Riverina Oils and BioEnergy

Integrated Oilseed Processing Plant

Appendix B
Process Description

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RIVERINA OILS & BIOENERGY

INTEGRATED OILSEED PROCESSING PLANT

WAGGA WAGGA, NEW SOUTH WALES, AUSTRALIA

INDICATIVE PROCESS DESCRIPTION OF THE MAIN PROCESSING BUILDINGS

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1. OILSEED CRUSHING BUILDING : SECTION 700 – PREPARATION PLANT (CASE CANOLA OR SAFFLOWER)

PROCESS DESCRIPTION

Oilseeds with high oil content, like canola or safflower, are difficult to extract in one step without leaving a substantial percentage of oil in the final cake or meal. To achieve maximum yield, most industrial plants use a two-step extraction process for canola and canola: mechanical pressing first (called pre-pressing), followed by solvent extraction. Justifying the capital and operating costs of a solvent plant is generally not possible for small capacity plants, and they rely on high pressure mechanical pressing (called full pressing) to extract as much oil as possible, but without approaching the yield of solvent plants.

Oilseeds as they arrive from the field or the silo are not or poorly extractable, and must first be prepared. The purpose of preparation is to weaken the oil containing cells and to shape the material in a form that makes the oil cells accessible for extraction, so as to ultimately achieve the desired capacity, high extraction yield (low milling defect), and high quality products (crude oil and meal), at low production cost. Extraction result is dictated in large part by the preparation.

The first step of the process consists in cleaning the seeds of foreign material.
The major preparation step consists in producing flakes, a shape that makes the oil cells accessible for extraction. Flaking efficiency and capacity is often enhanced by pre-heating the clean seeds prior to flaking.

The flakes are then cooked and dried. Cooking further weakens the cell walls and reduces the viscosity of the oil. Drying improves the gripping and the pressure build-up inside the press. In the press (also called expeller), oil is pressed out and the remaining solids form a cake, that is sent to solvent extraction.

Solid meal particles called foots are entrained with the oil. The oil clarification process consists in separating the solids and producing clean, crude press oil. The recovered solids are returned to the main stream.

The hot canola cake as it comes out of the press is fragile and friable. It must be handled gently and crisp-cooled as quickly as possible, in order to send in the extractor a product that maintains percolation.

786 / 740 WEIGHING, CLEANING AND DESTONING

The seeds are transported from storage to the preparation plant.

The seeds go to the weighing system. A buffer bin, item 785A, receives the seeds. Its function is to absorb incoming feed variations, allowing a constant and regular feed to the rest of the plant. Level detectors are used to control the feed to the bin.

The buffer bin 785A feeds the scale itself, item 786, by gravity through an inclined duct that absorbs the weight of the flow before it drops in the scale.

The scale is a high precision hopper scale with digital control. It is equipped with slide gates at inlet and at outlet that open and close sequentially. The purpose of the scale is not only to measure the feed to process, but also to set the production rate, simply by regulating the intervals between dumping of the hopper load.

From weighing, the seeds are conveyed to destining followed by final cleaning which removes impurities.

Small stones having the same size as canola are not separated by screening. If present in excessive number, it is prudent to foresee destoners. Destoner item 717 is a gravity table that uses the difference in density to separate heavy stones from lighter seeds. The separation results from combining vibrations with near fluidisation by air.

Cleaning is important in order to reduce the wear on the flaking rolls and in conveyors in general, and for obtaining high quality products. The fines, pods, sticks, stones and other impurities must be removed.

The cleaning is done on a multiple deck screener item 740. The cleaner 740 is composed of screens with opening sizes designed to segregate the following three fractions:

- The coarse fraction or oversized impurities which are retained by the upper screen. This fraction is evacuated to the hammer mill to be grinded . Impurities like leaves, sticks, etc are separated here. From the hammer mill, item 769, the add-mixture is sent to the meal shed by a pneumatic conveying system to be blended wih the meal.
- The clean fraction which is the intermediate fraction. It passes through the first screen, and stays on top of the bottom one.
- The small fraction - fines and sand - which pass through the bottom screen. This fraction is evacuated to a trash container.

Equipment, conveyors and bins are connected to dust control systems. Air is aspirated from the pieces of equipment through ducts that are connected to bag filters. The purpose is to contain the dust within the equipment and ducts, and conduct it to the filter, where it is recovered. Clean air is exhausted to the atmosphere and the dust is discharged from the filter by means of a rotary lock.

705 PRE-HEATING / CONDITIONING.

The cleaned seeds then proceed to pre-heater - conditioner, item 705.

The purpose of pre-heating - conditioning is to heat the oilseeds to 50-60℃, and soften them before flaking.

The stack heater consists of a succession of horizontal steam-heated pans stacked in a vertical shell. Indirect steam heat is introduced into the product via heated trays to warm the material. The seeds are introduced at the top of the vessel and are transported successively over each cooking pan, from top to bottom.

Each pan has an opening allowing the seeds to flow by gravity from one stage to the next. These openings are equipped with actuated gates that allow maintaining the product level to a preset height according to the required residence time. Gate actuation can be through mechanical links with level flags, or pneumatic.

Each successive compartment is equipped with sweep arms, connected to a central rotating shaft. The product is agitated and conveyed around the compartment by the slow moving arms connected to the central shaft via bolted hubs. Graphite drilled bronze bearings on the shaft maintain vertical shaft alignment. Long sections of vertical shaft are connected via bolted couplings. The shaft passes through a packing housing at the bottom tray, or in the roof, and is then direct coupled to a speed reducer. The speed reducer is driven by a fixed speed, high efficiency motor.

704 FLAKING

The warm, soft seeds, leaving the heater, are then sent to flaking. The flaking mills, item 704, are equipped with one pair of large diameter smooth rolls that will laminate the seeds into flakes. The distance from oil cells to surface is shortened in the process, and oil is available for extraction, through pressure in the expeller and with solvent in the extractor.

High roll pressure is necessary to form flakes of uniform thickness. This pressure is applied by means of a hydraulic system.

Each mill is equipped with a rotary feeder which distributes the material uniformly over the length of the rolls, at a constant and adjustable rate. Uniform feed is critical. The mills are in line and fed from a common chain conveyor.

Flaking releases moisture that migrates to the surface of the flakes, and could be a hindrance to pre-pressing and solvent penetration in the extractor. The surface moisture is removed by pulling air from the flakers discharge hoppers, item 730/04.

The moist air is pulled by a fan, item 736F. Entrained fines are separated in cyclone, item 714F, and discharged by rotary airlock valve, item 708F, into the flaker feed conveyor. The air is exhausted to atmosphere.

2. OILSEED CRUSHING BUILDING : SECTION 2700 DESMET CANOLA/SAFFLOWER PRE-PRESSING PLANT

2705 COOKING.

The flaked seeds are conveyed to the cooker-conditioner, item 2705. The purpose of the cooking-conditioning is to heat the flakes to almost 100℃, which softens the oil cells and facilitates the release of the oil. A moisture adjustment is also done. Drying the product in the cooker helps to transmit mechanical pressure to the product during mechanical extraction in the screw press.

The stack cooker consists of a succession of horizontal steam-heated pans stacked in a vertical shell. Indirect steam heat is introduced into the product via heated trays to warm the material. The latent heat of the steam is conducted through the steel tray and into a shallow layer of flakes being stirred above its upper surface. The condensed steam then exits the heated tray as condensate, has its flash steam recovered, and is returned to the boiler via a condensate tank.

The flakes are introduced at the top of the vessel and are transported successively over each cooking pan, from top to bottom.

Each pan has an opening allowing the flakes to flow by gravity from one stage to the next. These openings are equipped with actuated gates that allow maintaining the product level to a preset height according to the required residence time. Gate actuation can be through mechanical links with level flags, or pneumatic.

Each successive compartment is equipped with sweep arms, connected to a central rotating shaft. The product is agitated and conveyed around the compartment by the slow moving arms connected to the central shaft via bolted hubs. Graphite drilled bronze bearings on the shaft maintain vertical shaft alignment. Long sections of vertical shaft are connected via bolted couplings. The shaft passes through a packing housing at the bottom tray, or in the roof, and is then direct coupled to a speed reducer. The speed reducer is driven by a fixed speed, high efficiency motor.

