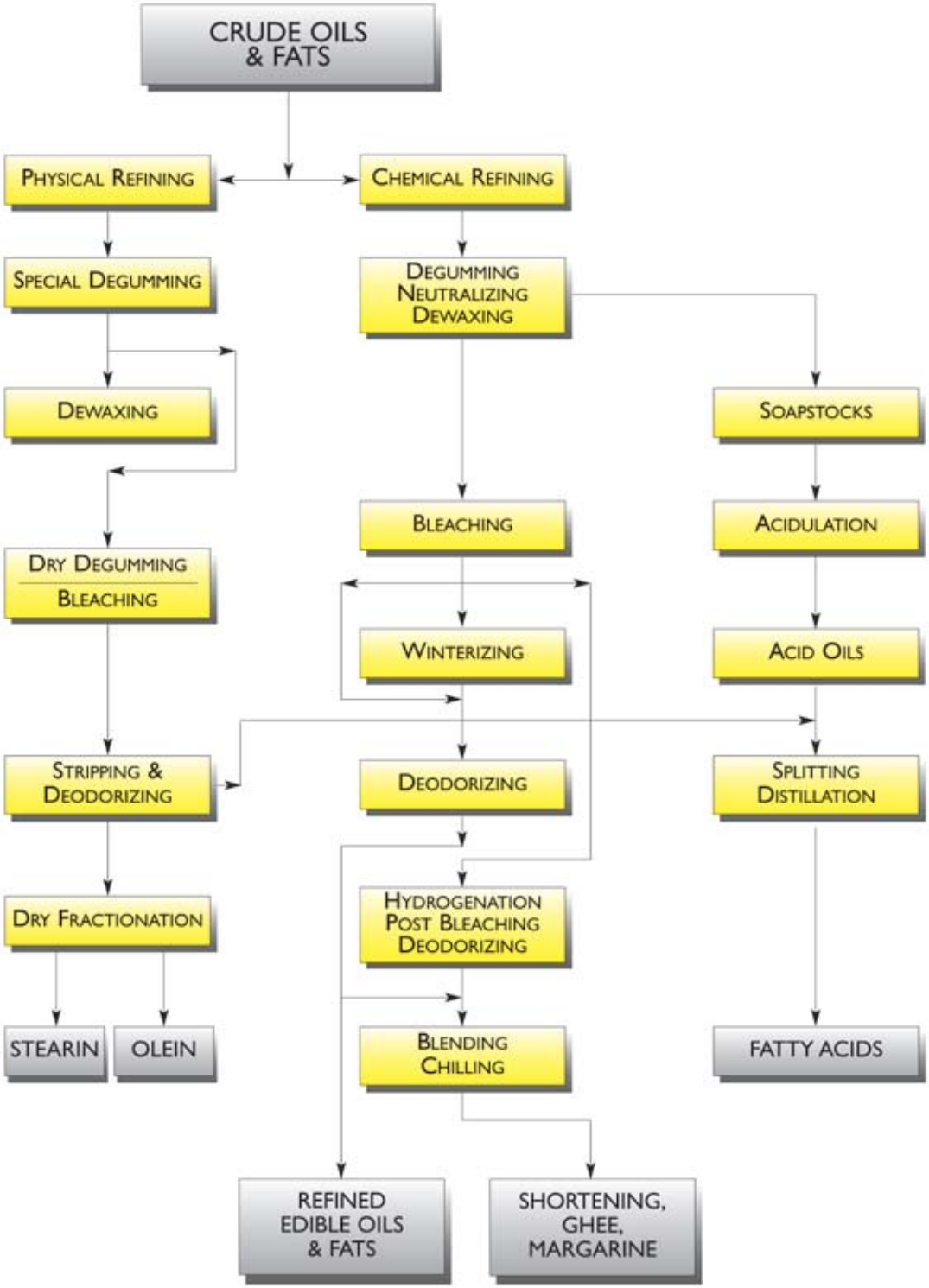
EDIBLE OILS AND FATS REFINING

BASIC TECHNICAL INFORMATION

GIANAZZA International

INDEX

EDIBLE OILS AND FATS REFINING



1. EDIBLE OILS AND FATS REFINING

EDIBLE OILS AND FATS REFINING

The most frequent and important application of oily seeds and natural fats is by far in the field of edible products.Gianazza International has been active in the manufacture of edible oil refining plants for over one century and now it is engaged in the development of advanced technologies and optimization of the ones already available, in terms of energy saving, pollution control and process automation.This booklet is aimed at giving information about the solutions that can be proposed according to the process block diagram on the previous page (from single plants to complete oil mills on turn-key basis).


1

Two refining methods are available basically:

- ALKALI REFINING (or classic chemical refining)
- PHYSICAL REFINING

In comparing the two refining systems, the following facts should be considered:

REFINING METHOD	CHEMICAL	PHYSICAL
Applicability	Almost no limit	Not recommended for some oils and fats
Final quality and keepability	Good to excellent	Some reserves on keepability
Oil yield	Standard	Higher
Degumming requirements	--	Very critical
Bleaching agent requirements	Standard	Higher
By-products	Diluted soapstocks	Fatty acids and deodorizing distillates
Effluents waters (quantity/quality)	Higher quantity/ Heavy pollution	Lower quantity/Minor pollution

In modern oil mills, where different types of oils and fats are processed, the best solution is often represented by an "universal" refining system suitable to perform, to the Customer's option, both chemical and physical refining process (the investment for an universal plant is only slightly higher than the cost of a standard chemical or physical refining line).


2

1 - Multipurpose refining plant - (Turkey)
Capacity: 300 t/d

2 - Continuous deodorizing plant

2. ALKALI REFINING

This refining process can treat almost any kind of edible oils and fats but it involves the production of soapstocks and has a refined oil yield lower than the one physically obtainable even if of more stable quality in the time. The standard steps in this refining process are:

- NEUTRALIZATION
- COMBINED NEUTRALIZATION AND DEWAXING (for sunflowerseed, corn and a few other oils)
- BLEACHING
- DEODORIZING

NEUTRALIZATION
In case of small capacities, batch or semi continuous plants (based on repeated runs) are proposed. Starting from 50 ton/d, fully continuous plants are recommended using centrifugal separators. The ideal continuous process foresees the use of three centrifuges (one neutralization stage plus two washing stages), but modern plants normally use two separators only, with the following process steps:

1. ACID CONDITIONING
2. REFINING (treatment with caustic lye and soapstocks removal)
3. WASHING (with water)
4. DRYING (under vacuum)

The acid conditioning is normally using food grade phosphoric acid for removing phosphatides that will be mixed with soapstocks and discharged.
In case phosphatides have to be recovered, a preliminary water degumming is necessary.
Metering pumps with double head or flowrate controllers enable to dose the lye and the process water at the wanted rate and concentration.

YIELD & PRODUCT QUALITY
The neutralization yield depends on the quantity of non-oil matter (FFA etc.), generally called Wesson loss (W) or Theoretical loss (T_L) according to the following formulas:

$L = 0,3 + 1,25\ T_L$ for $T_L \leq 3\%$
$L = 1,35\ T_L$ for $T_L > 3\%$
where:

L = Refining loss
T_L = Theoretical loss, % weight
T_L = (FFA + phosphatides + moisture + impurities + 0,3)%.

