

PROCESS AND SYSTEM FOR REGENERATION OF SPENT LUBRICATION OIL

Field of the Invention

[0001] The present invention generally relates to the disposal of spent lubrication oil, and more particularly to processes and systems for regeneration of spent lubrication oil into multiple fractions including base oil by employing rectification and multi-stage molecular distillations.

Background of the Invention

[0002] The refinery process of crude oil produces a fraction of oil that is suitable for lubricating purposes, called base oil. In practice, the base oil is obtained and separated into fractions in the vacuum distillation column which is fed by the residue of an atmospheric column. Generally, only about 3-5% of the crude oil is suitable for being used as base oil. Due to various viscosity requirements for different lubricating purposes, the base oil must not be either too volatile or too viscous.

[0003] As its term suggests, the base oil is used as the base for formulating lubrication oil. To improve the quality of the lubrication oil are added multiple additives. The additives include antioxidants, detergents, dispersing additives without ash, antiwear additives, additives improving the Viscosity Index, additives for lowering the pour point, antirust and anticorrosion additives, and antifoam additives.

[0004] Industries use many types of lubrication oils including engine lubrication oil, hydraulic oil, transformer oil, turbine oil, compressor oil, marine oil, and the like. After lubrication oils reach their usage life span, they are disposed as spent lubrication oil (waste oil).

[0005] Spent lubrication oils from various sources or applications have different characteristics and contain a cohort of contaminants. When lubrication oil is used, it is being contaminated by extraneous contaminants introduced from the surrounding air and the engine. Contaminants from the air include dust, dirt, and moisture; and air itself may be considered as a contaminant since it might cause foaming of the oil. The contaminants from the engine include the metallic particles resulting from wear of the engine, the

carbonaceous particles due to incomplete fuel combustion, the metallic oxides present as corrosion products of metals, the water from leakage of the cooling system, the water as a product of fuel combustion, and fuel or fuel additives or their byproducts, which might enter the crankcase of engines.

[0006] During lubrication oil usage are formed many matters causing the deterioration of the lubrication oil. The examples of the formed matters include sludge, lacquer, and oil-soluble products. Sludge denotes a mixture of oil, water, dust, dirt, and carbon particles that result from the incomplete combustion of the fuels. Sludge may deposit on various parts of the engine or remain in colloidal dispersion in the oil. Lacquer refers to a hard or gummy substance that deposits on engine parts as a result of subjecting sludge in the oil to high temperature operation. Oil-soluble products generated by oil oxidation remain in the oil, cannot be filtered out, and deposit on the engine parts. The quantity and distribution of engine deposits vary widely depending on the conditions at which the engine is operated. At low crankcase temperatures, carbonaceous deposits originate mainly from incomplete combustion products of the fuel and not from lubrication oil. In contrast, at high temperature, the increase in lacquer and sludge deposits may be caused by lubrication oil.

[0007] The properties of lubrication oil are affected by any contaminants that may occur during operation. For example, water even in small amounts causes rusting of iron or steel. The water also results in forming water sludge (emulsions) which may clog oil passages, pump valves and other oil handling equipment, contributes to foaming problems, and lowers the electricity insulation property of lubrication oil. Furthermore, solid particles such as dirt, dust, grit and metallic fragments cause excessive wear, scoring of bearing surface, and possible failure due to seizing of metal fatigue. In addition, sludge deposits clog small oil passages and clearances; lacquers or varnish cause sticking of valves, and resist against the continuous operation of oil pump. Finally, liquid contaminants such as unburned fuel from engines dilute lubrication oil and possibly reduce their viscosity beyond a safe load. Contamination of the lubrication oil with heavier oil increases viscosity and interferes with the oil circulation, affecting the lubricating valve and heat transfer capacity.

[0008] Current methods for treating spent lubrication oil include processing into fuel oil by simple processing and blending, acid treatment, conventional distillation,

solvent extraction, and ultrafiltration. Problems arising from acid treatment include environmental issues associated with the disposal of acid sludge and spent earth, low product yield (45–65%) and incomplete removal of metals, especially lead. For conventional distillation the main problems encountered are plugging of the lines, fractionators and furnace tubes due to formation of a resinous material that fouls the equipment, cracking of molecular due to high distillation temperature, polymerization to form solid substance. The conventional distillation process does not improve the dark color of the products. Solvent extraction process has the problems of high operating cost, complexity of process and generation of secondary waste, e.g. waste solvent and waste water. Ultrafiltration is still in experimental stage; main problem encountered is the fouling of membranes and incapability to manage the flash point of the products.

