Re-refining of Waste Oil

Solvent Is Used in Treatment/Distillation Process

INDUSTRIAL APPLICATION. A combination solvent treatment/distillation process has been designed for re-refining industrial waste oil (such as equipment lubricants, metal-working oil, and process oil) and used automotive lubricants (engine oil, hydraulic oil, and gear oil) for reuse.

WASTE ENERGY RECOVERY. Recycling of waste oil in the United States has the potential to save the energy equivalent of 7-12 million bbl of crude oil annually.1

WASTE OIL RECOVERY. Prior to 1960, a significant portion of the demand for automotive lubricating oil was met by re-relined used oil. At the time, 150 re-refineries produced 300 million gal of motor oil annually. Since 1960, however, the production of re-refined oil has steadily declined. In 1981, for example, out of about 1.2 billion gal of automobile lubricating oil and 1.6 billion gal of industrial lubricating oils purchased, 25 U.S. re-refineries produced only 50 million gal. About 50% of the total amount purchased was lost in service, leaving 1.4 billion gal available for recovery.

The level of re-refining has dropped for a number of reasons: an abundant supply of low-cost oil; a lack of reliable tests to evaluate the quality of re-refined oil; and the environmental problems associated with the conventional acid-clay re-refining process, problems that have decreased the available capacity of the industry. From a technology perspective, the re-refining industry can be expected to continue its decline unless new technology is developed to overcome problems associated with the acid-clay process.

In the acid-clay process, used oil is treated with sulfuric acid, which preferentially reacts with oxygen compounds, asphaltic and resinous substances, other nitrogen- and sulfur-based compounds, and soluble metallic components to form a sludge; paraffinic and naphthenic hydrocarbons are left essentially intact for further refining. Color and odor bodies remaining in the re-relined oil are subsequently removed through treatment with activated clay.

The major problem with the acid-clay process is safe disposal of large quantities of the sludge waste, which contains sulfuric acid. The sludge must be sealed in special landfills for hazardous wastes, and many areas of the country do not have adequate disposal space for such waste. Where disposal is possible, landfill costs are very high and negate the economic incentive for oil re-refining.

NEW OIL RE-REFINING TECHNOLOGY. A new re-refining technology that does not rely on sulfuric acid for contaminant removal is under development. In this process, contaminants are removed in a solvent-mixing process rather than by sulfuric acid. The solvent is made up of butanol, 2-propanol, and methyl ethyl ketone. The waste sludge that results from the solvent treatment process can be disposed of as nonhazardous waste and conceivably could be sold as an additive for asphalt.

R&D PROJECT DEVELOPMENT AND STATUS. The solvent-mixing process for re-refining oil has been developed by the U.S. Department of Energy's Bartlesville Energy Technology Center [formerly the Bartlesville Energy Research Center (BERC)]. Work began on the BERC process in 1972. Detailed engineering design studies and economic analyses of the process were successfully completed by the Bartlesville Energy Technology Center during 1980.[2]

TECHNICAL INFORMATION. The following describes the complete process in terms of a hypothetical 10-million-gal/yr plant. Used lubricating oil entering the re-refinery is sampled to test for moisture content and processibility (waste oil with a high moisture content or certain industrial contaminants may not be able to be processed by the plant). Acceptable oil is transferred to a used-oil inventory tank.

The used oil is pumped from the inventory tank into a dehydration vessel fitted with heat-exchange tubes. The bulk of the heat required for dehydration is supplied by a forced-circulation reboiler. The reboiler is operated with a slight back pressure to prevent steam condensation in the tubes, which would lower heat-exchange efficiency. The reboiler is heated with steam, rather than hot oil, to minimize the film temperature on the tube side.

The vaporized water, with some oil, passes through condensers, where it is subcooled, and then into an accumulator. A coalescing filter separates the oil and water. The oil is transferred to a fuel-oil storage tank to be used as re-refinery process fuel, and the water is used for cooling-tower makeup. Acidic constituents in the water phase lower the alkalinity of the circulating water and are thus beneficial for use in the cooling tower.

The bottom product from the dehydration process, dehydrated oil, is transferred to a fuel-stripping tower. The amount and nature of the low-boiling contaminants vary with the type or types of waste oil used. Therefore, the fuel-stripping tower is conservatively designed to separate the heavy ends of diesel fuel. There are two product streams from the stripping tower: overhead organic vapor and bottom product or fuel-stripped oil.

The overhead vapor from the fuel-stripping tower is condensed and used as reflux. Excess overhead product is subcooled in a total condenser and pumped to a fuel-oil storage tank to be used as re-refinery process fuel. The bottom product, lube oil at 475 °F, is pumped to solvent treatment in an in-line mixer. The sludge, which precipitates, is separated in a sludge tank. The clarified solvent/oil mixture is pumped to the solvent recovery tower. The sludge (or tower bottoms) is further processed in a thin-film evaporator, where additional oil is reclaimed, and the reduced sludge is loaded into containers for sale or disposal.

The solvent is recovered from the solvent/oil mixture in a distillation column operated at atmospheric pressure to allow condensation of the solvent vapors from the column overhead without the use of refrigeration. The solvent-treated oil is then distilled overhead in a vacuum distillation column under moderately high vacuum to minimize cracking. However, to maximize yield, the column-bottom temperature is maintained at 600°F. The overhead by-product is condensed for use as reflux or subcooled for transfer to the fuel-oil storage tank.

As the final step in the process, to remove color and odor contaminants in the oil, it is heated to 600-650°F and contacted with hydrogen over a nickel-cobalt catalyst.

ECONOMIC ANALYSIS. Capital costs for a used-lubricating-oil re-refinery using the solvent treatment/distillation process range from $3.85 million for a 2-million-gal/yr facility to $6.85 million for a 20-million-gal/yr facility.[2] Major support facilities are included in these estimates, but the estimates do not include working capital, or land or site-preparation costs.

References

1. Brinkman, D. W., et al., *Environmental Resource Conservation, and Economic Aspects of Used Oil Recycling,* U.S. Dept. of Energy Publication DOE/BETC/RI-80/11 (April 1981).

2. Stubbs, Overbeck & Associates, *Engineering Design of a Solvent Treatment/Distillation Used Lubricating Oil Re-refinery,* U.S. Dept. of Energy Publication DOE/BC/10008-9 (June 1980).

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