Typical quality parameters that can be obtained are:
- Acidity: 0,05 to 0,10% FFA
- Residual soap:
  100 ppm after one washing
  50 ppm after two washings
- Moisture (after vacuum drying):
  0,10%

Line of centrifugal separators for neutralizing/degumming plant

3. COMBINED NEUTRALIZATION AND DEWAXING

Some vegetable oils, mainly sunflowerseed oil and corn oil, contain waxes that give the oil an unpleasant cloudiness when cooled down to temperatures available in domestic refrigerators. In order to avoid this problem, it is necessary to submit the oils to a DEWAXING treatment.
The WET DEWAXING, carried out in fully continuous operation by using centrifugal separators and combined with the neutralization step, can be made in two different ways:

- COLD REFINING
- WET DEWAXING

COLD REFINING
Generally used for good quality sunflowerseed oils with low acidity, it involves the following steps by using two centrifugal separators only:

- ACID CONDITIONING
- COOLING & CRYSTALLIZING
- COLD REFINING & DEWAXING
- HOT WASHING
- VACUUM DRYING (optional)

In this process the soapstocks and the waxes are mixed and removed at the same time.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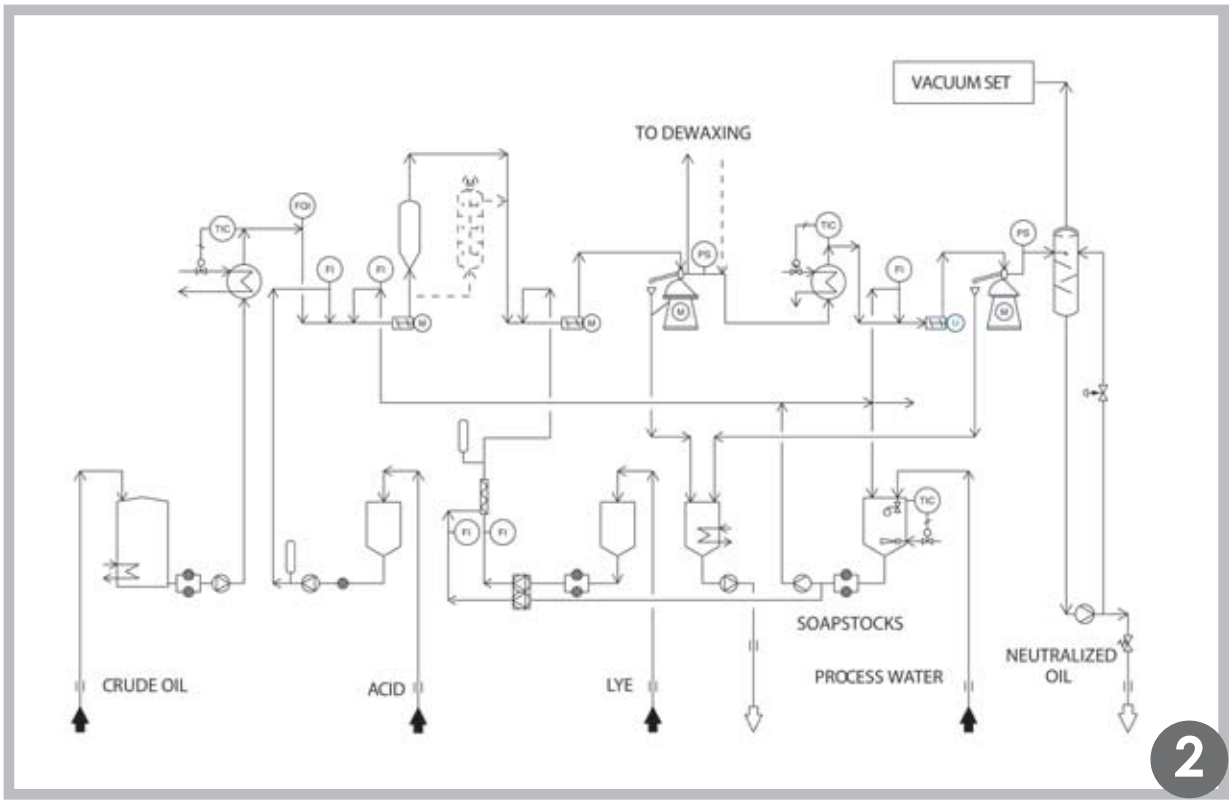

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1 - Line of centrifugal separators for neutralizing plant

2 - Neutralizing plant (schematic drawing)

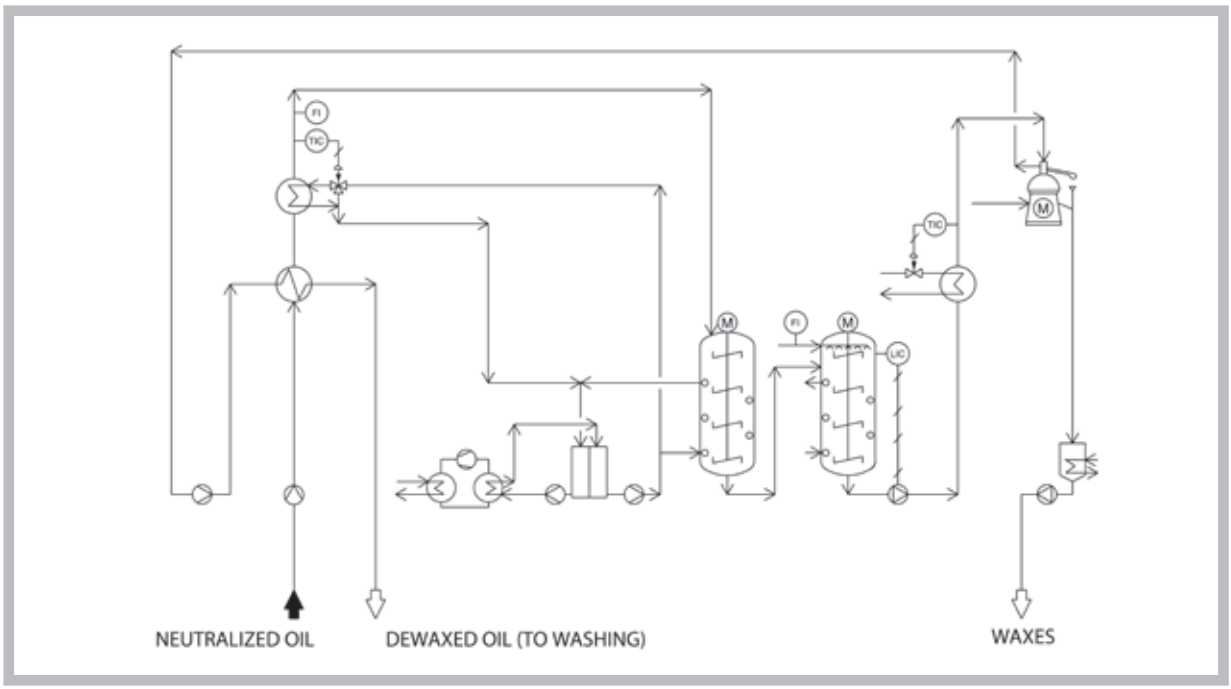
3.1 COMBINED NEUTRALIZATION AND DEWAXING

WET DEWAXING
Generally used for poor quality sunflowerseed and corn oils, it involves the following steps by using three centrifugal separators:

- ACID CONDITIONING
- HOT REFINING (soapstocks removal)
- COOLING & CRYSTALLIZING
- DEWAXING (WAX REMOVAL)
- HOT WASHING
- VACUUM DRYING

In this process the soapstocks and the waxes are separately removed by means of two centrifugal separators.
In both systems (cold refining and wet dewaxing) the oil is cooled at 7 ÷ 8°C and then sent to crystallizers where it remains from 8 to 12 hours.
In order to reduce the oil viscosity without dissolving the formed crystals, a light increase of the oil temperature up to 15°C is carried out before sending it to the dewaxing separator.
A typical flowdiagram of the dewaxing stage is shown below: by coupling the same with the flowdiagram of the refining plant on the previous page, a typical combined hot refining and wet dewaxing plant is obtained as final result.

