Fatty Acid Plant

120,000 MTPY

Visit us at: www.ippe.com
Brief Overview

- Capacity: 120,000 metric tons/year
- Technology: Free and Clear to Practice Worldwide
- Utilities: Electricity, Steam, Water and Fuel Gas
- Year Built: 1980
- Shutdown: 2009
- Product: Split Fatty Acids
- Raw Materials: Animal Fat and Vegetable Oil
Key Points

- The Glycerine Purification Section was Added in 2003.

- Process control systems and programming are completely up-to-date and are available for sale with the facility. They are Siemens PCS7 and Fisher-Provox systems.

- The Fatty Acid Plant Includes the Following Units:
  - (3) Fat Splitting (Hydrolysis) Columns: 5 or 6 metric tons/hr each of fat input (depending on product such as tallow or vegetable oil)
  - (1) Luwa Glycerine Distillation Unit: 2 metric tons/hr (may be purchased on its own)
  - (2) Fatty Acid Vacuum Distillation Units: 21 metric tons/hr total
  - (1) Fat Separation Unit (wet process): 7 metric tons/hr
  - (1) Fat Batch Hardening (Hydrogenation) Unit: 15 metric tons, batch cap.
  - (1) Drum/IBC Filling Unit: 5.5 metric tons/hr
  - (1) Flaking and Bagging Unit: 3.3 metric tons/hr

- This plant is designed to use the following vegetable oils: coconut oil, palm kernel oil, palm oil and soya bean oil. It can also use (3) grades of tallow: grades 2, 4 and 6
Major Equipment

- (3) Splitting Columns
  - 1.1 m diameter x 27 m tall, 316LSS clad, 850 psig @ 288°C.

- Kestner 4-Stage Evaporator: **5,600 lbs/hr product (22,400 lbs/hr feed)**
  - Feed specifications:
    - treated glycerine sweetwater
    - Flow rate: 22,400 lbs/hr
    - Glycerine: 10% w/w
    - Fats/fatty acids: 2% w/w max
    - Fats/suspended solids: 0.5% max
    - Feed temp: 90°C
    - Specific gravity: 0.95 approx
    - Viscosity: 0.4 c.p

  - Product Specifications:
    - Flow rate: 5,600 lbs/hr
    - Glycerine: 40% w/w
    - Product temp: 48°C
    - Specific gravity: 1.076
    - Viscosity: 1.4 c.p

- Steam Consumption:
  - Calandria C-1: 4,230 lbs/hr @ 20 psig
  - Pre-heater E-2: 310 lbs/hr @ 20 psig

- Cooling Water Consumption:
  - Condenser: 280 gpm @ 14.4°C
  - Vacuum pump: 15 gpm @ 15.4°C

- Dimensions:
  - 1st effect: 14” (dia) x 20' (h), 316SS,
  - 2nd effect: 21 ¼” (dia) x 20' (h), 316SS
  - 3rd effect: 23 ¾” (dia) x 20' (h), 316SS
  - 4th effect: 27” (dia) x 20' (h), 316SS
  - Pre-heater: 16” (dia) x 20' (h), 316SS
Unit Overview

Splitting Columns
The splitting columns take animal fats or vegetable oils and produce split fatty acids and glycerine. The hydrolysis process works at high temperatures and pressure. Filtered and heated fat is pumped to the bottom of the column and hot water is pumped to the top. Fat is less dense than water so it rises and water falls creating a counter-current process. Split fatty acid is drawn off the bottom of the splitting columns and sweetwater (dilute glycerine water) is drawn off the top.

Fat and hot water is pumped to the column using a heavy-duty, high-pressure Aldrich pump operating above 750 psig. The fat is first pumped through an “economizer” exchanger to heat it up to 92°C. The heat for the economizers comes from the sweetwater flash drums, which are covered later in this report. There are separate feed pumps and exchangers for all three columns.
The sweetwater moves to the Kestner 4-stage evaporator where the glycerine concentration is taken from 12% to 40%. This unit is designed to handle 22,400 lbs/hr of 10% glycerine in water with up to 2% fats/fatty acids and up to 0.5% suspended solids. This equates to approximately 0.95 specific gravity and 0.4 centipoise viscosity at the designed 90°C feed temperature. The final product design flow rate is 5,600 lbs/hr.

