degradation render waste oils more toxic and harmful to health.
4. If put into storm water drains or sewers they can affect waterways and coastal waters.
5. When dumped in soil or sent to landfill they can migrate into ground and surface waters.
6. Uncontrolled used oils threat to plant and animal life which result in economic losses.
7. Used oil from internal combustion engines accumulates a variety of contaminants.

V. SCOPE AND BENEFITS

1. With Recycle or Reuse of oil can reduce the cost of oil.
2. This process reduce the environmental pollution produce due to used oil that directly mixed with soil and water.
3. Recycle can produce the oil which id equal or better than the virgin oil.
4. Recycle is cost saving and beneficial process which produce the low sludge.
5. Recycle helps to complete the demands of lube oil supply.
6. Recycling or reuse of the used lube oil helps to reduce pollution and cost of oil.
7. As per the feature need this process are economical and ecofriendly.
8. The use of this method has increased in developed countries reaching up to 50% of the country's need for lubricating oil.
9. Recycling and re-refining of waste into virgin lubricating oil may be a suitable option for protecting the environment from hazardous waste.
10. Recycling process prevent ground water contamination and pollution.
11. Recycling process reduce sewage treatment cost.

VI. CONCLUSION

Regenerated of used oil with solvent extraction shows the extraction yield up to 90% which is more than the oil regenerated from the different acid. In the solvent extraction we need separate column for solvent recovery. But according to Yield and the quality of regenerated oil is better than the acid treated used oil. Selected solvent has lower B. P. hence, it can easily separate and can recycle to the system. Solvent treated process produce less sludge comparative with acid treated process. MEK are best selected solvents use for the extraction of lube oil from waste oil. Regeneration of oil is the best method for reduction pollution and cost of lube oil. That will be reduce the degree and nature of contamination, environmental/health risks associated with disposal. With help of Activated charcoal we can removes the various impurities presents in the recycled used oil by using different acids. The major drawback to the acid/clay method is the difficulty of removal of the clay sludge. The alumina/Silica gel are used for removal of color and impurities from regenerated oil. By experimental analysis maximum extraction yield with solvent MEK are 62%, 68% and 72% at feed to solvent ration 1:2, 1:4 and 1:6 settling time 24 hr., extraction 30-40 mins at temperature of 35-45 ^{O}C. As per analysis the optimum feed to solvent ration will be 1:4 in which yield of oil and its properties are satisfactory for further use of oil.

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