YIELD & PRODUCT QUALITY
Different formulas have been proposed to express the loss of oil in combined refining & dewaxing processes.
In COLD REFINING the acid oil obtained from soapstocks generally has an acidity in the range of 30÷50% FFA or lower.
In case of crude oil with acidity higher than 1÷1,5%, the process of WET DEWAXING (combined with hot refining) is preferred since it reduces the total losses of neutral oil.
As to cold stability, both systems are unable to remove the waxes entirely; the "cold test" is, therefore, generally 24 h at 5°C (or 5,5 h at 0°C).
Whenever a more stringent "cold test" is requested, the process should be completed by a FINAL POLISHING DEWAXING to be carried out on the refined oil by filtration of cold oil with filter-aid or on paper.



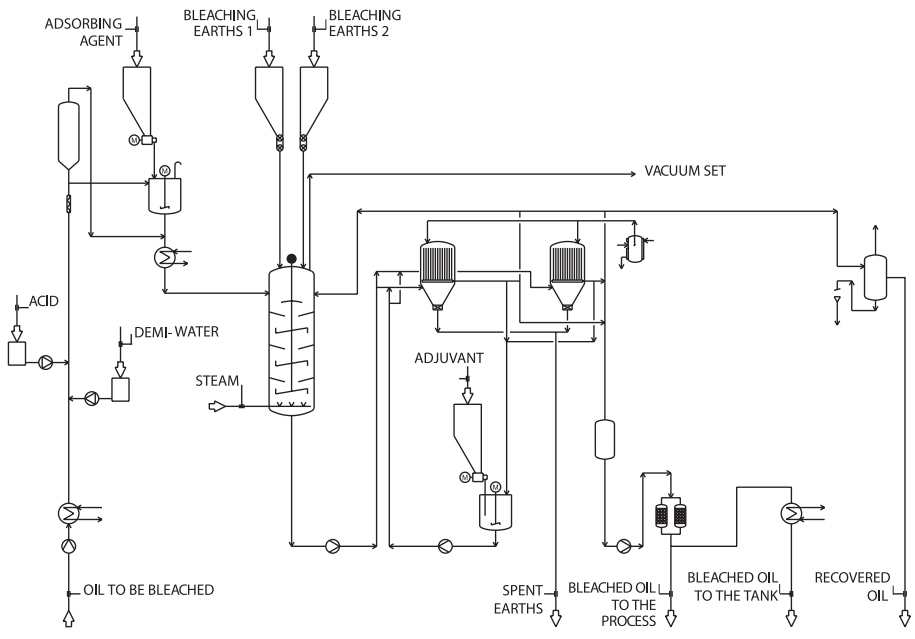
Wet Dewaxing plant (schematic drawing)

4. BLEACHING

Bleaching basically consists of impurities and colouring matter adsorption by means of bleaching agents: this operation is carried out under vacuum.
Bleaching earths (acid activated or not) of different grades and types are typically used as adsorbing agents.
Although the purpose of bleaching is to improve the colour of the oil, it is actually a refining step that removes many impurities, mainly soaps remained in the oil after alkali refining and phosphatides.
Fully continuous plants are available for capacities of 25 t/d upwards: the operation is rigorously continuous in the bleaching step proper, while filtration is semi-continuous in the sense that there is one filter in operation while the second one is being regenerated (sometimes one filter only is used, stopping the plant during the regeneration phase of the filter).
The filters are generally of vertical shape, equipped with stainless steel pressure leaves and discharged automatically by a vibrator (the whole operation can be automated, of course).
The flowdiagram of a typical continuous bleaching plant is shown here below.

YIELD & PRODUCT QUALITY

The bleached oil is practically free from solid impurities, moisture and soaps; phosphatides and heavy metals will be drastically reduced.Concerning yield, the loss of oil in the spent cake depends on care and modality of cake blowing: it can be as low as 20÷25% or less, according to the type of oil (solid fats or hydrogenated oils may have a higher loss).
The spent earths can be deoiled up to an oil residual of 5% approx. by means of a particular system using solvent.

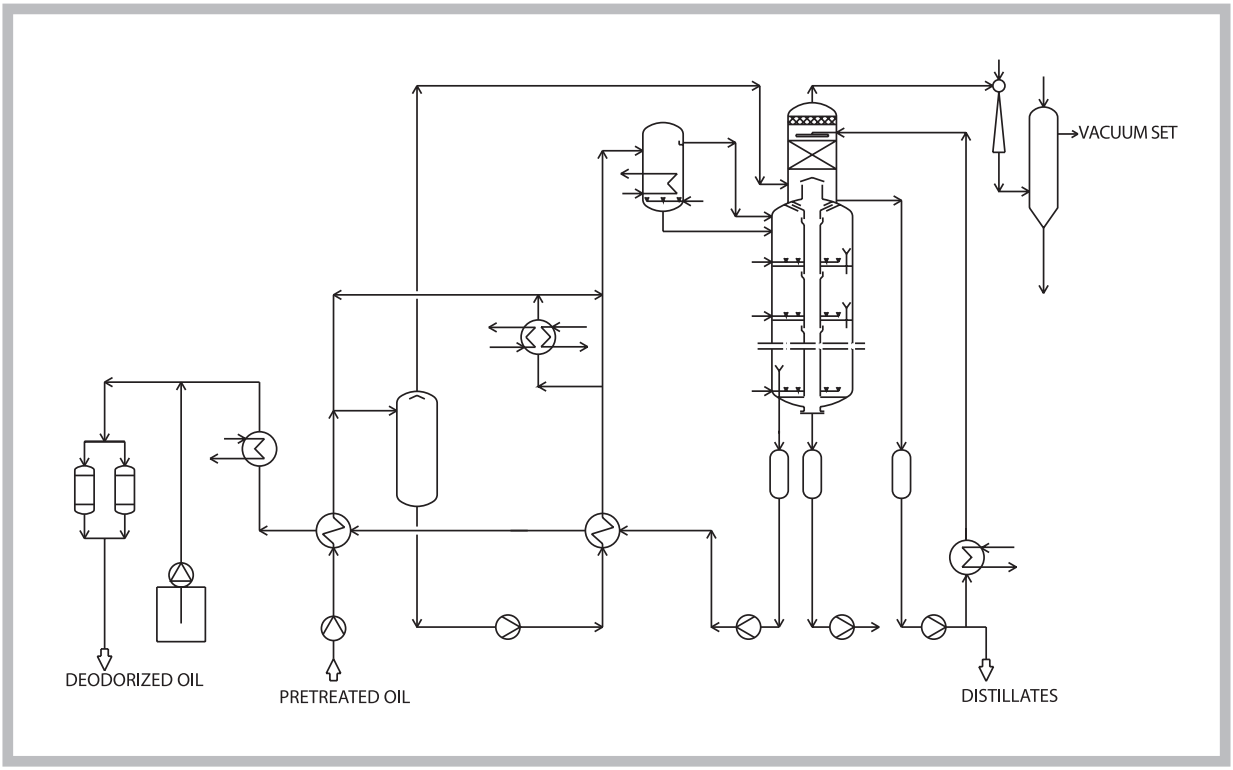


1 - Bleaching plant with vertical pressure leaves filters
2 - Bleaching plant with vertical filters fully made of stainless steel
3 - Bleaching plant (schematic drawing)

5. DEODORIZING

Besides batch deodorizers for small capacities, GIANAZZA International supplies fully continuous deodorizers (of superposed trays type), in a wide range of capacities, from 20 to 1000 t/d. Alternative technologies (packed column) are available for special cases.
The standard plant is called "**DOVERT CS**"; "**DOVERT CSV**" represents an alternative and more sophisticated model, while the model "**DOVERT TR**" is semi-continuous, fully automatic operating, particularly appreciated by the margarine producers.
The following features are common to all types of deodorizers:

- particular care to the fine distribution and dispersion of the stripping steam into microbubbles so that the deodorization efficiency is very high;
- the oil is flowing through an obliged path (except in semi-continuous models) in order to avoid preferential ways;
- the oil layer is limited, with a great surface of the oil being exposed to maximum vacuum;
- the deodorization temperature is kept to the lowest range so that the formation of transisomers is minimized and any other form of oil degradation is avoided;
- the oil heating to the final treatment temperature (as well as cooling of the deodorized oil in "CSV" and "TR" models) is carried out under vacuum and in presence of stripping steam to avoid any overheating;
- low consumptions, thanks to high heat recovery (70-75% in continuous plants);
- the vertical cylindrical design grants minimum installation space requirement and low cost of the building (the column is ground leaned);
- the column is easy to install, inspect and clean.



