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Rendering Systems for Processing Animal By-Product Materials

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ABSTRACT

These systems are divided into two classes, edible rendering of animal fatty tissue into edible fats and proteins for human consumption, and inedible rendering of animal by-product materials into animal fats and proteins for animal feed and other non-edible applications.

The inedible rendering process consists of two basic steps: "cooking" or moisture removal by evaporation, and separation of the melted fats from the protein solids. The basic rendering process involves the use of batch cookers. In recent years, continuous rendering systems which utilize continuous cooking have replaced many batch systems. These continuous systems are described.

A continuous system is described for edible rendering. This system features two stages of centrifuges: 1) a horizontal, solid-bowl centrifuge for separation of protein solids from the liquid, and 2) a disc centrifuge for separation of the edible fat from the sludge phase consisting of protein fines and water.

INTRODUCTION

Edible rendering refers to the process of producing a fat product which is human edible. Inedible rendering concerns the processing of animal by-product materials to manufacture fat and protein meal products which are not intended for human consumption, but instead for feeding animals and poultry.

This presentation describes various inedible rendering systems that include the basic rendering process known as the batch cooker system; the Duke continuous rendering system; the Anderson C-G continuous rendering system, and the Stord Bartz waste heat dewatering system. A continuous rendering system for producing edible fats known as the Sharples Trim-R Process also is described.

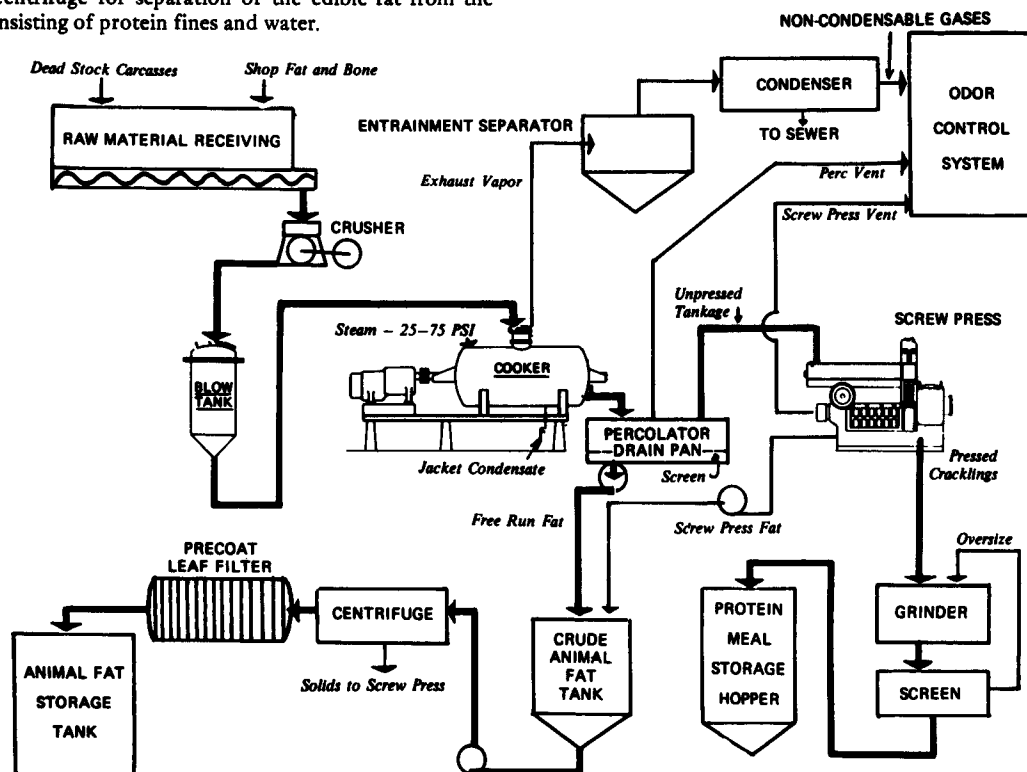


FIG. 1. Batch cooker rendering process.

INEDIBLE RENDERING

The rendering process consists of two basic steps. First, the animal by-product raw material is heated or "cooked" to evaporate the moisture, to melt the fat present and finally to condition the animal fibrous tissue. This conditioning process is important to accomplish efficiently the second step, the separation of fat from the solid proteinaceous material. This process is known as dry rendering because the raw material is "cooked" with no addition of steam or water.