Summary of the Invention

[0009] One embodiment of the present invention provides a process for treatment of spent lubrication oil. The process comprises the steps of pretreating the spent lubrication oil, rectifying the pre-treated spent lubrication oil to recover a light diesel fraction from the spent lubrication oil, resulting in reduced or eliminated interference in subsequent molecular distillation caused by the light diesel fraction, and performing multi-stage molecular distillations of the rectified spent lubrication oil to recover multi-grades of base oil, thereby the recovered light diesel fraction and base oils are obtained for further use, and the remaining of the spent lubrication oil is discharged.

[0010] In another embodiment of the process, the step of pretreating includes operations of sedimentation and precipitation to remove large particles or contaminants, centrifuge to remove particles and free water, vacuum for dehydration and deodorization, and/or application of chemicals for enhancements.

[0011] In another embodiment of the process, in the step of rectifying the recovered light diesel fraction includes petrol, light diesel or some hydrocarbon substance.

[0012] In another embodiment of the process, in the step of performing multi-stage molecular distillation, the molecular distillation is preferably performed in two or three stages.

[0013] In another embodiment of the process, in the step of performing multi-stage molecular distillation the performance is determined by operation temperature, pressure and distance between a condenser surface and evaporator surface.

[0014] In another embodiment of the process, in the step of performing multi-stage molecular distillation the operation temperature is increased sequentially in a series of molecular distillation, and the operation pressure is decreased sequentially in the series of molecular distillation.

[0015] Another embodiment of the present invention provides a system for regeneration of spent lubrication oil. The system comprises a pretreatment unit for pretreating the spent lubrication oil, a rectification unit fluidly coupled with the pretreatment unit, for rectifying the pre-treated spent lubrication oil to recover a light diesel fraction from the spent lubrication oil, resulting in reduced or eliminated interference in subsequent molecular distillation caused by the light diesel fraction, and a multi-stage molecular distillation unit fluidly coupled with the rectification unit, for performing multi-stage molecular distillations of the rectified spent lubrication oil to recover multi-grades of base oil, thereby the recovered light diesel fraction and base oils are obtained for further use, and the remaining of the spent lubrication oil is discharged.

[0016] In another embodiment of the system, the pretreatment unit is configured to perform operations of sedimentation and precipitation to remove large particles or contaminants, centrifuge to remove particles and free water, vacuum for dehydration and deodorization, and/or application of chemicals for enhancements.

[0017] In another embodiment of the system, the recovered light diesel fraction includes petrol, light diesel or some hydrocarbon substance.

[0018] In another embodiment of the system, the multi-stage molecular distillation unit is preferably configured to perform two or three stages of molecular distillation.

[0019] In another embodiment of the system, in the multi-stage molecular distillation unit the operation temperature is increased sequentially in a series of molecular distillation, and the operation pressure is decreased sequentially in the series of molecular distillation.

[0020] In another embodiment of the system, the multi-stage molecular distillation unit comprises a plurality of molecular distillation stage, where each of the plurality of molecular distillation stage comprises a molecular distillation column having a material

inlet that is located at the top of the column and connected to a material feeding pump for receiving the spent lubrication oil to be treated, where the molecular distillation column has a heating means configured to evenly heat up the molecular distillation column, a vacuum means coupled with the molecular distillation column to provide high vacuum within the molecular distillation column, and a condensing means disposed within the molecular distillation column for condensing the desired fraction of distillate.

[0021] One advantage of the present invention is the production of multi-grade base oils from a single process with a multi-stage molecular distillation design. This maximizes the value of recycled product and provides great flexibility in lubrication product manufacturing.

[0022] The objectives and other advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0023] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0024] FIG 1 is a functional block flowchart of the process for regeneration of spent lubrication oil in accordance with one embodiment of the present invention.

[0025] FIG 2 shows a schematic block diagram of the system for regeneration of spent lubrication oil in accordance with one embodiment of the present invention.

[0026] FIG 3 shows an exemplary cross-section view of the molecular distillation column in accordance with one embodiment of the present invention.

Detailed Description of the Invention

[0027] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0028] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties,

into this application in order to more fully describe the state of art to which this invention pertains.