"DOVERT CS" continuous deodorizing plant (schematic drawing)

5.1 DEODORIZING

AVAILABLE SOLUTIONS
The above-mentioned "DOVERT CS" plant is the standard and cheapest version but different solutions are available.
We wish to point out the following two:

"DOVERT CSV"
It is similar to the standard one with the same performances and consumptions; the difference is that pre-cooling of deodorized oil (up to 160°C approx.) by heat exchange with the oil to be deodorized is realized under vacuum and in presence of live steam inside the deodorizing column.

"DOVERT TR"
The basic principle of semi-continuous deodorizing is that the oil is processed per batches under automatically controlled operating conditions. Batches of different quality can be processed successively with negligible contamination and no loss of production. Actually, this plant is ideal whenever frequent quality changeovers are required (for example in the margarine industry); for this reason the heat recovery is not so high because counter-current heat exchange is not possible.

The typical semi-continuous plant involves seven superposed stages respectively destined to:

- Tray 1 dosing & deaerating
- Tray 2 pre-heating (heat recovery)
- Tray 3 heating & pre-deodorizing
- Trays 4 & 5 deodorizing
- Tray 6 pre-cooling (heat recovery)
- Tray 7 cooling & discharge

PRODUCT QUALITY & CONSUMPTIONS
The quality of deodorized oil, from any type of "DOVERT" plant, is normally complying with the best international standards. Moisture and impurities are absent; PV is generally zero when tested immediately after sampling; the residual acidity is in the range of 0,05÷0,10% FFA.
The energetic consumptions are:

- for heating: 30.000 Kcal/t with 75% approx. heat recovery are requested;
- for vacuum production the consumptions mainly depend on: the quantity of injected stripping steam (8÷ 15 Kg/t), the available steam pressure and the cooling water temperature.

"Dovert CS" continuous deodorizing plant

6. PHYSICAL REFINING

Physical refining basically consists in the removal of fatty acids by steam distillation under vacuum, which involves the following advantages:

- higher yield of refined product;
- no soapstocks formation;
- lower quantity of polluted effluents;
- lower refining costs.

Nevertheless, it must be emphasized that not all types of oil can be satisfactorily refined by physical system.
Generally speaking, physical refining is successful with some specific oils, typically PALM OIL, OLIVE OIL and LAURIC OILS while, on other oils, it can be successful only provided that a very effective pre-treatment is carried out, capable of drastically removing the phosphorus and heavy metals.
In most cases a versatile combined alkali/physical refining plant may be the best solution.
Physical refining normally involves the following steps:

- **Degumming**
- **Dry Degumming & Bleaching (DDB)**
- **Stripping/Deodorizing**

DEGUMMING
It is the most critical stage of the whole process.
By using two centrifugal separators it is generally possible to reduce the phosphorous content down to 30 ppm or less.
The target for a successful physical refining (5 ppm phosphorus) is reached by the further treatment.

DRY DEGUMMING & BLEACHING (DDB)
This is a modified bleaching, in which a preliminary oil treatment with a food grade acid is carried out before the bleaching agent addition (the plant must be entirely made of stainless steel).

STRIPPING/DEODORIZING
From the point of view of construction and dimensions, a stripper/deodorizer is practically the same as a simple deodorizer. Differences concern mainly the operating conditions namely: absolute pressure, temperature and quantity of stripping steam.
The plant, called "PHYSITRON", in case of physical refining is very similar to the deodorizing "DOVERT" plant described in the alkali refining section.
Also for the "PHYSITRON" plant three models are available:

- **"PHYSITRON CS":**
  for fully continuous operation with superposed trays;
- **"PHYSITRON CSF":**
  equipped with structured packing stripping COLUMN;
- **"PHYSITRON TR":**
  fully automatic semi-continuous stripper/deodorizer.

**In case of PALM OILS and some LAURIC OILS,
due to the low content of phosphatides, the pre-treatment
only consists of a dry degumming & bleaching.
In case of SUNFLOWERSEED OIL and other oils containing waxes,
the degumming step should be executed on cold oil in order
to contemporaneously carry out also dewaxing.**

6.1 PHYSICAL REFINING

"PHYSITRON CSF"
This plant uses, combined with a column with traditional trays (CROSSFLOW system), a special structured packing column, operating with very short contact times (COUNTERFLOW system).
This plant gives the following advantages:

- it permits to better utilize the stripping steam thus involving lower quantity of stripping steam and, consequently, lower energetic consumptions for the vacuum set;
- the "PHYSITRON" model is particularly recommended for the physical refining of oils with high acidity, typically PALM OIL and also OLIVE OIL with some reserves.

The plant, equipped with packed COLUMN, requires more cares and precautions in the operation and use as well as a more frequent and accurate maintenance.
The plant shown in the process flowdiagram (next page) is designed for a sophisticated type of heat recovery available on request: the heat exchange between the incoming oil and the deodorized oil is carried out inside the deodorization column (in the lowest tray).

In this way the deodorized oil is maintained under vacuum and it is stirred/protected by injection of live steam, while the incoming oil is flowing into coils submerged in the deodorized oil layer, thus granting the highest quality for the finished oil. In special cases, also precooling of the oil (by soft water) can be carried out inside the deodorization column, in similar way.

