

## PROCESSING DEVICE FOR WASTE COOKING OIL

The basis for the priority claim of the present application is Japanese Patent Application 2006-083473 (filed March 24, 2006), and the content thereof is described in the description of the present application.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a processing device for waste cooking oil capable of continuous processing thereof.

#### 2. Description of the Related Art

Attempts have been made to treat waste cooking oil after using a cooking oil such as tempura oil wherein methanol is mixed with caustic soda as a catalyst to cause an ester exchange reaction, and the reaction product is separated by a separator into glycerin and methyl ester, the latter used as a fuel for diesel engines (Japanese Patent Application Laid-open Numbers H10-182518, 2000-219886, and 2004-67937).

Cooking oil is composed of a fat which is glycerin ester, and, reacting with methanol in an ester exchange reaction, methanol is exchanged with highly viscous glycerin, and then methyl ester and glycerin are produced.

Waste cooking oil differs from freshly produced oil in that a variety of impurities used in cooking (fried tempura batter, water or the like) is mixed in the former and oxidation occurs when cooking with heat so that such impurities must be removed in order to carry out the ester exchange reaction.

However, even preprocessing is carried out, ester exchange reaction

is a batch operation, and no device has been developed for the continuous processing of waste cooking oil.

### SUMMARY OF THE INVENTION

It is therefore an object of the present invention to solve the problems described above and provide a processing device for waste cooking oil capable of continuous processing thereof.

In order to achieve the object described above, the present invention is a processing device for waste cooking oil by carrying out an ester exchange reaction to produce glycerin and ester, wherein after waste cooking oil and an ester exchange agent are mixed in an inline mixer, processing liquid obtained by the ester exchange reaction is alternately introduced into a pair of glycerin separation tanks and separated into glycerin and ester, the separated glycerin is burned in a boiler, and the heat generated in the boiler is used for heating the waste cooking oil, for the ester exchange reaction and also for removing the water in the recovered oil comprising ester.

Also, the present invention is a processing device for waste cooking oil, comprising: two or more receiving tanks for receiving waste cooking oil; mixing means for mixing the waste cooking oil in each of the receiving tanks; an stock supply tank for storing the mixed waste cooking oil; a first inline mixer for continuously mixing an ester exchange agent comprising an alcohol such as methanol and a catalyst such as caustic soda, with the waste cooking oil from the stock supply tank; a pair of glycerin separation tanks for alternately introducing the processing liquid from the first inline mixer after the ester exchange reaction and separating generated glycerin and coarse recovered oil comprising ester; a boiler for using glycerin separated by precipitation in the glycerin separation tanks as fuel; a second inline mixer for continuously mixing neutralizing cleaning water containing pure water, diluted sulfuric acid, and magnesium mixed therein, with the coarse recovered oil separated in the glycerin separation tanks; a pair of neutralizing cleaning water separation tanks for

separating the cleaning coarse recovered oil alternately introduced from the second inline mixer into cleaning water and recovered oil; a third inline mixer for continuously mixing the separated recovered oil along with the pure water; an oil-water separation tank for alternately introducing the recovered oil combined with the pure water from the third inline mixer to separate same into oil and water, and collecting recovered oil; and a steam heater for introducing the recovered oil separated in the oil-water separation tank and heating same with steam from the boiler to separate water in the recovered oil.

In the present invention, the receiving tank, the stock supply tank, the first to third inline mixers, and the respective separation tanks may be housed in a cabinet surrounding the boiler.

In the present invention, optical liquid level gauges may be provided in the glycerin separation tanks and the neutralizing cleaning water separation tanks, and a surface of separation is monitored by the optical liquid level gauges to separate liquid into a lower portion and an upper portion.

The present invention has a significant effect of continuously processing waste cooking oil as well as using a heat source generated by burning glycerin in a boiler.

### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows an aspect of the embodiment of the present invention.

Fig. 2 shows a flow chart showing other preferred embodiment of the present invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

The "processing device for waste cooking oil" noted and described in the present specification, claims, and drawings is described in Japanese

A suitable embodiment of the present invention is described below in detail based on the attached drawing.