[0029] While the description will relate to many specific elements and techniques in order to better illustrate the principles of the present invention, it is to be appreciated that the present invention is not limited to the specific descriptions. The present invention can be practiced with variations to any specific elements and techniques without departing from the principles of the present invention. At the same time, many details and specifics that their omissions will not affect the practices of the present invention will be omitted from the description in order not to obscure the principles of the present invention.

[0030] One aspect of the present invention provides a process for treatment of spent lubrication oil. Briefly, the process comprises pre-treatment of the spent lubrication oil, rectification of the pre-treated spent lubrication oil, and multi-stage molecular distillation of the rectified spent lubrication oil. As explained in detail hereinafter, the integration of the rectification operation into the regeneration process provides a prerequisite for the optimal performance of the molecular distillation, resulting in high rate recovery and high quality of the regenerated base oils.

[0031] Now referring to FIG 1, there is provided a process for regeneration of spent lubrication oil in accordance with one embodiment of the present invention. The process **100** comprises waste oil pretreatments **1**, rectification **2**, 1st stage molecular distillation **3**, 2nd stage molecular distillation **4**, 3rd stage molecular distillation **5**, and disposal of final residue oil **6**. It is to be appreciated that the process for regeneration of waste oil of the present invention is not limited to the three stages of molecular distillation; it can have two stages, or more stages depending upon the requirements of the qualities of the regenerated base oils.

[0032] The pretreatments **1** include any suitable means or operations that is needed to get the un-pretreated waste oil into a condition where the waste oil is ready for rectification and molecular distillation. The pretreatments **1** include sedimentation and precipitation to remove large particles or contaminants, centrifuge to remove particles and free water, vacuum system for dehydration and deodorization, and application of chemicals for enhancements.

[0033] The rectification **2** separates the light diesel fraction **21** from the waste oil, where the light diesel fraction includes petrol, light diesel or some hydrocarbon substance

depending upon the composition of the waste oil. The inventors of the present invention discovered that un-rectified waste oil was not suitable for molecular distillation because the existence in the waste oil of the light diesel fraction that is very volatile and non-stable affects/destroys the high and stable vacuum required for optimal molecular distillation, resulting in poor quality of the regenerated base oils. Without wish to be bound by any particular theory or explanation, it is believed that the light diesel fraction creates turbulence so as to affect/destroy the high and stable vacuum condition in the molecular distillation. Rectification column is commonly used to remove mixed volatile hydrocarbon substances and is therefore more suitable in doing this job.

[0034] The 1st stage molecular distillation **3** regenerates the first fraction base oil (base oil grade A **31**). Molecular distillation (short path distillation) is characterized by short exposure of the distilled liquid to elevated temperatures, high vacuum in the distillation space, and small distance between the condenser surface and evaporator surface; thus the operation temperature and pressure are the critical parameters for optimal molecular distillations. In addition, the distance from the evaporation surface and condensing surface is also one of the important design parameters. The short residence of the liquid on the evaporating cylinder, in the order of a few seconds to 1 min, is guaranteed by distributing the liquid in the form of a uniform thin film. By reducing the pressure of non-condensable gas in the evaporator to lower than 0-10 Pa, a reduction in distillation temperatures can be obtained. Molecular distillation shows promise in the separation, purification and concentration of natural products, usually composed of complex and thermally sensitive molecules. The base oil grade A **31** is usually the lightest fraction of the regenerated base oils.

[0035] The 2nd stage molecular distillation **4** regenerates the second fraction of the base oils (base oil grade B **41**). Depending on the quality and composition of waste oil and the demand for different grades of base oil, the multi-stage molecular distillation employs two or more molecular distillation columns that are configured in series to generate different grades of base oil by operating each stage under different working conditions. Principly, in a multi-stage molecular distillation, a prior stage uses lower operation temperature than a subsequent stage; e.g., 1st stage molecular distillation operates at a temperature of 200°C, and 2nd stage molecular distillation at a temperature of 240°C. Therefore, the fraction of base oil from the prior column is lighter and ready to be used,

and the residue waste oil is further treated in the subsequent column. In this manner, the base oil recovered can be fractioned into different grades.

[0036] The 3rd stage molecular distillation **5** regenerates the final fraction of the base oils (base oil grade C **51**) and final residue oil **6**. The final residue oil **6** after the multi-stage molecular distillation is then transferred into a residue tank for proper disposal. The base oil grade C **51** is the heaviest fraction of the regenerated base oils. The 3rd stage molecular distillation **5** operates at the highest temperature. During the process, the operation pressure is decreased sequentially, which also means that the operation vacuum requirement is higher sequentially.