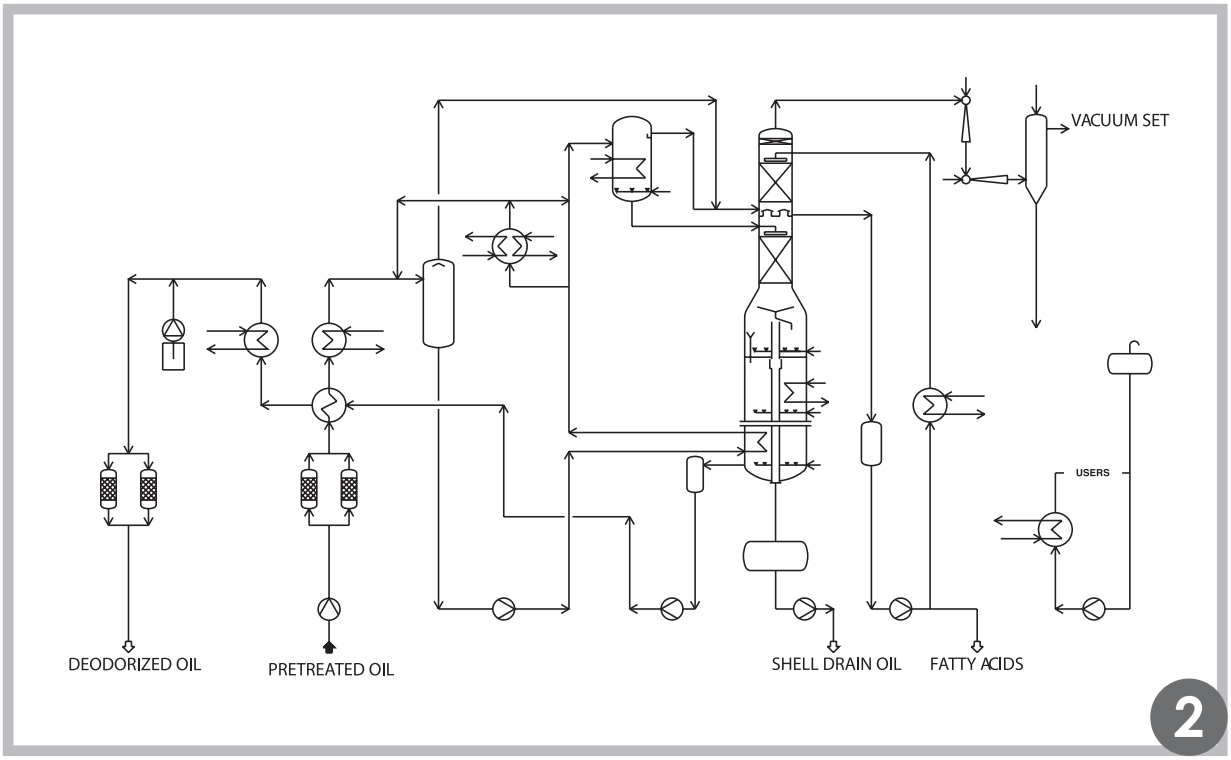
YIELD & PRODUCT QUALITY
The "Physitron" plant is capable of producing oils with final acidity lower than 0,10% (normally 0,05%) when starting from pre-treated oils with 5% FFA.
The quality parameters normally obtained from the deodorization process are also granted in case of the Physitron plant.
As to yield, a typical formula for the oil loss is:

$L = (K \times FFA + 0{,}10)\%$

where K is depending on the incoming FFA and ranges from 1,10 to 1,20%.
Consumption figures are similar to the corresponding figures of the deodorization process or slightly higher.

Deodorization/deacidification plant (Colombia) - Capacity: 500 t/d

6.2 PHYSICAL REFINING



1 - "Physitron CSF" (deodorizing section) (Colombia) - Capacity: 500 t/d
2 - "Physitron CSF" (schematic drawing)

COMPLEMENTARY PROCESSES

COMPLEMENTARY PROCESS

Besides the processes previously described as basic steps in any refining line, some complementary processes are often involved in production of edible oils and fats even if they cannot be exactly defined as refining stages. Among these processes, it is worth mentioning:

- **Water degumming & lecithin drying**
- **Dewaxing (by filtration) and polishing dewaxing**
- **Winterization**
- **Dry fractionation**
- **Hydrogenation**
- **Chilling & plastifying**
- **Soapstocks acidulation**

Different solutions are available according to the product type, capacity, quality requirements, etc.


1

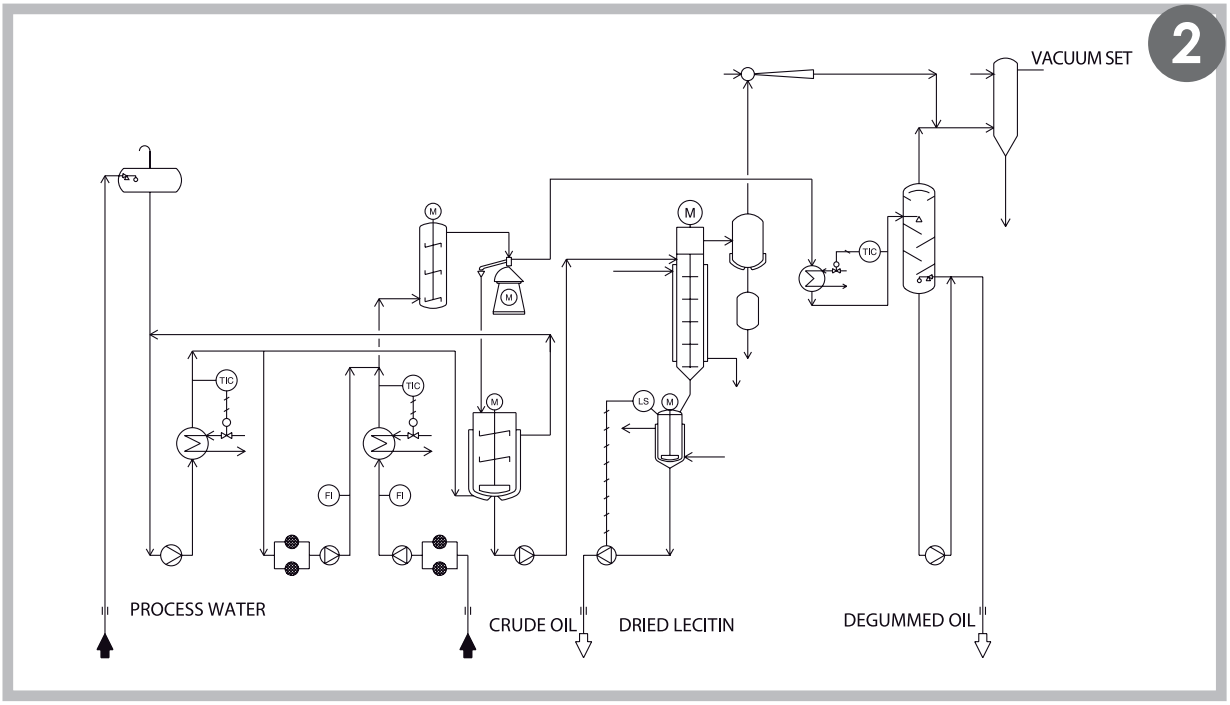
7. WATER DEGUMMING AND LECITHIN DRYING

WATER DEGUMMING AND LECITHIN DRYING

Some crude oils like soybean oil and sunflowerseed oil containing important quantities of hydratable phosphatides, are generally submitted to water degumming.
This process enables to recover, at the same time, a valuable product such as lecithin.
The product discharged from the centrifugal separator is an aqueous slurry typically containing:

- Phosphatides: 33%
- Entrained oil: 17%
- Water: 50%

It is dried under vacuum (usually in a thin film evaporator) up to a residual moisture content in the range of 1÷2%. A continuous plant is shown in the following diagram.



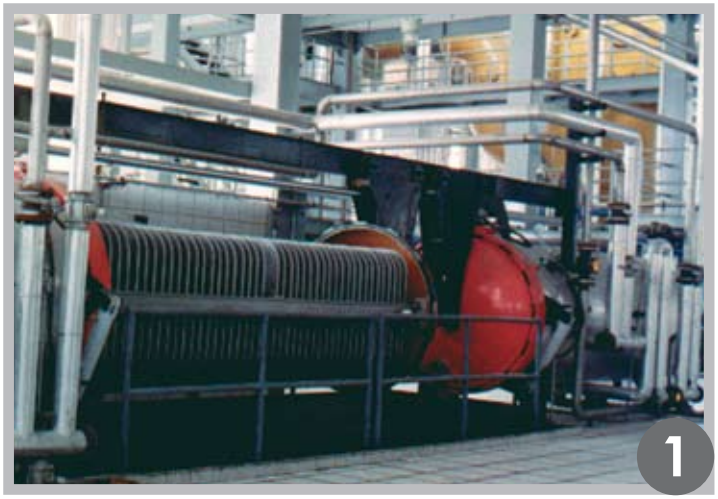
1 - 300 t/d edible oil factory (Turkey)
2 - Water degumming and lecithin drying plant (schematic drawing)