In Fig. 1, a stock (waste cooking oil) is received in a conveyance drum 11 using a tank truck receiving nozzle 10, solids and the like are removed from the conveyance drum 11 (or directly from the tank truck) with a strainer 13 through a receiving line 12, and the strained result is inserted from a discharge side line 15a into two or more receiving tanks 16 using a receiving pump 14.

The waste cooking oil received in the receiving tank 16 is of varied quality, with extremely poor quality being such that the ester exchange reaction described below does not happen readily, in which case good quality waste cooking oil is collected in one of the receiving tanks 16, then both the good quality and bad quality waste cooking oils are returned from a return line 15b to the strainer 13 using the receiving pump 14, and supplied from the discharge line 15a to a stock supply tank 17 to make waste cooking oil with a stable quality. The stock supply tank 17 can hold processing quantity of one day, a volume of approximately 800 L.

The stock from the stock supply tank 17 is filtered by a double strainer 18, and then sent to a first inline mixer 20 at 34 L/h, for example, using a fixed quantity supply pump 19.

Meanwhile, an alcohol 22 such as methanol and a catalyst 23 such as caustic soda are supplied to an ester exchange agent tank 21, and stirred by a stirrer 24 to make an ester exchange agent. The ester exchange agent is produced by adding 0.05 kg of caustic soda to 1 L of methanol, and is sent to the first inline mixer 20 through a fixed quantity (6.8 L/h) strainer pump 25.

The stock and the ester exchange agent are mixed while flowing in the first inline mixer 20, causing an ester exchange reaction. The inline

mixer 20 is housed in a cabinet C as described below whose ambient temperature is held between 40 and 60° C, and a continuous ester exchange reaction is enabled by mixing the stock and the ester exchange agent in the inline mixer 20.

The fluid after the ester exchange reaction flows into a first glycerin separation tank 27a and a second glycerin separation tank 27b switching alternately therebetween every 30 minutes by switching of a first three-way electromagnetic valve 26.

After receiving the liquid, precipitation separation alternately takes place in the glycerin separation tanks 27a and 27b, the surface of separation of the coarse recovered oil of the upper portion and the glycerin of the lower portion are monitored in the separation tanks 27a and 27b by optical liquid level gauges 28a and 28b, and the glycerin separated by precipitation and collected in the bottom portion is removed and sent to a glycerin storage tank 30 through switching valves 29a and 29b.

The switching valves 29a and 29b are then closed, and the coarse recovered oil comprising ester collected in the upper portion is received in an intermediate tank 32 through switching valves 31a and 31b. The operation described above is alternately repeated to realize continuous processing.

As described below, the glycerin collected in the glycerin storage tank 30 is supplied to a boiler 70 through a double strainer 71 and a pump 72.

The coarse recovered oil is sent again, this time to a second inline mixer 35 through a strainer 33 and a pump 34.

Pure water 41, diluted sulfuric acid 42, and magnesium 43 are mixed with a stirrer 44 in a neutralizing cleaning water tank 40 to form neutralizing cleaning water. The neutralizing cleaning water is made by mixing 0.02 L of diluted sulfuric acid and 0.25 kg of magnesium to 1 L of

pure water.

The neutralizing cleaning water is supplied to the second inline mixer 35 at 35 mL/h by a strainer 45 and a fixed quantity supply pump 46, then mixed with the coarse recovered oil, and the result is alternately sent to a pair of neutralizing cleaning water separation tanks 37a and 37b through a second three-way switching valve 36. The surface of separation is monitored through an operation similar to that of the glycerin separation, that is, monitoring the separation tanks 37a and 37b by means of optical liquid level gauges 38a and 38b, water separated by precipitation and collected at the bottom portion is either returned to the neutralizing cleaning water tank 40 through a gravity flow from a line 53 through an opening-closing valve 80 or supplied to an jacket type evaporator 61 described below through a gravity flow from a line 82 through an opening-closing valve 81 through switching valves 39a and 39b.