In the pre-treatment area of the process, sulfuric acid is added to the concentrated stream to remove the last bit of fat. After separation, the stream is neutralized with lime, and filter aid is added prior to going through the plate and frame filter. From there it proceeds to the glycerine distillation section of the plant. The fatty acids from the top of the splitter contain primarily oleic and stearic acids. This stream goes to the fatty acids distillation section of the plant, which is outlined later in this report.
Splitting Columns

This facility takes tallow from local rendering plants and converts it into fatty acids and glycerine. There are three splitting columns which are used to separate the oils and fats. The columns run at 750 psig and about 250°C. Live 1,500 psig steam at is fed into the bottom of the splitting column, which drives most of the fatty acids overhead. Glycerine accumulates in the bottom in a solution called “sweetwater” (12% glycerine in water). A chemical flocculent called Zeetag is injected to assist in the separation. There are six flash drums following the three columns, one for each column overhead and bottom stream. The overhead flash vessels have three compartments. The entry compartment is where the steam and any volatile liquids flash. The “large side” or separator compartment is where the water and fatty acid separates. The “small side” compartment is formed by a weir, and this is where the fatty acid collects. The bottom flash vessels are identical to the overhead flash vessels except that they have no steam coils.
Splitting Columns
Unit Overview

Glycerine Purification
PROCESS DESCRIPTION

- The Glycerine Purification Plant refines soap lye crude and splitters crude to produce glycerine with a high level of purity. These raw materials contain glycerine along with salt, water, and numerous other impurities. The process consists of a dryer to remove moisture, a Luwa evaporator where high temperature and vacuum remove most of the salt, a condenser to collect the glycerine, a bleaching column to remove color and odors, and a final evaporator to reduce the moisture content. The final glycerine product is 99.7% pure with less than 2 ppm chlorides.

- The raw material soap lye crude and splitters crude are blended together typically in an 80:20 ratio. The blended feedstock must meet the following general specifications: 80-90% glycerine, 10% water, an Ash/MONG ratio of 4:1, and less than 0.1% free alkalinity as Na2O.

- The pre-heater is a shell and tube exchanger operating at 105°C using 4 bar steam for heat. The flash dryer operates at 105°C and 45 mbar which reduces the water content to less than 1.5%. The pre-heater and flash dryer have a very high recycle flow rate of 40 m³/hr.
The dried product then proceeds to the Luwa wiped-film evaporator which operates at 156°C and the very high vacuum of 4 mbar. The steam jacketed Luwa has a glycerine/water mixture recirculated to the rotor seal and nitrogen for cooling the bottom bearing. There is a complete spare rotor for the Luwa. The glycerine evaporates as the salt and other impurities slowly fall downward. The salt is discharged via the “salt egg” using the “air lock” created with two slide valves. The salt is eventually dissolved in water and sent out as a waste.

Luwa Evaporator Structure

The glycerine vapor passed through a disentrainment vessel and on to the condensing column. The disentrainment vessel is baffled and packed to remove any entrained salt or high-boiling impurities. The condensing column contains three condensers operating at successively lower temperatures. They operate at 127, 101, and finally at 30°C.

The cool glycerine is then passed through one of the carbon bleachers where color and odor are removed. The carbon bleachers have 25 m³ capacity and utilize 54 filter nozzles in the bottom cone to keep the carbon in the vessel. Each filter nozzle has 20 plates which are 1 mm thick. There are two sets of Pall cartridge filters following the carbon bleachers to catch any carbon that escapes.
The glycerine product then proceeds through two heat exchangers operating with 4 bar steam. The product is heated to 130°C before going to the steam stripper which also operates with 4 bar steam. The stripper is under 4 mbar of vacuum, as is the final evaporator. The final evaporator is a wiped-film unit similar to but smaller than the Luwa. It operates at 130°C and removes the water down to less than 0.5%. The final product is then cooled, filtered, and sent to storage.

The vacuum for these units is supplied in two stages. Vacuum pumps take the process down to 40-60 mbar. Vacuum ejectors driven with 1.5 bar steam supply the lower vacuum pressures down to 2-3 mbar.