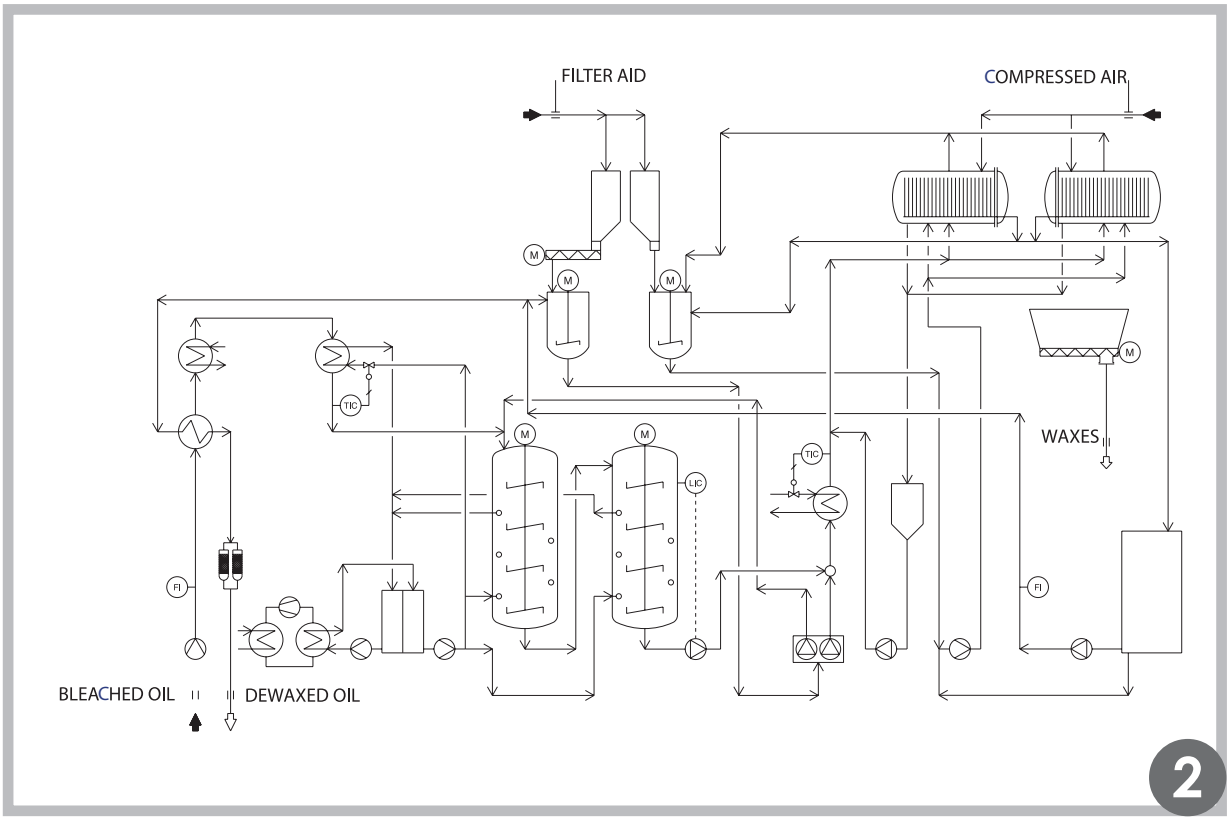
8. Dewaxing by filtration

Dewaxing by filtration is an alternative process to dewaxing by centrifugal separator (cold refining or wet dewaxing). It is not recommended when the waxes content in the oil is rather high (over 600 ppm) but, on the other hand, the process has a good or very good efficiency and can grant a lower "cold test" (24 h at 0°C or even more stringent).
The process needs to use filter aid, both for precoating of the filter pressure leaves and as continuous addition. The oil is cooled down to 7÷8°C and grained for 8 up to 12 h in vertical crystallizers equipped with stirring system, before filtration.
The loss is generally in the range of 2 kg of oil per 1 kg of filter aid being used (or 10 x waxes %).

POLISHING DEWAXING
Oils which have been dewaxed in the neutralizing stage (e.g. sunflowerseed, corn oil etc.) generally require a final wax removal in order to comply with most restrictive "cold test" requirements (24 h at 0°C plus 72 h at room temperature or 48 h at 0°C or similar).

This operation is called Polishing-Dewaxing. The operating principle of the plant is similar to the dewaxing already described, but it is usually carried out after deodorization and needs lower quantities of filter aid (0,1÷0,2% max).
Depending on the use of one or two filters, the plant runs in semi-continuous or fully continuous operation respectively; in most cases one filter only is used.





1 - Dewaxing plant (filters group)
2 - Dewaxing plant by filtration (schematic drawing)

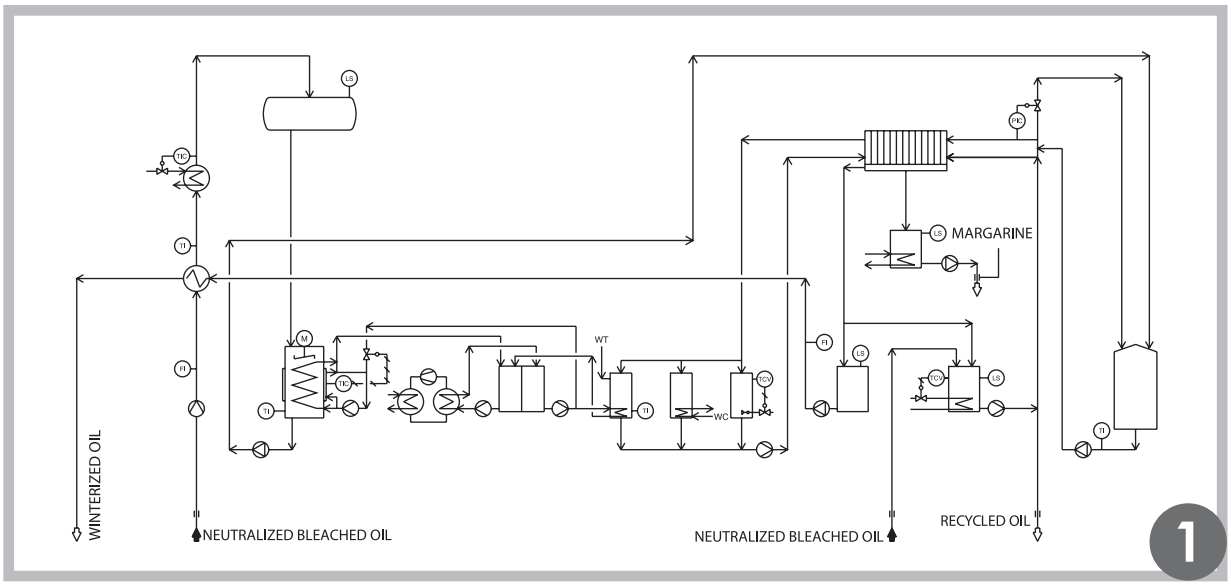
9. WINTERIZATION

WINTERIZATION

This process is similar to dewaxing, but it is destined to separate the solid triglycerides contained in the refined oil, instead of waxes. This operation involves:

- a longer retention time to facilitate the crystals growth (up to 24 h or more);
- a special type of filter (called WINTERPRESS) with high cake capacity and equipped with heated frames so that the cake is discharged by melting without opening the filter.

This process is particularly used for cottonseed oil destined to the production of salad oil, but it can also be used for other oils (olive husk, sunflowerseed, corn).