The cooker-conditioner also allows drying the flakes. Air is pulled from several compartments in the lower part of the unit, and evacuates the moisture released.

The moist air is aspirated by the fan item 2736/05 through a stainless steel stack.

2700 MECHANICAL PRESSING.

The cooked flakes are transported to the press, item 2725. where part of the oil is expelled and the remaining solid part forms a cake, which is further de-oiled in the solvent extraction plant.

The flow to the press is precisely controlled and automatically regulated by a programmer that ensures an optimisation of the press efficiency.

The press separates oil from prepared feed material by generating a pressure on the material as it passes along the machine. The oil and the residual solid material are discharged for further processing.

Feed assembly

Prepared material is drawn from the cooker or the plant distribution system and metered into the press using a variable speed horizontal conveyor followed by a fixed speed vertical screw conveyor.

The feed assembly mounts on top of the press and its orientation and dimensions are selected to suit the mill layout. Both conveyors are direct-driven from geared motor units.

The horizontal section is designed to meter accurately without blocking and is fabricated in stainless steel. In the case of the vertical portion, a combination of heavy section carbon steel and stainless materials is used to minimise wear and corrosion.

Press

The pressing section of the machine consists of a worm assembly, which turns inside a drained barrel or cage. The worm assembly is carried on a high tensile shaft, which is supported between a coupling at the material feed end and a bearing at the cake discharge end.

The press frame is a heavy welded construction in carbon steel. It supports the drainage cage and the worm shaft and is extended to provide a platform for the gearbox. A conveyor is fitted in the base to discharge oil.

A thrust housing/coupling is attached to the frame to carry the axial load generated by the worm shaft and to connect the worm shaft to the gearbox output shaft. The gearbox is of standard helical multi-reduction design with a generous service factor and is located at the feed-end of the press.

The multi-stage low compression worm assembly is designed to minimise operating costs by using energy efficiently and resisting wear. The worm assembly is made of Gold Star® material.

The drainage cage is cast from SG iron for maximum strength and toughness. The two halves of the cage open to the horizontal to provide easy access for maintenance of the cage linings and the worm assembly. The cage linings are hard faced for long life and have a special cross-section to minimise blocking.

2717 OIL CLARIFICATION

The expelled oil is first dumped into the oil screening tank, item 2744 designed to remove the large solid meal particles that have been entrained. The solids settle in the bottom of this large capacity tank. A moving chain drags the bottom of the tank and pushes the solids over an inclined slotted surface. Oil entrained with the solids pass through the slot and fall back in the tanks, whereas solids are returned to the cooker or the press feed.

The screened oil flows then to the screened oil tank, item 2782A. Fine solids in suspension are still present in excessive quantity, and must be taken out. Hermetic filters are used for this purpose, items 2716A1-2.

2713 CAKE COOLING.

The hot canola press cake is friable and tends to crumble to powder which can create percolation problems in the extractor and excessive fines content in the miscella. It must be handled gently and, as far as possible, crisp cooled before reaching the extractor. Cooling is done preferably in a belt type cooler, item 2713. The cake being sticky, a fixed bed model is used. The cake is gently dragged over a fixed, slotted bottom. Ambient air is pulled through the bottom and the shallow bed to effect cooling. Cooling hardens the cake and reduces the risk of crumbling.

The cake is conveyed to the solvent extraction plant by means of a low speed chain conveyor, item 1A, through the safety zone.

Cake temperature is generally still high enough to cause solvent evaporation in the extractor inlet section. The extractor is equipped with a dedicated condenser, item 35, in which solvent vapours vented out of the extractor are immediately condensed. This prevent pressure build-up in the extractor feed zone.

3. OILSEED CRUSHING BUILDING : SECTION 700 – PREPARATION PLANT (CASE SOYBEAN)

PROCESS DESCRIPTION

The purpose of preparation is to weaken the oil containing cells and to shape the material in a form that makes the oil cells accessible for extraction, and ultimately achieve the desired capacity, high extraction yield (low milling defect), and high quality products (crude oil and meal), at low production cost. Extraction result is dictated in large part by the preparation.

As first step of preparation the beans are thoroughly cleaned of foreign material. Cleaning improves the quality of finished products, and reduces the wear in conveyors and process equipment.
The major preparation step consists in producing flakes, a shape that makes the oil cells accessible for hexane penetration and consequently full de-oiling. The temperature and the moisture are first adjusted to the best conditions that will allow uniform flaking and high hexane percolation in the extractor.

786 / 740 WEIGHING, CLEANING AND DESTONING

Identical to rapeseed & safflower – see above

703 SEED CRACKING.

The clean soybeans are then cracked in pieces, in the cracking mill, item 703.
The mills are equipped with 2 pairs of corrugated rolls. The top pair breaks the beans in halves to quarters, the bottom pair in quarters to eighths. The mill is equipped with a rotary feeder 703F that distributes the beans uniformly over the length of the rolls, at a constant and adjustable rate.

The cracking mills are also connected to the plant dust control system, and dust produced by the cracking of the seeds is aspirated and recovered in the bag filter system 703/16D.

705 SEEDS COOKING – CONDITIONING.

The cracked soybeans or grits proceed to the cooker-conditioner, item 705.

The purpose of the cooking-conditioning is to heat the grits to 65-70°C, and soften them. A slight moisture adjustment, to 10-10.5% can also be done. Those are the best conditions for good flaking.

The cooker consists of a succession of horizontal steam-heated cooking pans stacked in a vertical shell. Each successive compartment is equipped with agitating arms, connected to a central rotating shaft. The grits enter at the top and are swept successively over each cooking pan, from top to bottom. Each pan has an opening allowing the cracks to flow from one stage to the next. These openings are equipped with actuated gates that allow maintaining the product level to a preset height according to the required residence time. Gate actuation can be through mechanical links with level flags, or pneumatic.

The top stage of the cooker-conditioner is equipped with level switches that inform of the level of material and allow stopping the feed in case high level is reached.

704 FLAKING.

The hot, soft cracks, leaving the 705 are finally sent to flaking. The flaking mills, item 704, are equipped with one pair of large diameter smooth rolls that will laminate the grits into flakes. Oil cells are weakened in the process, and the oil becomes accessible to the solvent in the extractor. In addition, the shape of the flakes, with their large surface to volume ratio, plus the short distance from oil cells to flake surface, facilitate the liquid – solid contact, and the migration of the oil to the liquid phase. Soybean flakes of the right moisture, temperature and thickness also form a solid bed of adequate resilience and permeability in the extractor. Flake thickness recommended for a Desmet extractor is 0.30 to 0.35mm.
High roll pressure is necessary to form flakes of uniform thickness. This pressure is applied by means of a hydraulic system.

The flakes are collected in a slow moving chain conveyor and conveyed through the safety zone to the extraction plant. An air break is foreseen in the succession of conveyors transporting the flakes from the preparation plant to the solvent extractor.

4. SOLVENT EXTRACTION BUILDING : SECTION 3LM – DESMET EXTRACTOR GROUP

A DESIGN

The LM extractor is a horizontal, rectangular-shaped deep bed extractor.

- Here is how the LM works:

1. Material enters through an inlet hopper and is soon saturated with miscella - extraction starts immediately after entry.
2. After the initial saturation, the bed of material is continuously washed with counter-current stages of miscella.
3. The initial stages are totally immersed in miscella, maximising contact time.
4. The later stages percolate miscella through the bed to finalise the extraction process.
5. Rakes at the surface of the material bed, along with an upward belt slope, maintain percolation and prevent miscella contamination.
6. Since the miscella has more contact time to penetrate the flake than in shallow bed designs, thicker flakes can be used to achieve desired residual oil.

- Maximum Material / Miscella Contact:

Contact time is the single most important factor for the efficient solvent extraction of vegetable oils. To maximise contact time, the LM's initial immersion sequence enables the oilseed material to be completely surrounded with miscella. This is followed by a long percolation sequence to keep the miscella stages separated and extract the remaining oil.

- Ease of Operation and Visibility

The LM extractor has a straight shell with sight glasses located at each miscella nozzle allowing operators to view the entire miscella distribution by simply walking along one side of the upper part of the extractor.
Each miscella stage has one or two miscella nozzles with external adjustment to allow flexible operation on a variety of oilseeds and drainage rates.