Process control systems and programming are completely up-to-date and are for sale with the facility. This unit uses the Siemens PCS7 system, which was installed in the 1980s but has been periodically updated. Promace is used as the process information management system (PIMS).
Glycerine Purification

EQUIPMENT

- Pre-Drier: 1.2m (dia) x 4.9m (h), 316LSS, 5.2 barg/FV @ 160°C.

- Condensing Column: 2.0m (dia) x 10.4m (h), 316SS, 1/-1 barg/FV @ 160°C.

- Stripping Column: 0.8m (dia) x 5m (h), 316Ti SS, 1/-1 barg/FV @ 200°C.

  - Internal operating pressure; -1 barg @ 250°C, 8,635 ltr
  - Jacket 1 operating pressure; 40 bar @ 250°C, 120 ltr
  - Jacket 2 operating pressure; 40 bar @ 250°C, 120 ltr
  - Jacket 3 operating pressure; 15 bar @ 200°C, 8 ltr
  - 1.2 m (dia) x 5 m (straight side)
  - Crane type 151 double mechanical seal
  - 55 kw motor, 415 volt, 1,475 rpm motor via David Brown size MFD 980 gearbox, input 1,475 rpm, output 130.2 rpm.
Luwa Evaporator: *Buss SMS small unit, wiped film evaporator, 2m\(^2\), 316Ti SS, CS jacket.*

- Internal operating pressure; -1 bar @ 200°C
- Jacket 1 operating pressure; 12 bar @ 200°C
- Jacket 2 operating pressure; 12 bar @ 200°C
- 410mm (dia) x 2,430mm (straight side)
- 5 kw motor, 380 volt, 1,410 rpm motor, 450 rpm gearbox
Glycerine Purification

Final Evaporator

Luwa Evaporator Structure
Unit Overview

Fatty Acid Distillation
The Lurgi distillation units are used to refine fatty acids by removing the heavy ends and the volatiles. The stream is primarily oleic and stearic acids. Vacuum is provided for this process from two sources. A vacuum pump is used for 40 mbar vacuum. A seven-nozzle steam ejector driven with 100 psig steam is used for lower vacuums.

Pre-Stills:
Basket filters are used to remove any larger clumps or particles from the incoming feed. The feed then runs through two spiral “economizer” heat exchangers in series, which heats it up to 70°C and then 180°C. This is followed by a high pressure steam (1,500 psig) exchanger which takes the feed up to 220°C. The stills use four high pressure steam candles in the bottom of the column for additional heating. Each candle has six inner pipes and twelve outer pipes with 1,500 psig steam on them. Sparge steam at 10 psig is injected into the base of the candle to assist in the vaporization process. There are eight bubble-cap trays in the columns located above the candles. The distillation columns run at 5-15 millibar of vacuum. Spiral coolers are used as the column overhead condensers.
Main Stills
Product is pumped from the pre-stills to the main stills. The main stills have ten candles similar to those described in the pre-stills section. These columns are packed with ceramic and stainless steel packing rings. Each of the main stills have four overhead condensers in series. The first condenser is used to generate 40 psig steam since the overhead product is at 270°C.

Back-end Stills
The back-end stills handle the residue stream from the main stills. They are designed for further removal of fatty acids from the residue stream to increase yields. There are two candles on each back-end still similar to those described in the pre-still section.
Fatty Acid Distillation

EQUIPMENT

Number 3 Distillation Unit consists of a topper, main still and back end still

- Pre-Still: 316Ti SS, 30mm HG abs @ 250°C
- Main Still: 2.4m (dia) x 11.5m (tall), 316 Ti SS, FV @ 275°C
- Back Ends Still: 1.3m (dia) x 4.5m (tall), 316SS, FV @ 250°C

Number 4 Distillation Unit consists of a main still and back end still

- Main Still: 2.75m (dia) x 10.4m (h), 2 barg/FV @ 250°C
- Back Ends Still: 1.5m (dia) x 4.23m (h), 2 barg/FV @ 250°C
Fatty Acid Distillation

Distillation Column Steam Candles

Distillation Tank Farm
Unit Overview

Wet Separation
PROCESS DESCRIPTION

During the splitting process, oils and fats are separated into fatty acids and glycerine. The distilled split fatty acid contains a mixture of saturated (solid stearine) and unsaturated (liquid oleine) fatty acids. Wet separation is the process whereby the two types of fatty acids are separated from each other.