10. DRY FRACTIONATION

DRY FRACTIONATION

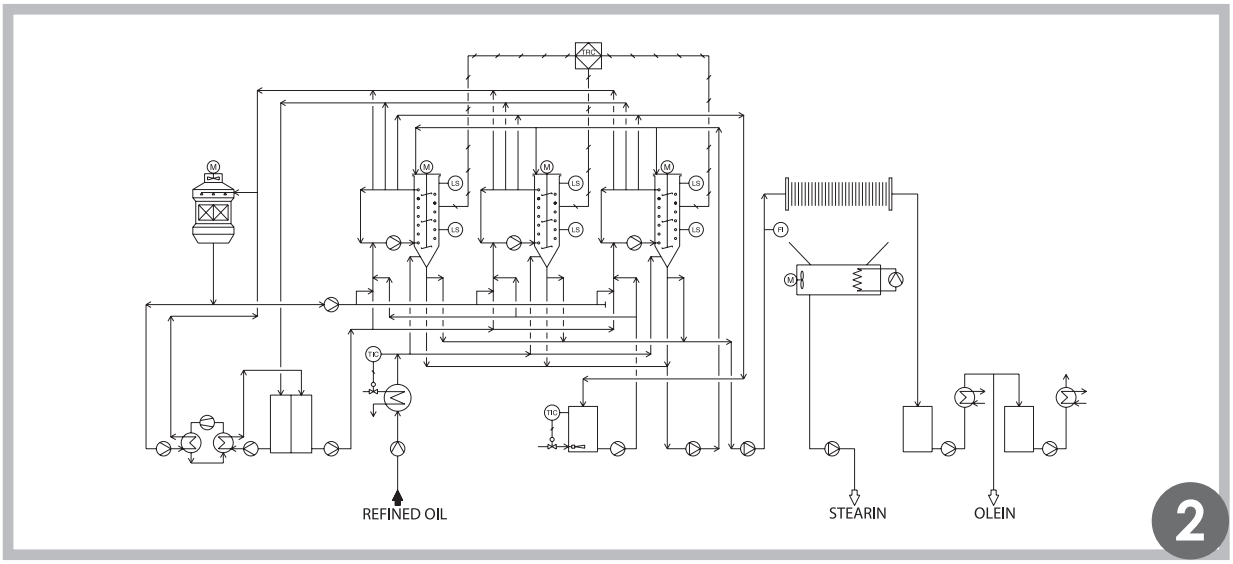
This process, mainly used for palm oil, is designed to separate the feedstock into two fractions, the so called OLEIN (fluid fraction) and STEARIN (hard fraction) without adding any chemical nor solvent nor catalyst.

The fatty matter is cooled according to a prefixed program of temperature reduction, so that crystals can form and grow before being filtered in a continuous rotary filter operating under vacuum, or in a membrane filter press to squeeze the cake properly.

An olein yield up to 80% with 56÷58 I.V. can be obtained.

By executing a refractionation in a further step, a super olein can be obtained with I.V. up to 65 and very low cloud point from 2 to 4° C, of course with a lower yield (in the range of 50%).

The plant is normally provided with a fully computerized control system.



1 - Winterization plant (schematic drawing)

2 - Dry fractionation plant (schematic drawing)

11. HYDROGENATION

This process is used for hardening the natural oils in order to produce solid or semisolid edible fats, in particular margarine and shortening.
Hydrogen with high purity (99,9%) and nickel catalyst are necessary.
The proposed process is normally batch, with operating pressures from 0,5 to 5 bar max and temperatures in the range of 180 to 220°C.
The plant can be equipped with partial or integral heat recovery system (in this case there is no steam consumption).

TYPES OF REACTOR
The Gianazza reactor uses a special type stirrer (particularly designed for gas-liquid reactions in presence of suspended solid catalyst), capable of obtaining the recirculation of gas in the liquid mass without any compressor nor any other external circulation device.

In alternative, plants based on the "**Loop Reactor**" technology can be supplied.
Neutral oils and fats can be hydrogenated totally or selectively to any desired I.V.
Computerized instruments are available to pre-set and automatically stop the injection of hydrogen as soon as the prefixed quantity and therefore the wanted I.V. are reached.
In order to completely remove the nickel catalyst, a post bleaching treatment is normally carried out.
Standard capacities cover the range from 10 to 200 t/d.

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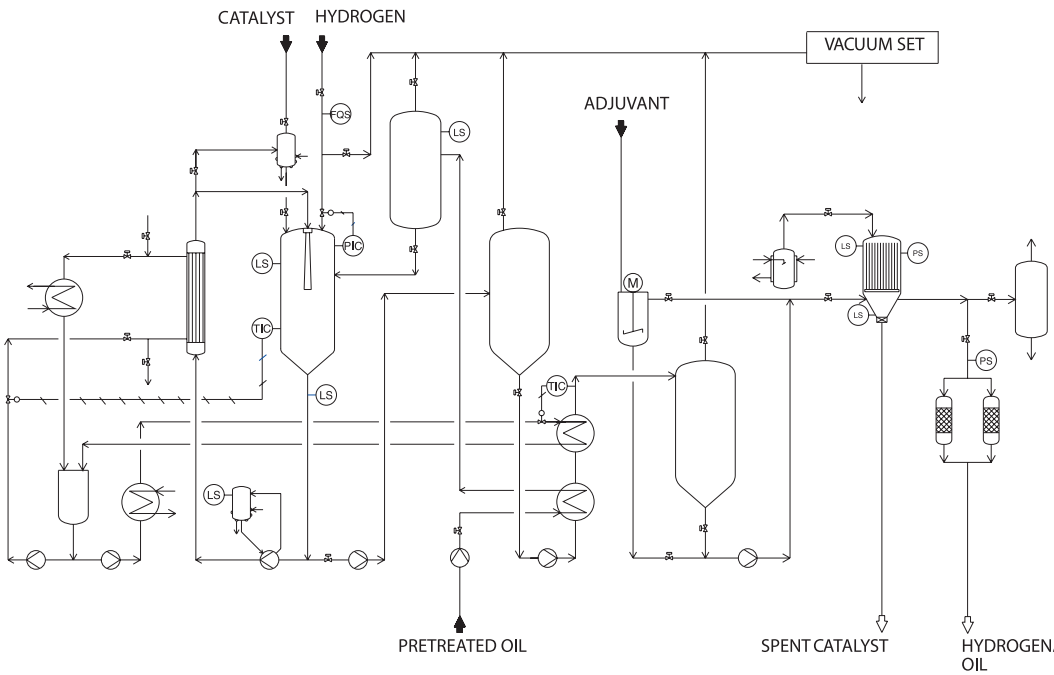