In the bottom collection pan, the miscella weirs are positioned to ensure any overflow automatically passes to the more concentrated stage.
The extractor is designed to self-compensate for short-term process variations after initial adjustments.

- Improved Belt Design and Belt Cleaning

The oil-bearing material enters and is carried on a segmented belt conveyor composed of a series of frames, each fitted with wedge bar screens, and supported by rollers. The material discharges off the opposite end of the belt, into a discharge hopper.

Two belt washing devices and a mechanical scraper are provided on the return span of the wedge bar belt. The mechanical scraper removes any large pieces of material stuck on the belt surface, and is located inside the discharge hopper.
The first belt wash is installed just after the material discharge hopper, using high-pressure hexane to remove small residue of material left on the belt.
Finally, the second wash lubricates the belt with rich miscella just before the material enters, reducing the risk of fouling

- Special Rakes Maintain Percolation

Each spraying section is separated from the next one by an articulated rake, which scrapes the top of the bed. These rakes have a double purpose :

1. To restore percolation of the top surface of the bed, which might have been blinded with surface moisture or fines.
2. To prevent mixing of miscella between stages at the upper surface of the bed, by forming material barriers in front of each rake.

- Even Material Bed and constant Discharge

The feed hopper is provided with an ultrasonic level-control device. This device sends a signal to the variable frequency drive to automatically control belt speed. The material passes under an adjustable gate from the feed hopper, forming a very level material bed. Rakes along the way keep the material bed even across the full extractor width.

A rotary picker ensures a constant and uniform discharge of the extracted meal at the end of the extractor's moving-belt assembly.

- Clear Miscella

The full miscella is washed twice through the bed of flakes in order to reduce fines content before it exits the extractor. Only a one-pass liquid cyclone is needed for final miscella clarification.

B PROCESS DESCRIPTION

The prepared material is conveyed to the extractor via an en-masse chain conveyor, item 1A, which links the preparation section with the extraction unit and feeds the feed conveyor, item 1B, followed by the rotary valve 8A.

The feed conveyor, item 1B, is opened in its first part to ensure that any hexane vapour that would be accidentally present could not escape to the outside.

The extractor feed hopper, item 2, is equipped with a level controller that maintains the material level in the feed hopper by automatically adjusting the speed of the extractor belt.
A first spray of miscella in the feed hopper soaks the material, which increases its bulk density and also helps maintaining the optimum bed depth in the extractor.

In the extractor, item 3, the oil-bearing material is carried on an articulated belt conveyor composed of a series of frames, each fitted with stainless steel wedge bar screens.
As it moves through the extractor, the bed of material is thoroughly washed by a succession of liquid sprays, each one distributed uniformly across the extractor width.

Fresh hexane is returned from a solvent-water separator to a pre-heater and the final heater, item 49P1, up to a head tank, item 58P1. The latest feeds the high-pressure belt-rinsing pump, item P1HP, at a constant flow, while the hexane in excess overflows to the hexane distributor for the final extraction stage.

The hexane, extracting oil, becomes an oil-solvent mixture called miscella. After percolating through the bed and extracting oil, the miscella from each washing stage is collected in a corresponding hopper located at the bottom of the extractor, each of which feeds a pump, item P3. Each P3 pumps the miscella to the spray distributor installed above the same hopper or the next one. Individual valves permit to regulate the spraying rate in each circuit.

The miscella becomes progressively richer in oil as it progresses through the extraction stages, counter-current to the oil-bearing material.
At the material inlet side of the extractor, concentrated miscella is taken to the distillation system by a transfer pump, item P15.
The miscella has already been filtered by passing through the material layer, and is further clarified in hydro-cyclones, item 16H. Fines separated in item 16H are dropped back in the extractor.

Two belt rinsing devices are provided on its return span, the first one just after material discharge, using hexane, the second one, using miscella, at the tightening end. A dedicated hopper below each rinsing system collects the solid laden liquid, that is returned to the top of the material layer thanks to pumps item P2A & P2B.

This second rinse also lubricates the screen-belt just before it receives the new load of material, as a safeguard against hot and damp product sticking to the screens.

The belt is driven from an in-line gear reducer mounted directly on the drive shaft, and its speed is automatically adjusted through a variable frequency drive motor.

The transfer of extracted material to the desolventiser is constant and uniform, thanks to a scraper drum, item 3G, acting on the layer at the end of the screen-belt and to a variable speed screw installed in outlet hopper, item 4.

The extractor is connected to a vent condenser in order to keep it under slight negative pressure and ensure safe working conditions by preventing hexane escape.
The extractor is protected against excessive pressure by a relief valve that automatically opens and discharges vapours to the outside in case of accidental pressure build-up.

5. SOLVENT EXTRACTION BUILDING : SECTION 18H – 22HB - MISCELLA DISTILLATION, OIL FINISHING AND DRYING

A DESIGN DESCRIPTION

The miscella passes from the miscella tank to a first stage evaporator, miscella/oil heat exchanger, second stage evaporator, edible oil stripper, edible oil dryer, miscella/oil heat exchanger, edible oil cooler and on to crude oil storage.

- First Stage Evaporator – Item 60

The Desmet first stage evaporator concentrates the miscella from approximately 25 percent oil / 75 percent solvent to 80-90 percent oil / 10-20 percent solvent, depending on evaporator area and water temperature.

The first stage evaporator is a rising-film evaporator that operates at approximately 400 mbar (40 kPa) absolute pressure on the tube side, and is heated with DT and wastewater stripper vapours on the shell side. Miscella enters the vessel through a lower bonnet and the solvent begins to evaporate immediately after it enters the tubes. The solvent vapour quickly rises and pulls a thin film of miscella up the walls of the tubes to maximise evaporation efficiency. The concentrated miscella/vapour exits the tubes at high velocity and impacts an impingement plate to break bubbles. Two swirl deflectors then spin the miscella/vapour into a large dome mounted above. Solvent vapours exit the top of the dome to solvent recovery while concentrated miscella exits out the lower edge to a pump.

Large surface area insures maximum concentration of miscella with minimum temperature DT vapours. The tubes are large in diameter with segmental baffles to minimise pressure drop for DT vapours passing through the shell side. This low-pressure drop enables the DT to consistently operate under slight vacuum.

- Miscella / Oil Heat Exchanger – Item 81A

The Desmet miscella/oil heat exchanger increases the concentrated miscella temperature to approximately 75℃, while simultaneously cooling the oil from 100° C down to 70℃.
The heat exchanger is shell and tube type for ease in cleaning.

- Second Stage Evaporator – Item 18A

The Desmet second stage evaporator heats the miscella from approximately 75℃ to 100℃ and then concentrates the miscella from approximately 80-90 percent oil / 10-20 percent solvent up to 95-97 percent oil / 3-5 percent solvent.

The second stage evaporator is a special three-pass device with two-pass heat exchanger combined with a rising-film evaporator, all in one vessel. The first two heat exchanger passes operate with back pressure from a control valve, while the third, rising-film evaporator pass operates under approximately 400 mbar (40 kPa) absolute pressure. The entire shell side is heated with low-pressure steam. Concentrated miscella enters the vessel through a lower bonnet and is forced through two tube passes at high velocity to prevent fouling.

The hot, concentrated miscella then exits the lower bonnet and passes through an external control valve. After the control valve the miscella flashes and enters the tubes. The solvent vapour quickly rises and pulls a thin film of miscella up the walls of the tubes to maximise evaporation efficiency and prevent fouling. The concentrated miscella/vapour exits the tubes at high velocity and enters a separator dome mounted directly above the oil stripper. Solvent vapours exit the top of the dome to solvent recovery and concentrated miscella exits directly into the edible oil stripper below.

Large surface area insures maximum concentration of miscella with minimum steam pressure to minimise fouling. The special three-pass design maximises velocity to also minimise fouling. By minimising fouling, the unit increases uptime between vessel cleaning.

- Edible Oil Stripper – Item 18B/22A

The Desmet edible oil stripper concentrates the miscella from approximately 95-97 percent oil / 3-5 percent solvent up to 99.97 percent oil / less than 300 ppm (parts per million) solvent.

The edible oil stripper is a two-stage disc and donut vessel operating under approximately 400 mbar (40 kPa) absolute pressure. In the first stage, the oil cascades down over a series of discs and donuts while sparging steam ascends up from below. The counter-current, superheated steam acts as a stripping agent and carrier gas.
In the second stage, the oil completely floods the disc and donut section. The sparge steam bubbles up through the oil and the discs and donuts increase agitation and mixing.