Basic Rendering Process—Batch Cooker System

Figure 1 illustrates the basic rendering process where batch cookers are used. These are multiple units arranged in a row or series of rows, depending upon the size and arrangement of the rendering plant. Each cooker consists of a horizontal, steam-jacketed cylindrical vessel equipped with an agitator. This vessel is known as a batch cooker because it follows a repetitive cycle: the cooker is charged with the proper amount of raw material, the cook is made under controlled conditions and finally the cooked material is discharged.

The raw material from the receiving bin is screw conveyed to a crusher or similar device for size reduction. For batch cookers, the raw material is reduced in size to 1 or 2 inches to provide efficient cooking which normally requires 1½ to 2½ hours. The raw material is quite variable depending upon the source, and adjustments in the cooking time and temperature may be required to process the material. The final temperature of the cooked material ranges from 250 to 275 F, depending upon the type of raw material.

After the cooking process is completed, the cooked material is discharged to the percolator drain pan which contains a perforated screen allowing the free run fat to drain and be separated from the protein solids, which are known as "tankage." After one or two hours of drainage, the protein solids still contain about 25% fat and are conveyed to the screw press which completes the separation of fat from solids, which have a residual fat content of 10%.

The solid protein material discharged from the screw press is known as "cracklings." It is normally screened and ground with a hammer mill to produce protein meal that essentially passes a 12-mesh screen. The fat discharged from the screw press usually contains fine solid particles which are removed by either centrifuging or filtration.

Continuous Rendering Systems

Since the 1960's, a variety of continuous rendering systems have been installed to replace the batch cooker systems. Continuous rendering, as its name implies, is synonymous with continuous cooking. The raw material is fed continuously to the cooker, and the cooked material is likewise discharged at a constant rate.

A continuous rendering system normally consists of a single continuous cooker, whereas the batch cooker system consists of multiple cooker units. A continuous system usually has a higher capacity than the batch cooker system it replaces. This increased capacity provides for more efficient processing of the raw material by processing more material in less time.

Continuous rendering also has a number of other inherent advantages over the batch system. Since a continuous process requires less cooking time or exposure to heat, improved product quality normally results. Further, the continuous system occupies considerably less space than a batch cooker system with equivalent capacity, thus saving building construction costs. Finally, a single cooker unit is inherently more efficient than multiple cooker units in

terms of steam consumption and achieves a significant saving in fuel usage by the boilers. Likewise, less electrical power is consumed for agitation in the single continuous cooker unit.

The Duke Continuous Rendering System is manufactured by the Dupps Company, in Germantown, Ohio. This rendering system is illustrated by Figure 2.

The Duke system is designed to provide a method of cooker operation similar to that of the batch cooker. The Equacooker is a horizontal, steam-jacketed cylindrical vessel equipped with a rotating shaft to which are attached paddles that lift and move the material horizontally through the cooker. Steam also is injected into the hollow shaft to provide increased heat transfer.

The feed rate to the Equacooker is controlled by adjusting the speed of the variable speed drive for the feed screw which establishes the production rate for the system. The discharge rate for the Equacooker is controlled by the speed at which the control wheel rotates. The control wheel contains buckets similar to those used in a bucket elevator that pick up the cooked material from the Equacooker and discharge it to the drainor.

The drainor performs the same function as the percolator drain pan in the batch cooker process. It is an enclosed screw conveyor that contains a section of perforated trough for the free melted fat to drain through to the crude tallow tank. The protein solids containing residual fat are then conveyed to the pressors or screw presses for additional separation of fat. The pressors and other components of the Duke continuous system are similar to those used for the batch cooker system.

A central control panel is provided to consolidate the process controls. The temperature record, steam pressure indications, equipment speed settings, motor ampere readings and start-stop pushbuttons are located at the control panel.

Another variation of the continuous rendering system provides for use of a Rotadisc continuous drier, instead of the Equacooker shown in Figure 2. The Rotadisc unit is similar in design to the Equacooker, except that it contains a series of hollow discs mounted on a rotating shaft. These hollow discs are of nearly the same diameter as the internal shell and are steam heated providing significantly more heat transfer surface for evaporation of moisture from the raw material. The Rotadisc drier has certain operation and maintenance features of interest to the rendering industry. The Rotadisc drier is manufactured by Stord Bartz A/S, Bergen, Norway.

The Anderson C-G continuous system is manufactured by the Anderson International Corp., Cleveland, Ohio. This rendering system is illustrated by Figure 3.

The Anderson continuous process differs considerably from other systems. Fat is recycled to carry the raw material as a pumpable slurry instead of using screw conveyors. A secondary grinding step is used to further reduce the particle size of the raw material. A conventional evaporator system with vacuum is used for moisture removal. Currently, a vacuum pump with electrical motor is used instead of steam ejectors as a vacuum source.