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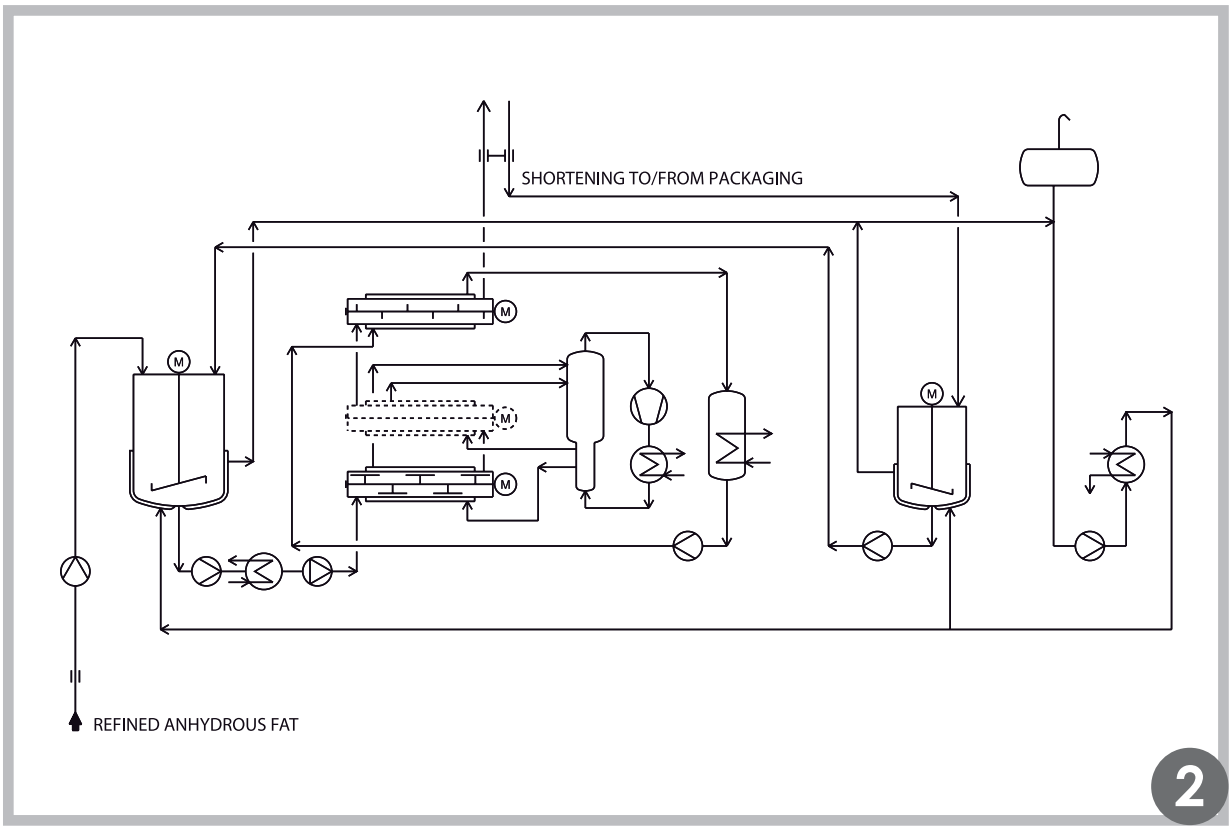
1 - Fatty acids hydrogenation plant (China) - Capacity: 250 t/d
2 - Hydrogenation plant "Loop reactor" type (schematic drawing)

12. CHILLING and PLASTIFYING

The Gianazza TURBOFRIGOR is a continuously operating cylindrical scraped cooler/crystallizer, in which the product flows into an annular section, the outer surface being permanently scraped by several knives mounted on a central rotor.
The external jacket is cooled by an evaporating frigorific fluid.
One or more cooling tubes can be used in series, normally combined with one or more plastifying tubes (equipped with a special type comb stirrer).
The Turbofrigor is used for a wide range of plastified fats, shortening, ghee, etc.



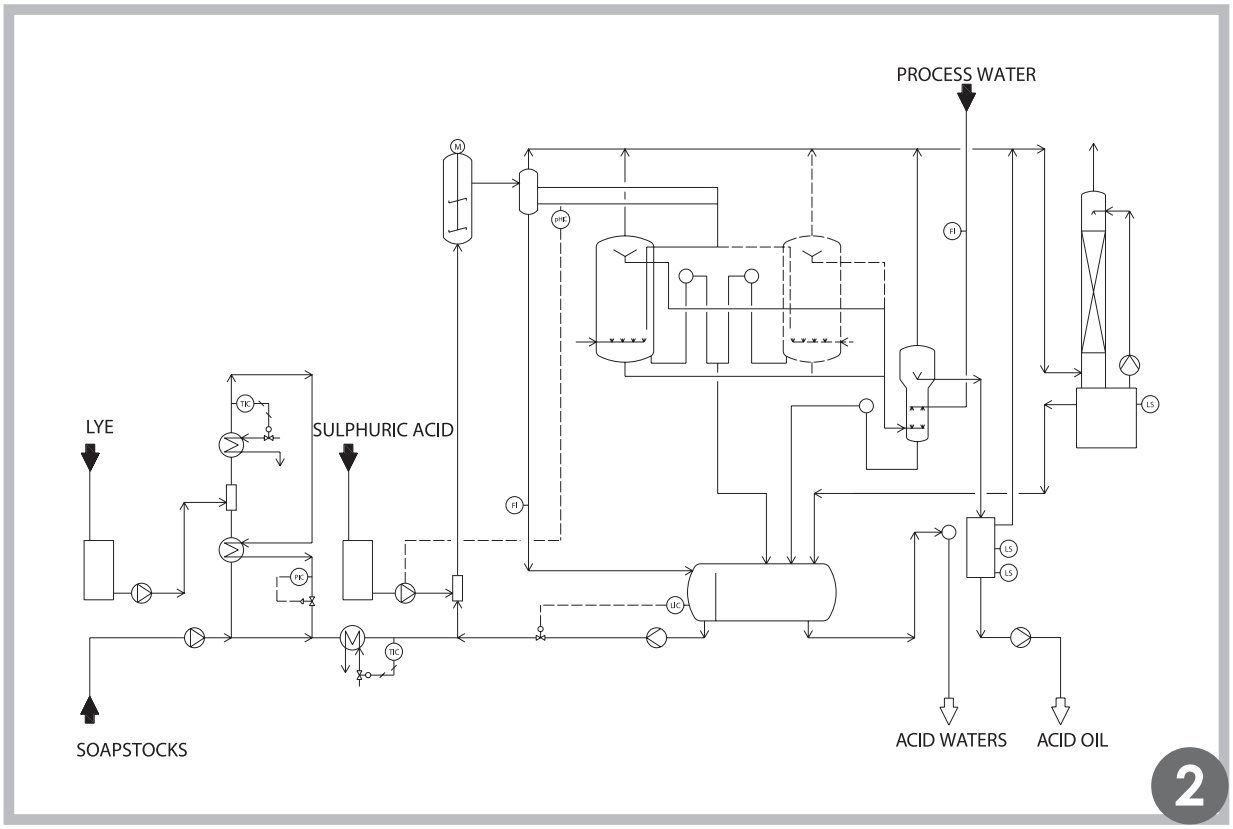
1 - "Turbofrigor" shortening production plant - Capacity: 50 t/d
2 - Shortening production plant (schematic drawing)

13. SOAPSTOCKS ACIDULATION

Soapstocks are transformed into acid oils by means of acidulation with sulphuric acid.
According to the capacity, batch or fully continuous plants can be proposed.
In some cases (mainly for cottonseed soapstocks) it is recommended to carry out a total and complete saponification of the fatty matters in order to obtain, after acidulation, crude fatty acids with 90÷95% FFA.

ACIDS OILS obtained by a standard acidulation are normally submitted to splitting in high pressure vessels, in order to produce crude fatty acids with a FFA content ranging between 94 and 96% or more, to be sent to final distillation.
The main problems of this process are:

- corrosion due to the use of sulphuric acid: for this reason the vessels are made of plastic material;
- effluent water with very low pH and high C.O.D. levels.



1 - Soapstocks acidulation plant - Capacity: 75 t/d
2 - Soapstocks acidulation plant (schematic drawing)

Gianazza International has acquired the rights of brand Gianazza. Gianazza has realized over 250 successfully operating plants for edible oils and fats refining as well as more than 300 plants for oleochemicals throughout the world.

Considering the world continuous evolution, Gianazza International is determined to continue Gianazza's century old commitment to quality, with focus on introduction of new technologies, plants and facilities as well as providing the necessary parts needed to maintain a first class production.

Gianazza International has the technology and the know-how of Gianazza under a new structure in order to offer reliable services for years to come.

The support of skillful personnels from Gianazza ensures the continuity of more than 120 years of experiences gained since 1892.

Gianazza International is devoted to provide long term satisfaction to Customers.

GIANAZZA INTERNATIONAL srl

Via Canipari, 3
25125 – Brescia (BS) - Italy
info@gianazzainternational.com
www.gianazzainternational.com