A grid type stripper is used in very large plants instead of the disc and donuts. The column contains a series of horizontal grid trays distributed over its height. The oil is moving down through the slots of the grids, counter-current to the steam that is moving up. Oil and steam pass through the same slots. A level of oil is maintained above each tray. The sparge steam bubbles up through the oil.
Segmented baffles are used instead of disc and donuts in small plants.
Steam and hexane vapours that exit the top of the column enter an expanded dome where the velocity slows. Drips of oil, or foam collapse back into the column while solvent and steam vapour exits the side of the dome to solvent recovery.

- Edible Oil Dryer – Item 22B

The Desmet edible oil dryer concentrates the miscella from approximately 99.97 percent oil / less than 300 ppm solvent up to over 99.99 percent oil / less than 100 ppm solvent while simultaneously lowering moisture.

The edible oil dryer is a one-stage vessel operating under approximately 70 mbar (7 kPa) absolute pressure. The oil is sprayed into the vessel and downward through a series of grids to create a thin film and break foam. A very small amount of counter-current, superheated steam is added to act as a carrier gas if the oil does not have sufficient incoming moisture

Water and hexane vapours that exit the top of the edible oil dryer are pulled over to the edible oil stripper via a steam ejector. The ejector's spent motive steam is used as sparging steam in the edible oil stripper.

Degumming of the crude oil, when taking place in the solvent plant, is done after stripping and before final drying. The oil dryer then becomes part of the degumming section (item 506)

- Edible Oil Cooler – Item 81B

The Desmet edible oil cooler cools the edible oil leaving the miscella/oil heat exchanger from approximately 75° C down to 40°C.

The heat exchanger is preferably a shell and tube type for ease in cleaning, though a plate-type heat exchangers is often used.

Cooling medium is cooling water or boiler make-up water. Heat recovery at the boiler level is achieved by using boiler make-up water as cooling medium. The boiler water is pre-heated to approx. 55°C in the edible oil cooler, then is further heated to 95°C in the flash recovery tank.

- Vacuum Condenser – Item 19

The Desmet vacuum condenser condenses the vapours from the tube side of the first and second stage evaporators, vapours from the edible oil stripper, and vapours from the mineral oil stripper.

The condenser is a horizontal, split-flow, shell and tube design. The vapours enter into an expanded chamber at the top centre of the tube bundle. The vapours split and pass left and right above a horizontal baffle separating the top 2/3 of the condenser from the bottom 1/3. The vapours pass around each end of the horizontal baffle and back toward the centre. The vacuum ejector pulls from the lower centre of the condenser. The water flows through the condenser in three passes, from bottom to top. The coldest water contacts the final vapours to maximise the vacuum, generally achieving 400 mbar (40 kPa) absolute pressure with 30° C cooling water.

- Solvent Pre-heater – Item 23A

The Desmet solvent pre-heater increases the solvent temperature exiting the solvent/water separation tank from approximately 45°C up to approximately 57°C, while simultaneously condensing excess DT vapours and wastewater stripper vapours that have passed through the first stage evaporator without condensing.

The solvent pre-heater is a vertical, shell and tube type vessel. The tubes are on a square pitch with large spacing to minimise pressure drop on the shell side.

This vessel saves solvent heater steam, saves atmospheric condenser cooling water, and keeps the solvent/water separation tank cooler for better decanting with less emulsion.

- Atmospheric Condenser – Item 20B/C

The Desmet atmospheric condenser condenses the remaining DT and waste water stripper vapours that pass through the first stage evaporator and solvent pre-heater, the vapours from the extractor, as well as the vapours from the solvent/water separation tank, miscella tank, and solvent storage tanks.
The condenser is a typical shell and tube design.

- Solvent/Water Separation and Solvent Work Tank – Item 32/34

The Desmet combination solvent/water separation tank and solvent work tank decants the water from the solvent and stores the solvent prior to re-circulation back to the extractor.

The solvent and water enter the solvent/water separation tank on one end, at the interface elevation. The solvent and water pass through a plate pack to speed the decanting process by eliminating turbulence. After decanting, the solvent overflows a weir to the work tank, and the water flows out through an external adjustable standpipe to the wastewater stripper pump.

The Desmet design with plate pack allows the decanting process to occur in shorter time, saving tank size, foundation requirements, and process inventory.
The solvent/water separation tank has an on-line cleaning system to clean the bottom of the unit during normal operation, preventing the accumulation of dust on it.

- Wastewater Stripper - Item 45

The Desmet wastewater stripper heats the wastewater from 80°C to 95°C and evaporates trace hexane from the wastewater stream prior to discharge to the wastewater sump.

The wastewater stripper is a two-stage vessel. In the first stage, water cascades down across grid trays while waste vacuum condenser motive steam rises counter-current to the water flow to strip out hexane. In the second stage, a slight amount of live steam can be injected into a flooded section for final heating and stripping if required.

- Solvent Heater – Item 49P1

The Desmet solvent heater heats the solvent leaving the solvent pre-heater from approximately 57°C up to 60°C if needed.
The heat exchanger is shell and tube type with solvent on the shell side and low-pressure steam on the tube side.

B PROCESS DESCRIPTION

The miscella is transferred from the extractor section thanks to the pump, item P15, through the hydro-cyclones, item 16H, up to a small buffer tank, item 17, which works as a buffer to compensate and smooth the extractor small variations.

From this buffer tank, the pump, item P8, sent the miscella through a flow control - to adjust the flow of the miscella - to the first stage evaporator / economiser, item 60A. In this vessel, most of the solvent is distilled by mere recovery of the latent heat contained in the gases leaving the desolventiser-toaster.

The miscella is separated from the gases in the dome separator, item 60B. This vessel is a cyclone-type separator placed on top of the first stage evaporator 60A.

The pump, item P60, then sends the miscella to the oil/miscella heat exchanger, item 81A. There, the miscella is heated by the oil outgoing the distillation, and through the first heater, item 18A, heated by low-pressure steam. And from there, to the dome, item 18B, upper part of the stripper, item 22A. From the dome, the oil overflows to the stripper. This column operates at the distillation vacuum and, to complete evaporation of the hexane, necessary live steam is injected in counter-current to the oil falling flow.

From the striping column, thanks to the transfer pump, item P22A, the oil goes directly to the oil dryer, item 22B, working under deeper vacuum, maintained by a steam ejector, item 41/22B. The steam and the exhausted gas of this ejector are used as stripping steam in the stripper, item 22A.

The dried oil is then sent by the pump, item P22B, to the heat exchanger, item 81A, and to the oil final cooler, item 81B. The energy is recovered by pre-heating the boiler water.

The gases leaving the economiser and the evaporator are condensed in a condenser, item 19, maintained under vacuum by a steam ejector, item 41/19; the exhaust steam of this ejector is used in waste water boiler, item 45.

From the condenser, the mixture of condensed hexane and water is sent thanks to the pump, item P19, to the mixing water/hexane decanter, item 32/34.

All condensates, from condensers 19, 23A, 20B/C and from economiser 60, flow to the hexane water separator, item 32, in which these liquids are separated. Hexane is recycled through a solvent tank, item 34.
The pump, item P1, transfers the hexane to the extractor through a heat exchanger, item 23A, which uses the latent heat from the desolventiser gases after the economiser.

The overflowing water of the decanter is sent by the pump, item P32, to safety waste water boiler, item 45, through a heat exchanger, item 81C. The overflowing water is boiled thanks to the heat exchange, thanks to the steam from ejector 41/19 and from live steam direct injection whenever necessary. After safety boiling, the water overflows to the heat exchanger 81C and then to effluent water treatment. Venting of the safety wastewater boiler is connected to vapours inlet into the economiser, item 60.

The latent heat contained in the condensates from the heaters and from the double bottoms of the desolventiser-toaster produces - in a flash tank, item 46/70– low-pressure steam, that is used in production of hot water for boiler or other user.

6. SOLVENT EXTRACTION BUILDING : SECTION 100H - SOLVENT RECOVERY

The material to be extracted entrains into the extraction unit air that must necessarily be rejected to atmosphere. But in doing so, this air will entrain a certain amount of hexane, dependent on its temperature.