[0037] The advantage of multi-stage molecular distillation process is that relative highly pure base oil can be produced as product. The impurities and contaminants that exist initially in the waste oil are concentrated and retained in the residue and discharged from the system at the end of the treatment. A range of different grades of base oils with different properties, e.g. viscosity, flash point, are produced from the system.

[0038] In the multi-stage molecular distillation, the number of molecular distillation stages is preferably from 2 to 5. More preferably, 2 or 3 stages of molecular distillations are used in spent lubrication oil treatment.

[0039] The operating conditions of each molecular distillation column, e.g. temperature, vacuum pressure, material residential time, are determined basing on the targeted distillation fraction requirement.

[0040] Another aspect of the present invention provides a system for regeneration of spent lubrication oil. Briefly, the system comprises a pretreatment unit, a rectification unit, and a multi-stage molecular distillation unit. The pretreatment unit functions to remove large precipitates and odor from the waste oil so that the pretreated waste oil is suitable for rectification. The rectification unit is fluidly coupled with the pretreatment unit to receive the pretreated waste oil, and functions to separate a light diesel fraction from the waste oil so that the rectified waste oil is suitable for molecular distillation. The multi-stage molecular distillation unit is fluidly coupled with the rectification unit and has two or more molecular distillation columns that are so configured to operate in a sequential manner, where each molecular distillation column operates at a different temperature, pressure or material residential time; thereby each molecular distillation column functions to separate a fraction of base oil with a characteristic specification. In order to save the

cost, each molecular distillation column could be the same for the convenience of manufacture and installation. It is also possible that each molecular distillation column has its own configuration so that they can operate at different conditions for producing different base oils.

[0041] Now referring to FIG 2, there is provided a schematic block diagram of the system for spent lubrication oil regeneration in accordance with one embodiment of the present invention. It is to be noted that the pretreatment unit is not shown in the system **200** of FIG 2, and that the molecular distillation unit has three molecular distillation columns. All of these details are shown for the only purpose of illustrating the principles of the present invention.

[0042] The composition of the waste oil is still very complicated even after of pretreatment processes like dehydration and deodorization. The light diesel fraction is removed with the rectification process to decrease the flash point of the waste oil, and at the same improve the efficiency of vacuum system for the following molecular distillation process. The main component in the waste oil is base oil that can be extracted and fractionated into different grades using a series of molecular distillation columns. In the early stage of molecular distillation, lower distillation temperature is carried out. The base oil distillate is the lighter fraction of all base oils. It has lower viscosity and lower flash point. The intermediate stages of molecular distillation use higher distillation temperatures. The base oil distillates from intermediate stages are with intermediate viscosities and flash points. The last stages of molecular distillation use highest operation temperatures and produce heavy fractions of base oil with high viscosities and high flash points.

[0043] The residue waste oil from the upper stage of molecular distillation column is used as feed material for the next stage of molecular distillation column. In the way of series connection, all grades of base oil are extracted according to the design parameters. The final residue is discharged for disposal.

[0044] The present invention operates under highly vacuum conditions (0.1Pa-80Pa) at the designated temperature. It is able to produce different grades of base oil basing on the difference in molecular free length that is ultimate determined by the molecular weight. The present invention has the advantages of efficient liquid thin film forming, avoiding liquid stuck on distillation surface, short residential time of liquid in the

reactor, low distillation temperature and high distillation efficiency. At the same time, the vacuum system further remove trace amount of very light substance that may has leak through the rectification process. It also serves as an enhanced deodorization process. The present invention avoids problems like thermal cracking, polymerization, carbonization and equipment chocking that are commonly encountered in conventional distillation process. The recovery rate of base oil is normally above 85%. It does not generate secondary pollutions, e.g. waste acid, wastewater, acidic residue.

[0045] Molecular distillation under low temperature and high vacuum is not only able to distillate more efficiently but also to better preserve the quality of the base oil products. It also has better energy efficiency. The system for regeneration of spent lubrication oil is controlled by an auto-control system, which will further enhance the smooth operation of the system.