Fatty acid is firstly cooled to 10°C and fed though banks of crystallizers. The stearine solidifies first and forms a slurry with the liquid oleine. There are 12 crystallizers total which use -2°C brine for cooling. There are three groups of four crystallizers and only two groups are normally in service. The crystallizers were manufactured in Germany and have internal mechanical scrapers to keep the walls clean. The scrapers operate at 50 rpm with 9 kW motors, except for the last two crystallizers in each bank, which have 15 kW motors due to the higher viscosity. There is a 400 kW York chiller used for refrigerating the brine solution.
The slurry is then mixed with a surfactant before being processed through a set of seven centrifuges operation at 2,280 rpm. The surfactant is WAS, which is a mild detergent (sodium decylsulfate), magnesium sulfate, and water. There are five Heine units and two Krauss-Maffei centrifuges. These units separate the fatty acid streams into the stearine and oleine components. The WAS surfactant goes with the heavier stearine stream. The oleine goes to storage. However, if the oleine is to be sold, it goes through a dryer to remove the moisture from 1-2% down to less than 0.3%.

The stearine and WAS mixture is then heated to 95°C and fed to a decanter where the WAS goes overhead and the stearine goes out the bottom with about 0.3% WAS contamination. The decanter internals include three baffles and a castellated weir. The WAS stream is cooled and recycled back to the mixer.

The stearine stream proceeds at 95°C to the mixer/settler where 5% sulfuric acid and water are used to remove the last amounts of WAS. The mixer/settler has 10 compartments and approximately five hours of residence time. The WAS is hydrolyzed by the acid to decanol and sodium bisulfate salt. Caustic is used later to neutralize the remaining sulfuric acid. The WAS must be removed as it will kill the hydrogenation catalyst in the hardening process.
EQUIPMENT

- Crystallizer Banks (12): 368mm (dia) x 8.5m (l), 316Ti SS, 6/5 barg @ 100°C.
- WAS Mixer: 1.2m (dia) x 2.9m (h), 316SS, 2.9 barg/FV @ 150°C.
- Heine Centrifuges (5): 316SS.
- Krauss Centrifuge: Model HZ80 SO321, 800mm (bowl dia), 316SS.
- Krauss Centrifuge: Model HZ100 SO305, 1m (bowl dia), 316SS.
Wet Separation

WAS Mixer

Crystallizers

Krauss-Maffei Centrifuge
Unit Overview

Hydrogenation
The batch hardening plant uses hydrogenation to harden a range of fatty acids. The fatty acids are dried and then reacted with hydrogen using a nickel catalyst before being filtered through a plate and frame press. The hydrogenator runs at about 20 bar of pressure and has 15 metric ton batch sizes.

The nickel catalyst is removed with a Schenk catalyst recovery filter and reclaimed by Johnson-Matthey. The catalyst used in this process is Johnson-Matthey Pricat™ 9932. There are 7 stainless steel storage tanks with a total capacity of 900 metric tons associated with this plant.
Hydrogenation

EQUIPMENT

- Dryer Vessel: 2.5m (dia) x 6.3m (h), 316SS, 2 barg/FV @ 200°C.
- Reactor Vessel: 2.4m (dia) x 5.5m (h), 316SS, 35 barg @ 350°C.
- Filtration Tank: 3.0m (dia) x 4.9m (h), SS, 15 psig @ 110°C.
Hydrogenation

Hydrogenator (center vessel)

Hydrogenation Structure
Unit Overview

Stearine Flaking
The stearine flaking unit is used to convert molten fatty acids into solid flake. Fatty acid is cooled and flaked on a Simons Dryers water-cooled rotary drum flaker. This unit is rated for 100 psig at 120°C and is constructed of carbon steel with a stainless steel liner. There are two liquid stearine raw material tanks (with heating coils) feeding this unit which hold 47 metric tons of product. The hot liquid stearine is pumped from one raw material tank at a time into a tray within the stearine flaking unit building. This tray has a rotating stainless steel drum that is cooled with a closed loop glycol water circuit operating at 0°C with a 150 kW York chiller unit. As the drum rotates, the difference in temperature between the liquid stearine and the drum allows a thin layer to coat the drum. As this happens, a fixed PTFE blade at the back of the roller allows the solidified stearine to be scraped off. This scraping action along with the aid of a breaker box allows the stearine to be chopped up into small flakes which then fall into a conveyor system.
The flake is then conveyed with a bucket conveyor through a vibrating sieve and into automatic bag filling machines. The smaller bags (25kg) are automatically palletized and shrink wrapped. The bagging machine actually makes its own plastic bags “in situ”. The machine was constructed by Esse Gi of Italy and is a model CTX-50. There is a Domino printer/stenciling unit for labeling the bags. The product then proceeds to a Moeller model 4420 automatic palletizer and stretch wrapping machine. The capacity of this facility (flaking and bagging) is 3.3 metric tons per hour.
Unit Overview