The hexane content is higher for higher temperature. At 55°C, the equilibrium concentration is of 10.9 kg of hexane per m^3 of air ! At 35°C, the concentration is reduced at 1.6 kg.

Using an absorption unit with a special mineral oil circulating in a closed circuit will drastically reduce the hexane loss.

The hexane-laden air leaving the condenser is brought into contact with mineral or vegetable oil, absorbing the hexane, sprayed in counter-current in the absorber, item 120. The air rises from bottom to top of the absorber and the height of the column and the number of successive stacks determine the absorption efficiency. Desmet uses columns with a huge height with two or three stacks. And the oil flow is designed according to the quantity of hexane to absorb, thus related to the plant capacity, but also according to the gas temperature, in order to limit the oil concentration at the column bottom.

The air, with a relatively low solvent content, is released from top of the column to the scrubbing system thanks to a fan, item 136. The fan is foreseen with a frequency inverter to allow the speed control in relation to the depression to ensure in the extractor or/and in the desolventiser head.

Now the hexane-laden oil has to be regenerated by evaporating its hexane content.

The oil is sucked at the absorber bottom by the pump, item P120, and is heated up firstly by heat exchange with desolventised oil in item 181A and then by low-pressure steam in item 121, to enter the stripper, item 122, at the required temperature. There the hexane is distilled and further condensed and recycled to the solvent circuit. To maintain the absorption oil qualities, it's important to desolventise it totally and to reduce its degradation. Working under vacuum and at a temperature of about 100°C and without air contact but with steam injection will ensure the best working conditions.

The oil is returned by the pump, item P122, to the absorber after cooling firstly in the heat exchanger, item 181A, and finally in water cooler, item 181B.

7. SOLVENT EXTRACTION BUILDING : SECTION 63 - SOLVENT STORAGE

For safety reasons, a storage volume equal to twice that of the solvent in circulation within the extraction plant is foreseen.

One tank, item 63A, will be dedicated to receive fresh hexane and the other one, item 63B, is foreseen to receive the overflow of the plant. Both are connected to separator, item 32A/B-34, for venting safety.

The pump, item P63, will transfer the hexane or the overflowing miscella to the plant.

8. SOLVENT EXTRACTION BUILDING : SECTION 70DIMDC - DESOLVENTISER-TOASTER-DRYER-COOLER

A DESIGN

The patented Desmet-DIMAX® D.T.C. is made of a cylindrical vertical body comprising :

- Compartments of indirect steam pre-desolventisation
- Compartments of direct steam desolventising-toasting
- Final stripping section
- Air drying/cooling section.

Material is conveyed around the vessel by slow moving sweep arms connected to a single shaft and underneath drive. It is designed for maximum steam stripping efficiency, while maintaining full control of the meal flow by limiting the pressure drop.
Meal cooling is done in compartments that constitute the bottom section of the DTC.

- Pre-desolventising Section

In the pre-desolventising section, a portion of the solvent is removed and the spent material is heated from 55-57 °C to 67-70 °C.

Indirect steam heat is introduced into the spent meal via heated trays to warm the spent material and evaporate solvent. The latent heat of the steam is conducted through the steel tray and into a shallow layer of meal being stirred above its upper surface.
The condensed steam then exits the heated tray as condensates, has its flash steam recovered, and is returned to the boiler via an atmospheric condensate tank. It is important to note that this source of heat does not add moisture to the meal. The amount of pre-desolventising is important to reduce D.T. outlet moisture, and therefore D.C. air heater steam consumption.

The top pre-desolventising tray is a disc-type geometry, forcing ascending vapours into the dome where their velocity is slowed to drop out most of the fines. The remaining pre-desolventising trays are donut-type geometry, keeping the maximum heat transfer area near the outside of the vessel where linear sweep speed is maximised to optimise heat transfer.

All pre-desolventising trays are of the disc-type geometry when processing materials that produce corrosive vapour.

Level control requires no external devices. The material simply passes over 330 degrees of the tray and then falls to the tray below in a sequential manner.

- Desolventising Section

In the desolventising section, the majority of the solvent is removed and the spent material is heated from 67-70 °C to 95-100 °C. Meal moisture increases by a few percentage points when the steam condenses. The increase in moisture is proportional to the amount of solvent still present in the meal after pre-desolventising.

Direct steam is introduced into a deep layer of spent meal from below in a counter-current manner as the meal flows downward. The steam condenses into the meal, providing its latent heat to vaporise a solvent-water azeotrope. This azeotrope vaporises as low as 62 °C, but most DT's are operated at 72-75 °C vapour temperature, or higher, to insure adequate safety factor.

The desolventising tray is full D.T. diameter with new, patented partial screen technology to support the meal while allowing the ascending steam to pass through the tray. This tray design, with 10 percent open area, has half the pressure drop of older Schumacher trays with 2 percent open area. The new tray insures very even distribution of the steam into the deep layer of meal above to minimise the depth of the condensation plane, thereby, keeping the formation of meal balls to a minimum.

Level control is automatic. The depth of meal is measured by a rotational level detector and sends a signal to a rotary valve or to an actuated chute lower in the DT.

- Stripping Section

In the stripping section, the temperature is increased and maintained at 105-110 °C and the moisture is maintained.

The live steam drops in temperature as it rises up through the meal, providing specific heat and a carrier gas to strip final traces of solvent from the meal. Also, time spent under high temperature and moisture conditions deactivates anti-nutritional factors in the meal.

The stripping trays are full D.T. diameter. The initial trays include the new, patented partial screen technology to support the meal while allowing the ascending steam to pass through the tray. This tray design, with 10 percent open area, has half the pressure drop of older Schumacher trays with 2 percent open area. The new tray insures very even distribution of the steam into the deep layer of meal above to optimise stripping. The final tray is a sparging tray with perforated upper plate for evenly introducing the superheated live steam into the meal.

Level control is automatic. The depth of meal is held fixed by a chute with one self-adjusting wall. The speed of the rotary valve in the lowest tray is automatically controlled by the level signal sent from the rotational level detector above.

- Air Cooling Section

In the air cooling section, the meal temperature drops from approximately 55 °C to 7 - 10 °C above ambient, while meal moisture drops from approximately 13 percent down to 12.0 – 12.5 percent.

Ambient air is blown directly into a deep air chamber with perforated upper plate for evenly introducing the air. From the air chamber, the air flows evenly up through the meal at an 18 – 20 m/min. velocity that enables fluidisation of the meal. Fluidisation optimises transfer of moisture and heat into the air. After picking up moisture, the air exits the vessel and passes to a cyclone collector. Dust is removed in the cyclone collector, and then the cooling air is returned to atmosphere.
Air is sometimes pulled through the meal rather than blown, when a close temperature approach is required between ambient air and final meal temperature.

Level control is automatic. The depth of meal is held fixed by a mechanical gate assembly that uses a direct linkage between a rotational level detector above to a rotating gate below. The gate is equipped with a pneumatic actuator when processing meals of differing flowing characteristics, or at different flow rates.
The lowest compartment is often equipped with a rotary valve of same design and control as the one equipping the DT.

- Main Drive

The meal is agitated and conveyed around the vessel by slow moving sweep arms connected to the central shaft via bolted hubs. Graphite drilled bronze bearings on the vertical shaft maintain vertical shaft alignment. Long sections of vertical shaft are connected via bolted couplings. The shaft passes through a packing housing at the bottom tray, and is then direct coupled to an underneath speed reducer. The speed reducer is a shaft-up, right angle configuration supplied with extra heavy thrust bearing. The speed reducer is driven by a fixed speed, high efficiency motor.

The main advantages of the design are :

- Excellent utilisation of the sparge steam evidenced by a low temperature of the gases at the outlet of the D.T.

- Efficient and homogeneous desolventisation of the meal. Even for products difficult to desolventise, the homogeneous distribution of the stripping steam permits to reach low residual solvent content in the meal without excessive toasting.

- Simplicity : DT and DC are combined into one piece of equipment.

- Vapour Scrubbing

Vapours composed of approximately 90-92 percent hexane vapour and 8-10 percent steam exit the top of the DT with slight amounts of entrained fines. These fines are scrubbed out of the vapours in the vapour duct by hot water sprays. The clean vapours and fines laden water are then separated in a vapour scrubber. Clean vapours exit to the first stage evaporator while the hot water is re-circulated back to the inlet duct. Fines laden overflow water in the scrubber is drained back into the DT with the meal.