[0046] Now referring to FIG 2, the exemplary molecular distillation column **DZ101** has a material inlet that is located at the top of the column and connected to the material feeding pump **P103** for receiving the waste oil to be treated. Trace amount of lighter than the targeted distillate fraction substance is extracted from an outlet located on the top of the molecular distillation column **DZ101** and is captured by a vapor trap. The heating medium is connected to the heating blanket of the molecular portion of the column. The vacuum system is connected to the vacuum valve located at the lower portion of the molecular distillation column. The cooling water is connected through the inlet valve and outlet valves located at the bottom of the column. The targeted distillate fraction and the residue waste oil are connected to the effluent pumps through outlet valves.

[0047] Now referring to FIG 3, there is provided an exemplary cross-section view of the molecular distillation column in accordance with one embodiment of the present invention. The molecular distillation column comprises an outer heating means **301** for controlling the temperature within the molecular distillation column, a plurality (e.g., 4) of film forming devices **302** disposed onto the inner surface of the heating means **301** for spreading the waste oil so as to cause the waste oil to form a film **305** onto the inner surface of the heating means, a condensing core **303** in conjunction with an arc **304** to be configured to form a structure for condensing the evaporated waste oil fraction to produce different base oil grades. The materials for making each component of the molecular distillation column are apparent for one skilled in the art.

[0048] The pre-treated waste oil is drawn by the feeding pump to 1st stage molecular distillation column. The waste oil is spread evenly by a spreader to form a uniform thin film on the evaporation surface in the molecular distillation column. The targeted fraction of base oil is distilled and condensed by the condensing core and flow through the fractionate outlet to the semi-product tank. Trace amount of lighter than the targeted distillate fraction substance is drawn with the vacuum system to the distillate vapor trap integrated with the vacuum system. The remaining liquid on the evaporation surface flows is the residue waste oil and flows through the residue outlet and is pumped to the next stage. The process is repeated for each molecular distillation column until the required stages of processing are achieved.

[0049] The following examples are provided for the sole purpose of illustrating the principles of the present invention; they are by no means intended to limit the scope of the present invention.

[0050] Example 1

[0051] Example 1 of the regeneration of spent lubrication oil will be described in connection with the system **200** with three stages of molecular distillations as shown in FIG 2.

[0052] After pretreatments with dehydration and deodorization, the pre-treated waste oil in the storage tank **V101** was pumped by the pump **P102** to the rectification column **RC101** to remove the light diesel fraction, where the light diesel vapor was condensed by the condenser **EX101** and transferred to the storage tank **V102** and further transferred for any suitable purpose by the pump **P101**. **(please provide conditions for rectification; even it is a conventional operation, it is better to include our conditions)**

[0053] The residue waste oil after rectification treatment was pumped by the pump **P103** to the 1st stage molecular distillation **DZ101**. The 1st stage molecular distillation was operated at the temperature of 200°C and the vacuum of 80Pa, where the distillation range was 370 - 450°C, and the product recovery rate was 27%. The flash point and viscosity specifications of the product are compliance with MVI 100 base oil specifications. In operation, the distillate from molecular **DZ101** was condensed by the condensing core of **DZ101** and was transferred to the storage tank **V103** from which the fraction was pumped out by the pump **P104** as base oil 1. The specifications of the base oil 1 and its comparison with MVI 100 base oil are summarized below in Table 1. Any trace amount of very light

fraction was extracted by the vacuum system, and condensed and trapped by **EX102**. The residue waste oil was transferred into the storage tank **V104**.

[0054] The residue waste oil after the 1st stage molecular distillation was then transferred to the 2nd stage molecular distillation **DZ102** by the pump **P105**. The 2nd stage molecular distillation was operated at the temperature of 240°C and the vacuum of 5 Pa, where the distillation range was 450 – 500 °C, and the product recovery rate was 46%. The viscosity and flash point specifications of the product are in compliance with MVI 250 base oil specifications. In operation, the distillate from the 2nd stage molecular distillation **DZ102** was condensed by the condensing core of **DZ102** and as transferred into the storage tank **V105** from which the fraction was pumped out by the pump **P106** as base oil 2. The specifications of the base oil 2 and its comparison with MVI 250 base oil are summarized below in Table 2. Any trace amount of very light fraction was extracted by the vacuum system, and condensed and trapped by **EX103**. The residue waste oil was transferred into the storage tank **V106**.