Drum Filling Unit & Tank Farm
Drum Filling Unit

- The Bilanciai D450 drum filling unit is semi-automated and was installed in 2006. It is capable of filling palletized drums and IBCs at the rate of 5.5 metric tons per hour.

Tank Farm

- There are about 190 storage tanks in this facility, the majority of which are constructed of stainless steel.
Unit Overview

Utilities
There are three boilers in this facility. Two are Volund units, each producing 17 mt/hr of steam at 80 bar pressure. There is a Minster unit producing 20 mt/hr at 10 bar pressure. All three boilers were installed in 1998. They are dual-fuel units capable of burning natural gas or fuel oil.

There are two Ingersoll-Rand Centac air compressors capable of producing 900 CFM at 100 psig. There is no waste water treatment at this facility, but there is a sump where any residual fat is floated and skimmed off the water prior to discharge to the city sewer. They also do some slight pH adjustment of the waste water and they have two Seres 2000 COD analyzers checking the carbon content in the waste water.
Utilities

Volund Boiler

Volund Boiler Burner

Air Compressor
Flow Diagrams
Glycerine Purification

Diagram showing the processes involved in glycerine purification, including:
- Pre-Heater
- Dryer
- Luwa Column
- Disentainment Vesel
- Condensing Column
- Steam Stripper
- Evaporator
- Bleacher
- Salt Egg
- Feedstock

Final Product
Splitting and Glycerine Finishing

12% GLYCERINE
"SWEET WATER"

KESTNER 4-STAGE EVAPORATION

40% GLYCERINE

PRE-TREATMENT:
1) SULFURIC ACID
2) SEPARATION
3) LIME NEUTRALIZATION
4) PLATE & FRAME FILTER

TALLOW OR NATURAL OILS

SPLITTING COLUMNS (3)
850 psig
288 °C
316L SS CLAD
1.1m Ø x 27m

WATER

FAT

40% GLYCERINE

FINAL EVAPORATION
(5-STAGES)

83% GLYCERINE

WATER

VACUUM

LUMA EVAPORATOR
600 psig STEAM
250 °C
316L SS
1.2m Ø x 9.9m

99.9% GLYCERINE

FATTY ACID
(DRAWING 2 OF 5)
Fatty Acid Finishing

Fatty Acid from Splitter Column Bottoms

Main Stills (2)
- Full Vac.
- 275 °C
- 316Ti SS
- 2.4m Ø x 11.5m Lurgi

Crystallizers (12)
- 88 psig
- 100 °C
- 316Ti SS
- 0.4m Ø x 8.5m

Centrifuges (7)
- Heine (5)
  - 316 SS
- Krauss-Maffei (2)
  - HZ 80 & 100
  - 316 SS

Hydrogen

Hydorgenator
- 515 psig
- 350 °C
- 316L SS
- 2.4m Ø x 5.5m Ni CAT

Crude Stearine (with traces of Oleine)

Pure Stearine

Oleine
Contact IPP Today!

MICHAEL JOACHIM  
DIRECTOR, PLANTS DEPT.  
Tele: 609-838-5930 (direct)  
Mobile: 609-516-9107  
MichaelJ@ippe.com

SANJEEV REGE  
VP GLOBAL PLANT SALES  
Tele: 609-838-5938 (direct)  
Mobile: 609-510-2616  
SanjeevR@ippe.com

IPP World Headquarters  
17A Marlen Drive  ♦ Hamilton, NJ 08691 ♦ USA  
Tele: +1 (609) 586 8004 ♦ Fax: +1 (609) 586 0002  
Visit us at: www.ippe.com