The neutralizing cleaning water tank 40 and the jacket type evaporator 61 are provided lower than the neutralizing cleaning water separation tanks 37a and 37b at a position in the cabinet C, and the neutralizing cleaning water separated in the separation tanks 37a and 37b flows into the neutralizing cleaning water tank 40 or the jacket type evaporator 61 by a gravity flow from line 53 or 82, respectively.

The concentration of the neutralizer is checked, and when the concentration is low, the opening-closing valve 80 is opened to return the neutralizing cleaning water from the line 53 to the neutralizing cleaning water tank 40, and when the concentration is high, the opening-closing valve 81 is opened to supply same from the line 82 to the jacket type evaporator 61.

The switching valves 39a and 39b are then closed, and the coarse recovered oil collected at the upper portion is received in a recovered oil tank 48 through switching valves 47a and 47b.

The recovered oil is supplied from the recovered oil tank 48 to a

third inline mixer 52 through a double strainer 50 and a pump 51, pure water 54 is supplied from a pure water tank 55, where the pure water 54 is stored to the inline mixer 52 by means of a pump 56, the recovered oil and the pure water 54 are continuously mixed in the inline mixer 52, and alternately sent to a pair of oil-water separation tanks 57a and 57b switched through a third three-way switching valve 56.

The water is similarly separated in the oil-water separation tanks 57a and 57b, the surface of separation is monitored by the optical liquid level gauges 58a and 58b, and the water separated by precipitation and collected at the lower portion is supplied from the line 60 to the jacket type evaporator 61 through switching valves 59a and 59b.

The switching valves 59a and 59b are then closed, and the recovered oil collected at the upper portion is supplied to a steam heater 66 through switching valves 63a and 63b.

Steam generated in the boiler 70 is supplied to the steam heater 66 and used to indirectly heat the recovered oil to approximately 100° C. The recovered oil is then supplied to a separator 74, the steam in the recovered oil is separated, the water concentration is kept within a prescribed value, and the recovered oil is stored as the final product in a product tank 76.

In the boiler 70, the glycerin is sent to a burner 73 and burned, and saturated steam of 1.1 kg/cm<sup>2</sup>h is generated.

The waste water separated by the oil-water separation tanks 57a and 57b as well as the cleaning water from the line 82 are supplied to an jacket type evaporator 61, steam is supplied from the steam heater 66 to the jacket of the evaporator 61, the waste water is heated in the jacket type evaporator 61, the steam is discharged through a line 75, and the reduced waste water is discharged to a waste water pot 77, then discharged outside the device.

The condensed water from the jacket is collected in a water tank 78

and cyclically supplied to the boiler 70 using a condensate pump 79.

As described above, the cabinet C surrounds the boiler 70 and houses therein nearly all the apparatuses except for the conveyance drum 11, the receiving tank 16, the stock supply tank 17, and the fixed quantity supply pump 19; and because the inside of the cabinet C is maintained at an environment of 40 to 60° C, the stock does not have to be heated for the ester exchange reaction, and separate heating of the first inline mixer 20 is not required. Furthermore, because the second and third inline mixers 35 and 52 as well as the separator devices 27, 37, and 57 are maintained in a range of 40 to 60° C, favorable mixing and separation can be carried out.

In Fig. 2, other preferred embodiment of the present invention is shown.

In the preferred embodiment of Fig. 1, an example is shown wherein the waste cooking oil being separated into ester and glycerin after ester exchange reaction, the separated ester being neutralized with sulfuric acid and magnesium, and the ester separated from neutralized water being cleaned with pure water. In this preferred embodiment, ester is neutralized with hydrochloric acid as a preprocessing step before neutralizing ester with sulfuric acid and magnesium, ester is then neutralized with sulfuric acid and magnesium, and resulted ester is further cleaned two times with pure water.