- Vapour Condensation

The scrubbed vapours flow through a steam economiser, item 60, a solvent pre-heater, item 23A, and a surface condenser, item 20B/C.

They are progressively condensed by exchanging heat with miscella in the economiser / first stage evaporator, item 60, with solvent in hexane heater, item 23A, and with cooling water in condenser, item 20B/C.
All these heat exchangers are of the shell and tube design. Item 20B/C is designed and sized for condensing the total DT vapour flow when there is no heat exchange in items 60 and 23A.

B PROCESS DESCRIPTION

The extracted material laden with solvent is transported to the desolventiser - toaster - dryer - cooler by a chain conveyor, item 5.

The meal from the chain conveyor enters the desolventiser through a rotary valve, item 8B.
In the desolventiser, the meal will flow down as described here above in the successive sections before to reach the outlet.

The dust carried by the gases leaving the DT is separated in a wet dust catcher, item 29, fed by pump P29 circulating hot water in closed circuit.

From there, the gases flow through a steam economiser, item 60, a hexane heater, item 23A, a surface condenser, item 20B/C, and to the solvent recovery section.

Both the air leaving the drying section and the air leaving the cooling section are freed from dust in an adequate cyclone, item 14B, before being blown off to the atmosphere. The cyclone is equipped with a discharge rotary valve, item 8D/B.

Ambient air used for the drying is heated through a bundle heater, item 94, before entering the drying section. Adequate fans, items 36, are foreseen to push and pull the air through the drying and the cooling sections.

The meal is sent to storage thanks to conveyor 10A.

The steam condensates from the DT heating trays are collected in a flash tank, item 46/70, where latent heat produces low-pressure steam that is used in the distillation heating.
Condensates will then be sent back to boiler house or be used as washing water for the water degumming or similar use.

9. OILSEED CRUSHING BUILDING AND SOLVENT EXTRACTION BUILDING : NOTE ON VENT EMISSIONS

The release of odoriferous compounds is likely to happen while crushing canola due to presence of sulphur in the canola seed; crushing being the process of first conditioning and pre-pressing the seed, then solvent extracting the remaining oil in the cake.

The emission points releasing H_2S, which as a worst case scenario is assumed as a marker for the odor nuisances are combined at the level of each building as being of the same kind.
One combined vent for the oilseed crushing building, item 757B, and one for the solvent extraction building, item 29/57C.
These combined vents are going through a wet scrubbing system before being released at height by means of a stack (> 25m).

Stack 757B combines vents of the flakers, item 704, the pre-conditioner, item 705, the cooker, item 2705, the cake cooler, item 2713 and the filter blowing tank, item 2782C.

Stack 29/57C combines vents of the DT cyclones, item 14A & 14B and the recuperation vent fan, item 136.

To be noted that the remaining vents of the oilseed crushing building which are not releasing H_2S are also combined but in a different stack, item 757A, and released at height too (> 25m). It is combining vents of the destoner, item 717, the cleaner, item 740, the hammer mill, item 769 and the cracking mill, item 703.

It should also be noted that H_2S is produced under anaerobic conditions and that the residence time of hydrogen sulfide in the atmosphere is fairly short as it breaks down readily.

The vent gas scrubbers for stacks 757B & 29/57C are protected from dust coming in with the air system by a spray chamber located upstream of the scrubber, which will remove the particulates. The scrubber is of the packed column type and the scrubbing liquid a dilute alkali solution. In order to maintain the concentration of the alkali solution and also the quantities of fines a bleed off is foreseen, which will be sent to the water effluent treatment plant.

10. REFINERY BUILDING : SECTION 518 - CONTINUOUS WATER DEGUMMING OF CRUDE OIL

The crude desolventised oil is pumped to the oil-water static mixer, item 504A, where it is mixed with demineralized water. The aim of the mixer is to finely disperse the water in the oil phase

A flowmeter is provided to control the quantity of water added to the oil. The oil-water mixture is fed into the maturation column, item 503, where the degumming reaction takes place. The reactor is provided with a slow moving agitator, and with internal baffles, to maintain uniform residence time of 25-30 minutes. From there the mixture is pumped to the centrifugal separator, item 518.

Two phases are separated :
- a light phase i.e. the moist degummed oil (moisture : 0,3-0,4%)
- a heavy phase i.e. the gums emulsion (composition : approx. 40-50% water, 35-40% lecithin and 15-20% oil).

The degummed oil is then transferred through a heater, item 521, to the oil dryer, item 506. The edible oil dryer is a one-stage vessel operating under approximately 70 mbar absolute pressure. The oil is sprayed into the vessel and downward through a series of grids to create a thin film and break foam. A very small amount of counter-current, superheated steam is added to act as a carrier gas if the oil does not have sufficient incoming moisture
Vapours that exit the top of the edible oil dryer are pulled over to the edible oil stripper via surface condenser with vacuum pump, item 541/06.

The oil cooler, item 581B, cools the edible oil leaving the dryer from approximately 90° C down to 40 °C.

The wet lecithin emulsion falls by gravity from the separator into a small vessel, item 582GL. From there it is transferred by means of a positive displacement (volumetric) pump, item P582GL, back to the DT or to storage.

11. REFINERY BUILDING : SECTION W500 - ACID DEGUMMING WITH WASHING STAGE

GENERALITIES

A/ Physical refining - also called steam refining - is the combined neutralisation and deodorisation of fats and oils by steam stripping under vacuum.

This process is well suited to most edible oils provided they are thoroughly degummed and purified which is the main condition for producing first class edible end products.

Main advantages of the physical refining system towards the conventional one are:

1. The refining factor of the whole refining process is superior in physical refining than in chemical refining mode.

2. Moreover, in physical refining, there is no production of soapstock, a main source of pollution in alkali refining.

3. Production costs as well as investment costs are lower in physical refining.

4. The treatment of effluent water is reduced to a minimum i.e.: floor washing water and bleed-off of the barometric water systems from bleaching, deodorising and acid gums drying units.

To obtain first quality oils, it is essential to make sure the crude oils entering the neutraliser / deodoriser are free of impurities.
Specifically designed for the physical refining of unsaturated oils, the "acid degumming" is the first step in the refining line. However for complete elimination of all impurities and undesirable compounds, the oil can be further pre-treated and bleached.

Therefore physical refining of unsaturated oils, like soybean oil, sunflower oil, corn oil, etc ..., comprises 3 steps:

1. Acid degumming step with washing
2. Dry pre-treatment combined with bleaching step
3. Neutralising-deodorising step

B/ It should be noted that the refinery is also foreseen to work in chemical mode in case the crude oil quality doesn’t fit to the minimum requirements of the physical refining method.

Caustic refining is a process that chemically neutralizes crude vegetable oils and fats. It consists in mixing the oil with caustic soda, which saponifies the fatty acids present in the oil, and in removing this precipitate by centrifugal separation.

A preliminary step will allow the transformation of the non-hydratable phospholipids into hydratable form thanks to the action of a strong acid (usually phosphoric or citric). The phospholipids are then complexed by water present in the caustic soda solution and they will be separated from the oil together with the soapstock.

Remaining soaps are further reduced by washing the oil with hot process water.

This process is well suited to most edible oils and gives first class edible end products at the outlet of the refinery.

To obtain first quality oils, it is essential to make sure that the crude oils entering the deodoriser are free of impurities. Caustic neutralising and bleaching are the necessary processes that yield such purified oil.

Chemical refining of unsaturated oils, like soybean oil, sunflower oil, corn oil, etc..., comprises 3 steps:

1. Acid conditioning step
2. Neutralisation step
3. Water washing step

Usually, only two separators are used, one for removing gums and soapstock and one for the washing step. It is largely enough for most oils and it reduces investment, effluents as well as maintenance.

PROCESS DESCRIPTION

Acid degumming

Crude oil being transferred by the feed pump, item PW501, is at first heated up to about 75°C in heat exchanger, item W521A, by means of heat exchange with the outgoing oil. Then in heater, item W521B, the oil is further heated to 95°C by means of low pressure steam. After that the oil is mixed in contactor, item W504AC, with the acid coming from dosing device, item W534AC1-PW534AC1.