[0055] The residue waste oil after the 2nd stage molecular distillation was then transferred to the 3rd stage molecular distillation **DZ103** by the pump **P107**. The 3rd stage molecular distillation was operated at the temperature of 330°C and the vacuum of 3 Pa, where the distillation range was 500 – 540 °C, and the product recovery rate was 19%. The viscosity and flash point specifications of the product are in compliance with MVI 350 base oil specifications. In operation, the distillate from the 3rd stage molecular distillation **DZ103** was condensed by the condensing core of **DZ103** and as transferred into the storage tank **V107** from which the fraction was pumped out by the pump **P108** as base oil 3. The specifications of the base oil 3 and its comparison with MVI 350 base oil are summarized below in Table 3. Any trace amount of very light fraction was extracted by the vacuum system, and condensed and trapped by **EX104**. The residue waste oil was transferred into the storage tank **V108**.

[0056] The final residue from the 3rd stage of molecular distillation column **DZ103** was discharged by the pump **P109**. The quantity of final residue was about 7.8%.

[0057] Table 1. The comparison of the specifications of the base oil 1 from the 1st stage of molecular distillation column **DZ101** with that of MVI 100.

[0058]

Item	Product from 1 st stage	MVI 100	Testing Method
Appearance	Yellowish, transparent	Transparent	Visual
Smell	Insignificant	-	Smell
Viscosity (40°C)/(mm ² .s ⁻¹)/CST	20.7	18 - 21	ASTM D445
Viscosity (100°C)/(mm ² .s ⁻¹)/CST	4.17	-	ASTM D445
Viscosity Index	108	≥60	ASTM D2270
Flash point (°C)	195	≥165	ASTM D93
Pour point (°C)	-16	≤-9	ASTM D97
Moisture content (%)	Not detectable	-	ASTM D95
Acid number/(mg KOH/g)	0.01	≤0.05	ASTM D974
Carbon residue /%	-	-	ASTM D189

[0059] Table 1. The comparison of the specifications of the base oil 2 from the 2nd stage of molecular distillation column **DZ102** with that of MVI 250.

[0060]

Item	Product from 2 nd stage	MVI 250	Testing Method
Appearance	Yellowish, transparent	Transparent	Visual
Smell	Insignificant	-	Smell
Viscosity (40°C)/(mm ² .s ⁻¹)/CST	43.64	42 - 55	ASTM D445
Viscosity (100°C)/(mm ² .s ⁻¹)/CST	6.5	-	ASTM D445
Viscosity Index	98	≥60	ASTM D2270
Flash point (°C)	224	≥190	ASTM D93
Pour point (°C)	-14	≤-9	ASTM D97
Moisture content (%)	Not detectable	-	ASTM D95
Acid number/(mg KOH/g)	0.01	≤0.05	ASTM D974
Carbon residue /%	-	-	ASTM D189

[0061] Table 1. The comparison of the specifications of the base oil 3 from the 3rd stage of molecular distillation column **DZ103** with that of MVI 350.

[0062]

Item	Product from 3 rd stage	MVI 350	Testing Method
Appearance	Yellowish, transparent	Transparent	Visual
Smell	Insignificant	-	Smell
Viscosity (40°C)/(mm ² .s ⁻¹)/CST	70.66	65 - 75	ASTM D445
Viscosity (100°C)/(mm ² .s ⁻¹)/CST	8.42	-	ASTM D445
Viscosity Index	89	≥60	ASTM D2270
Flash point (°C)	246	≥200	ASTM D93
Pour point (°C)	-11	≤-5	ASTM D97
Moisture content (%)	Not detectable	-	ASTM D95
Acid number/(mg KOH/g)	0.02	≤0.05	ASTM D974
Carbon residue /%	0.01	≤0.02	ASTM D189

[0063] Example 2

[0064] The regeneration of spent lubrication oil of the present invention could be operated with a system employing only two stages of molecular distillations in a similar configuration as shown in FIG 2. Thus, the description will be made in connection with FIG 2, where only the differences from Example 1 are highlighted below.

[0065] The 1st stage molecular distillation column **DZ101** was operated at the temperature of 210°C, and the vacuum of 80Pa, where the distillation range was 370 - 440°C, and the product recovery rate was 51%. The flash point and viscosity specifications of the product are in compliance with MVI 200 base oil specifications.

[0066] The 2nd stage molecular distillation column **DZ102** was operated at temperature of 320°C, and the vacuum of 3 Pa, where the distillation range as 440 – 540 °C, and the product recovery rate was 39%. The viscosity and flash point specifications of the product are in compliance with MVI 250 base oil specifications.