The processing steps are as follows: separating waste cooking oil 100 into ester and glycerin 101 by ester exchange reaction; separating 102 these into ester 103 and glycerin 104; neutralizing ester 103 with hydrochloric acid 105, then separating 106 into ester 107 and neutralizing water 108; neutralizing ester 107 with sulfuric acid and magnesium 109, then separating 110 into ester 111 and neutralizing water 112; cleaning ester 111 with pure water 113; further cleaning 116 ester 115 which cleaning water 114 is separated with pure water, and separating cleaning water 117 to produce recovered oil 118.

Inline mixers shown in Fig. 1 are used to mix to neutralize with hydrochloric acid, a pair of separation tanks of precipitation separation type is used to separate, and inline mixers and a pair of separation tanks of precipitation separation type are used to clean with pure water.

In this preferred embodiment, very pure recovered oil may be obtained by neutralizing two times with hydrochloric acid and magnesium sulfate, and then by cleaning two times with pure water.

### What Is Claimed Is:

1. A processing device for waste cooking oil for carrying out an ester exchange reaction of waste cooking oil to produce glycerin and ester, wherein after waste cooking oil and an ester reaction agent are mixed in an inline mixer, processing liquid obtained by the ester exchange reaction is alternately introduced into a pair of glycerin separation tanks and separated into glycerin and ester, separated glycerin is burned in a boiler, and heat generated in the boiler is used for heating the waste cooking oil, for the ester exchange reaction, and for removing water in recovered oil comprising ester.

2. The processing device for waste cooking oil according to claim 1, wherein separated ester is neutralized with magnesium sulfate solution to separate ester, ester is cleaned with pure water and separated therefrom to obtain the recovered oil.

3. The processing device for waste cooking oil according to claim 1, wherein separated ester is neutralized with hydrochloric acid to separate ester, ester is further neutralized with magnesium sulfate solution to separate ester, and neutralized separated ester is cleaned two times with pure water to produce the recovered oil.

4. The processing device for waste cooking oil according to claim 1, comprising: two or more receiving tanks for receiving waste cooking oil; mixing means for mixing the waste cooking oil in each of the receiving tanks; a stock supply tank for storing the mixed waste cooking oil; a first inline mixer for continuously mixing an ester exchange agent comprising an alcohol such as methanol and a catalyst such as caustic soda, with the waste cooking oil from the stock supply tank; the pair of glycerin separation tanks for alternately introducing the processing liquid from the first inline mixer after the ester exchange reaction and separating generated glycerin and coarse recovered oil comprising ester; the boiler using glycerin separated by precipitation in the glycerin separation tanks as fuel; a second inline mixer for continuously mixing neutralizing

cleaning water containing pure water, diluted sulfuric acid, and magnesium mixed therein, with the coarse recovered oil separated in the glycerin separation tanks; a pair of neutralizing cleaning water separation tanks for separating the cleaning coarse recovered oil alternately introduced from the second inline mixer into cleaning water and recovered oil; a third inline mixer for continuously mixing the separated recovered oil along with the pure water; an oil-water separation tank for alternately introducing the recovered oil combined with the pure water from the third inline mixer to separate same into oil and water, and collecting recovered oil; and a steam heater for introducing the recovered oil separated in the oil-water separation tank, and heating same with steam from the boiler to separate water in the recovered oil.

5. The processing device for waste cooking oil according to claim 4, wherein the receiving tank, the stock supply tank, the first to third inline mixers, and the respective separation tanks are housed in a cabinet surrounding the boiler.

6. The processing device for waste cooking oil according to claim 4, wherein optical liquid level gauges are provided in the glycerin separation tanks and the neutralizing cleaning water separation tanks, and a surface of separation is monitored by the optical liquid level gauges to separate liquid into a lower portion and an upper portion.

7. The processing device for waste cooking oil according to claim 4, wherein the coarse recovered oil separated in the glycerin separation tanks is neutralized with hydrochloric acid before neutralizing with the neutralizing cleaning water which is a mixture of pure water, diluted sulfuric acid and magnesium.

8. The processing device for waste cooking oil according to claim 4, wherein the recovered oil separated in the neutralizing cleaning water separation tanks is mixed with pure water, then separated therefrom, again mixed therewith, and finally separated therefrom.