The intimate mixture oil/acid is introduced in multi-compartment reactor, item W503AC, where after a long and systematic sojourn of the oil, the non-hydratable gums are transformed to hydratable.

A second contact of the oil in mixer, item W504NA, with a diluted caustic soda, added by the dosing unit, item W578NA1-PW578NA2, is then carried out to agglomerate the gums before separation in the centrifugal separator, item W518NA.
The contact is ensured in the multiple-compartment reactor, item W503B. Heat exchangers, items W581A and W581B, are foreseen to adjust the oil temperature.

Subsequently, by means of pump, item PW503B, the degummed oil is pumped to heater, item W521C, and to the centrifugal separator, item W518NA. There the gums are separated from the oil, which is sent directly to the washing stage.

The gum phase is collected in a tank, item W582G, from where it will be pumped with the pump, item PW582G, either to a dryer or to any other treatment.

Washing

After the separation of the gums, a washing stage is usually performed in order to reduce further the phosphorus content. So the oil passes first through the oil heater, item W521W, and then through a mixer, item W504W1, where hot water and some citric acid are dosed. Citric acid is added by the dosing unit, item W578AC-PW534AC2. After a short reaction time, in item W503W1, the oil is sent to the washing separator, item W518W1.

The hot soft water (usually boiler feed water or steam condensates) is buffered in the hot water tank, item W578HW1, and supplied by pump, item PW578HW1, in a pressurised loop system.

The wash water is collected in a decanter, item W532C. Any recovered oil is recycled with the pump, item PW532C, towards the crude oil tank, item W501.

By adding this stage, the unit is also more flexible and could be able to process oils in chemical refining mode in case the crude oil quality doesn't fit to the minimum requirements of the physical refining method.

12. REFINERY BUILDING : SECTION T5/600PU - DESMET DRY PRETREATMENT COMBINED WITH CONTINUOUS BLEACHING

GENERALITIES

Physical refining - also called steam refining - is the combination of neutralisation and deodorisation by steam stripping under vacuum.

The process is particularly well suited for most edible oils provided they are thoroughly degummed and purified which is the main condition to produce first class edible end products.

The main advantages of physical refining over conventional refining are the following:

1. The refining factor is 1,1 against 1,8 with conventional systems; moreover, with the physical refining, there is no production of soapstock, which is the main source of pollution with the alkali refining.

2. Production as well as investment costs are lower with the physical refining.

3. No treatment whatsoever of the effluent water is necessary.

The oil which has been already acid degummed still contains some traces of phosphatides, metals and other minor undesirable compounds which have to be thoroughly removed prior to deodorisation-neutralisation.

For this purpose, the oil is again treated in a dry pre-treatment with a strong acid; it is then introduced in bleaching section in which all precipitated compounds by the action of acid and bleaching earth, are removed by filtration.

PROCESS DESCRIPTION

Acid degummed oil from washing stage is sprayed under vacuum into the buffer tank, item T501, to be dried. From there, it will be transferred by pump, item PT501.

Acid degummed oil pumped from the centrifugal separator is introduced into acid mixer, item T504, in which acid is continuously fed via a dosing pump, item PT534AC.

The intimate mixture oil/acid is then introduced into mixer, item 635, where oil is mixed with bleaching earth stored in earth tank, item 630A, and delivered by a variable speed metering screw, item 607A.

Upstream of this and dependant of the outgoing specifications of the oil, the oil can be first mixed with activated carbon. The intimate mixture oil/acid is then first introduced into mixer, item T503AC, where oil is mixed with activated carbon stored in carbon tank, item 630AC, and delivered by a variable speed metering screw, item 607AC.

From the bottom of the multi compartment reactor, item 635, the oil is sucked into the upper part of the bleacher (heater part), item 621, where it is heated up to the required temperature.

This procedure ensures optimum deaeration of both oil and earth, as well as intimate mixing of both together with acid activation.
From there, the oil overflows to the bleacher itself, item 622.

Vertical partitions ensure a uniform flow of the mixture and a well-determined retention time without any risk of short-circuiting. Finally, the oil-earth mixture is sent to filters, item 616A, by means of pump, item P622.
The filters are of the hermetic type operating alternatively.

The filtered oil is kept under vacuum in filtered oil receiver, item 682B, to avoid any oxidation at this stage of the refining line and then pumped with the pump, item P682B, through security filter, item 616C, to ensure that traces of impurities are eliminated.

After the filtration operation, oil recovery from spent cake is done by steam blowing and the spent cake is discharged and evacuated. The vapours are collected into a decanting tank, item 682A, and condensed into a condenser, item 629.

The filter cake discharge needs no manual intervention, as vibrations from the filter leaf detach the cake of earth, that falls in the discharge chute, item 657CK.

<u>THE MAIN ADVANTAGES OF THE DESMET SYSTEM ARE :</u>

- Savings of both labour and floor space, as well as in a lower bleaching earth consumption to obtain the same bleaching result.

- Accurate and convenient metering of oil and earth for obtaining quickly oil of the desired colour.

- Continuous and perfect dispersion of bleaching earth in the oil, ensuring simultaneous and intimate contact of all earth particles with the processed oil under optimum conditions of vacuum (75 mbar), temperature (90-100℃).

- Uniform holding time of the oil-earth mixture in the bleacher (30 minutes).

- Oil filtration in hermetic leaf filters with stainless steel frames and cloths, requiring no maintenance.

- Filtered oil is kept under vacuum during whole process.

- No formation of decomposition residues.

- No decantation/settling during bleaching, due to effecting agitation.

- A safety filter is foreseen for removal of possible earth traces after main filtration.

- Oil content in spent cakes not exceeding 24%.

- No mechanical agitation for the bleacher since it is equipped with the unique Desmet sparge steam agitation device. The live steam injected in the oil actually increases the de-coloration efficiency of the activated earth.

- Virtually no maintenance of the bleacher is necessary.

- The filtration operation is completely computerised thus avoiding any human supervision. A few valves only must be operated to control cleaning of the filters, which can easily be done by the operator in charge of the other refining sections, especially as these are also continuous in operation.

13. REFINERY BUILDING : SECTION 800QPU - DESMET CONTINUOUS OIL NEUTRALISING / DEODORISING PLANT QUALISTOCK®

GENERALITIES

THE QUALISTOCK® DEODORISER

Our deodorising plants have always been very valuable tools at the disposal of the vegetable oil industry. Nowadays the demands of the market are more exacting than ever before. The key word today is simplicity - simplicity of design and of operation in more and more complex markets
This new challenge is highly stimulating. We have modified our previous generation of continuous deodoriser, integrating the entire process into a low maintenance single tower called the QUALISTOCK®.

Starting from the top the QUALISTOCK® incorporates:
- Final heating of the oil
- One or more deodorising compartments
- Heat recovery where deodorised oil is cooled and undeodorised oil is heated.
- Oil discharge buffer compartment
- Neutral oil recovery compartment
- Feed buffer/ deaeration compartment
- Vapour scrubbing

Oil enters the feed buffer compartment from where it is pumped through coils in the heat recovery compartment. The oil is heated by hot deodorised oil on the outside of the coils.

From the heat recovery coils the oil passes to the top of the deodoriser and then flows by gravity through the deodorising compartments and the heat recovery compartment to the oil discharge buffer.

Vapours from each compartment enter a chimney in the centre of the deodoriser, which leads to the vapour scrubbing compartment. The entrained neutral oil is separated from the vapours in the neutral oil recovery compartment..The chimney also reinforces the columns construction.

This concept has enabled us to design a number of standardised vessels covering virtually every deodorising capacity. The design of each section of the deodoriser is modular so that different compartments can be easily added to, or taken away from, the standard configuration if a special design is required. Building the deodoriser from standard modules facilitates design and construction leading to a fast delivery time with strict quality control.

In the heat recovery section the two oil streams flow countercurrently at a constant flow rate in order to maximise the efficiency of heat transfer. The energy required to heat the oil and the water to cool the oil are therefore kept to a minimum. There are no major fluctuations in the use of utilities so that the peak demand rates are kept low.

The deodorising and all additional processes are operated at the same vacuum (2 to 3 mbar). Performing the heating and cooling at low pressure, with continuous steam agitation, preserves the quality of the oil. The quality of the oil is further guaranteed by using the ideal combination of processing time and temperature.