[0067] The residue from the 2nd stage of molecular distillation **DZ102** was discharged. The quantity of residue was about 8.2%.

[0068] The application of the molecular distillation to spent lubrication oil recycling has the advantages of high distillation efficiency, high quality fractionated base oil of multiple grades, low operating temperature, high vacuum and being environmental-friendly. The process also avoids the problems of cracking, polymerization, carbonization

and choking that are commonly encountered in normal distillations and other existing spent lubrication oil recycling technologies. In addition, molecular distillation does not produce any secondary pollution such as acid residue, waste acid or waste water.

[0069] While the foregoing has presented descriptions of certain preferred embodiments of the present invention, it is to be understood that these descriptions are presented by way of example only and are not intended to limit the scope of the present invention. It is expected that others skilled in the art will perceive variations which, while differing from the foregoing, do not depart from the spirit and scope of the invention as herein described and claimed.

CLAIMS

What is claimed is:

1. A process for treatment of spent lubrication oil, comprising the steps of:
pretreating the spent lubrication oil;
rectifying the pre-treated spent lubrication oil to recover a light diesel fraction from the spent lubrication oil, resulting in reduced or eliminated interference in subsequent molecular distillation caused by the light diesel fraction; and
performing multi-stage molecular distillations of the rectified spent lubrication oil to recover multi-grades of base oil;
thereby the recovered light diesel fraction and base oils are obtained for further use, and the remaining of the spent lubrication oil is discharged.
2. The process of claim 1, wherein the step of pretreating includes operations of sedimentation and precipitation to remove large particles or contaminants, centrifuge to remove particles and free water, vacuum for dehydration and deodorization, and/or application of chemicals for enhancements.
3. The process of claim 1, wherein in the step of rectifying the recovered light diesel fraction includes petrol, light diesel or some hydrocarbon substance.
4. The process of claim 1, wherein in the step of performing multi-stage molecular distillation, the molecular distillation is preferably performed in two or three stages.
5. The process of claim 1, wherein in the step of performing multi-stage molecular distillation the performance is determined by operation temperature, pressure and distance between a condenser surface and evaporator surface.
6. The process of claim 1, wherein in the step of performing multi-stage molecular distillation the operation temperature is increased sequentially in a series of molecular

distillation, and the operation pressure is decreased sequentially in the series of molecular distillation.

7. A system for regeneration of spent lubrication oil, said system comprising:
 - a pretreatment unit for pretreating the spent lubrication oil;
 - a rectification unit fluidly coupled with the pretreatment unit, for rectifying the pre-treated spent lubrication oil to recover a light diesel fraction from the spent lubrication oil, resulting in reduced or eliminated interference in subsequent molecular distillation caused by the light diesel fraction; and
 - a multi-stage molecular distillation unit fluidly coupled with the rectification unit, for performing multi-stage molecular distillations of the rectified spent lubrication oil to recover multi-grades of base oil;thereby the recovered light diesel fraction and base oils are obtained for further use, and the remaining of the spent lubrication oil is discharged.
8. The system of claim 7, wherein the pretreatment unit is configured to perform operations of sedimentation and precipitation to remove large particles or contaminants, centrifuge to remove particles and free water, vacuum for dehydration and deodorization, and/or application of chemicals for enhancements.
9. The system of claim 7, wherein the recovered light diesel fraction includes petrol, light diesel or some hydrocarbon substance.
10. The system of claim 7, wherein the multi-stage molecular distillation unit is preferably configured to perform two or three stages of molecular distillation.
11. The system of claim 7, wherein in the multi-stage molecular distillation unit the operation temperature is increased sequentially in a series of molecular distillation, and the operation pressure is decreased sequentially in the series of molecular distillation.

12. The system of claim 7, wherein the multi-stage molecular distillation unit comprises a plurality of molecular distillation stage, where each of the plurality of molecular distillation stage comprises:

a molecular distillation column having a material inlet that is located at the top of the column and connected to a material feeding pump for receiving the spent lubrication oil to be treated, where the molecular distillation column has a heating means configured to evenly heat up the molecular distillation column;

a vacuum means coupled with the molecular distillation column to provide high vacuum within the molecular distillation column; and

a condensing means disposed within the molecular distillation column for condensing the desired fraction of distillate.