Advanced automation simplifies the operation and monitoring of the equipment.

PROCESS DESCRIPTION

1. The de-aerator / buffer feed tank

The bleached oil, fed at constant flow and usually at a temperature of 85-95℃, is first de-aerated in lowest oil tray, item 802. It constitutes an integral part of the deodorising tower and works at the same vacuum as the deodoriser. The tray also acts as buffer feed capacity.

2. The Oil Heat Exchange

Oil is sent by pump, item P802, through a heat exchanger tray, called item 880A, to be pre-heated by the heat exchange with the deodorised oil to a temperature between 190° and 210℃.

The heat exchange is counter-current. Bleached oil circulates inside the coils of the cooling tray, cooling the deodorised oil to a temperature of about 135℃. Depending on the capacity, the heat exchange coils take up one, one and a half or two levels of the deodoriser.

3. The Final Oil Heating Tray

In this upper tray, item 821A, the de-aerated and preheated bleached oil is heated up to the final deodorising temperature by immersed coils, which are fed by high-pressure steam.

This tray can be described as an annulus containing several pigtail coils, which are all connected to circular headers. The tray has been dimensioned for ease of access and maintenance.

The oil entering the heating tray flows along the coils and then overflows into the first deodorising tray. The channel is equipped with live steam gas lift pumps (also called mammoth pumps), located in middle of each coil, to increase the heat transfer coefficient by thorough agitation.

All trays have a 3° slope to allow drainage but this is not enough to cause a significant variation in oil depth.

4. The Deodorising Trays

The deodorising trays, item 822Q, like the heating stage above, are designed as an annulus but here it is divided into 2 or 3 concentric channels. The oil enters at the centre of the compartment and follows a long serpentine path until it reaches the discharge point at the outside. The long oil path ensures an even residence time for each oil particle.

Sparge steam distribution throughout the oil path is enhanced by a series of so called "mammoth" pumps and steam distribution pipes containing many holes. The mammoth pumps are made out of conical pipes and designed for long life and ease of maintenance

The oil is vigorously agitated by steam injection in each successive deodorising compartment.

In addition to the systematic contact of all parts of the oil with steam, the large surface area exposed to vacuum ensures highly effective deodorisation.

The residence time is calculated according to the customer requirements. To obtain this time the number of stages varies according to the capacity and the deodoriser diameter. Sometimes, the last stage is a shallow bed tray containing steam injection pipes but no mammoth pumps.

5. The Cooling Tray

The oil coming from the final deodorising tray is discharged by gravity into the cooling tray, item 880A, operated under the same vacuum as the whole tower.
This cylindrical tray is divided into successive sectors or compartments, each of them containing coils. Coils are wound around a hollow pipe, in order to reduce the oil volume and to enhance the efficiency of the heat exchange. Live steam is continuously injected below each coil in order to improve heat exchange and eliminate undesirable volatile material.

On passing through the compartments, the temperature of the deodorised oil is lowered to about 135℃, by countercurrect flow with bleached oil circulating in the coils.

Like all of coils in this equipment Desmet's long experience has lead to an efficient heat transfer design with a robust and precise standard of construction. For some capacities there are heat exchange coils in part or all of the following compartment.

6. Deodorised oil buffer Tray

Deodorised oil overflows into this compartment, item 880B, that acts as feed compartment to the outgoing oil pump, item P822.
Citric acid or any antioxidant in a water solution can be added at this stage and still under vacuum.
From there, the oil is pumped to final cooling and polishing filtration.

7. Central chimney and neutral oil recovery Tray

Vapours from each compartment enter a chimney located in the centre of the deodoriser. The vapours undergo a 180° turn in the neutral oil recovery compartment, item 808, so as to separate the entrained neutral oil from the vapours. The neutral oil is recuperated in the feed buffer/deaeration tray, item 802, while the vapours flow to the fatty acids recovery tray, item 814/23.

8. The fatty acids recovery Tray

The fatty acids recovery tray is a combined condenser/separator (item 814/823). Scrubbing of the deodoriser vapours with cooled fatty acid, allows virtually recovery of all the fatty matter present.
All gases collected in the central chimney are washed by a series of sprays of cooled liquid fatty acid, once co-currently and once counter-currently. On exiting into the final compartment the gas velocity slows to allow disentrainment of droplets. Liquid fatty acids accumulate at the bottom of the vessel, from where they are sent by pump, item P814AG, through a cooler, item 881AG, and back to the sprayers. P814AG also sends the excess fatty acid to the customer's storage tank.

Let us point out another important factor: the large vapour ducts reduce the pressure drop to a minimum leading to a low pressure inside the deodoriser itself.

9. Final oil cooling

Finally, the oil is transferred by pump P822 and cooled down to storage temperature in external heat exchangers. The oil enters water-cooled shell and tube heat exchanger, item 881B1 which, when required, also acts as a shutdown cooler. Final cooling is by a water-cooled plate heat exchanger, item 881B2.

After final cooling, filtration in hermetic polishing filters, item 816B removes the last traces of impurities.

In Conclusion

The QUALISTOCK® deodoriser is easy to install and operate, low maintenance, highly efficient and trouble free.
It is the latest of a long tradition of excellence.

THE DESMET CONTINUOUS DEODORISER QUALISTOCK®

The most important features of this design are as follows:

* All items are assembled in one single self-standing tower; this dramatically simplifies the erection and the building costs.

* Ideal bed height, large evaporation surface and efficient neutral oil recovery tray to limit entrainment.

* Large number of sparge steam holes per square meter and efficient steam lift agitation pumps.

* Chamfered sparge steam holes to avoid blockage.

* All equipment and piping, which are in contact with the oil, are made of stainless steel, guaranteeing excellent end-product stability.

* Particularly efficient fatty acids condensation, done by means of cooled liquid condensed fatty acids flowing once co-currently and once counter-currently with the vapours.

* High-purity condensed FFA.

* Top heating tray with a large evaporation surface to avoid carry-over, especially for physical refining of olive or other foaming oils.

* The oil cannot be overheated due to the constant immersion of the heating coils.

* Very systematic deodoriser design to avoid short-circuiting and ensure a constant residence time.

* Very easy access to the deodoriser trays for occasional inspection.

* Coils constructed to rigorous standards

* The oil is deaerated before it is heated inside the deodoriser.

* The low operating pressure in the deodoriser of 3 mbar or less is made possible by the use of large diameter vapour ducts.

* Cooling the deodorised oil under vacuum ensures the best possible quality. Cooling under pressure in spiral heat exchangers or other closed devices is not recommended, particularly for unsaturated oil.

* The excellent scrubbing system limits the contamination of barometric water (when processing non lauric oils) to 8 –10 ppm of fatty matter for each pass of water through the condenser.

* The installation is such that no cold surface is in contact with the oil or cold gases. By this way, re-condensation of the distilled FFA or other matters is avoided before gases reach the condensation tray.
  And what is more, all internal parts are maintained at a constant temperature so that there are no cyclic loads that could lead to metal fatigue.

14. REFINERY BUILDING : SECTION 800BW - BAROMETRIC WATER CHILLING SYSTEM

In order to reduce motive steam consumption and effluent water of the vacuum equipment, the vacuum condenser will be operating with chilled water at 10℃ so that the barometric vacuum will be about 20 mbar.

The motive steam of the vacuum unit booster will be drastically reduced compared to the motive steam necessary for two boosters in series, when cooling water is somewhere in the range of 32℃.

The condensed water volume is thus much reduced and can easily be treated It includes oil and fatty acids that escape from the fatty acids scrubbing system. The effluent water will decant in the barometric legs tank, item 832B, and overflows from top.

A circulating pump, item P832B, keeps the water in circulation through the heat exchangers, item 881W, back to the barometric condenser. A circulation of chilled water does the cooling. The circulating pump, item P878GL, takes the oil from the buffer tank, item 878GL, through the chilling unit, item 811, to the heat exchangers.

To avoid clogging, caustic soda, distributed by a dosing pump, item 834NA, keeps the pH of the water on the alkali side.
The number of heat exchangers includes always one in stand-by in order to have the possibility of cleaning them in place. A pump, item P878W, is foreseen to circulate the cleaning solution from the doubble tank, item 878W, through the heat exchanger back to the C.I.P. tank.

The pumps are controlled and the heat exchangers are equipped with ON/OFF valves.