Partially ground raw material from the prebreaker is fed continuously by a screw feeder at a controlled rate. The fluidizing tank receives this material, which is mixed and suspended in the recycled fat at 220 F. This slurry is pumped to the Reitz disintegrators for further size reduction from one-inch to 3/8-inch pieces. This ground slurry is then pumped to the evaporator.

The evaporator system consists of a vertical shell with tubular heat exchanger and vapor chamber. The slurry of solids and fat is pumped to the top of the heat exchanger

RENDERING ANIMAL BY-PRODUCT MTLs.

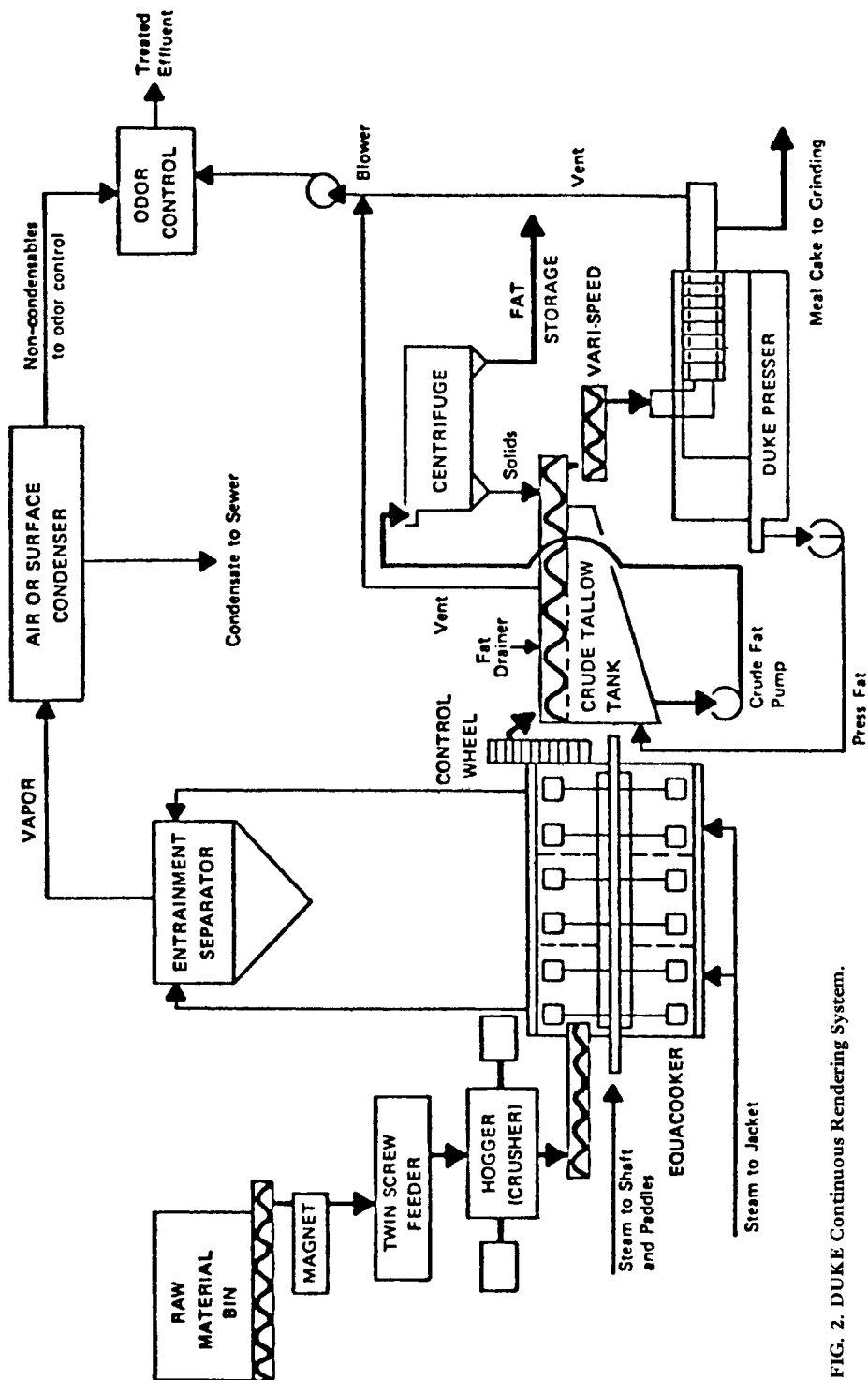


FIG. 2. DUKE Continuous Rendering System.

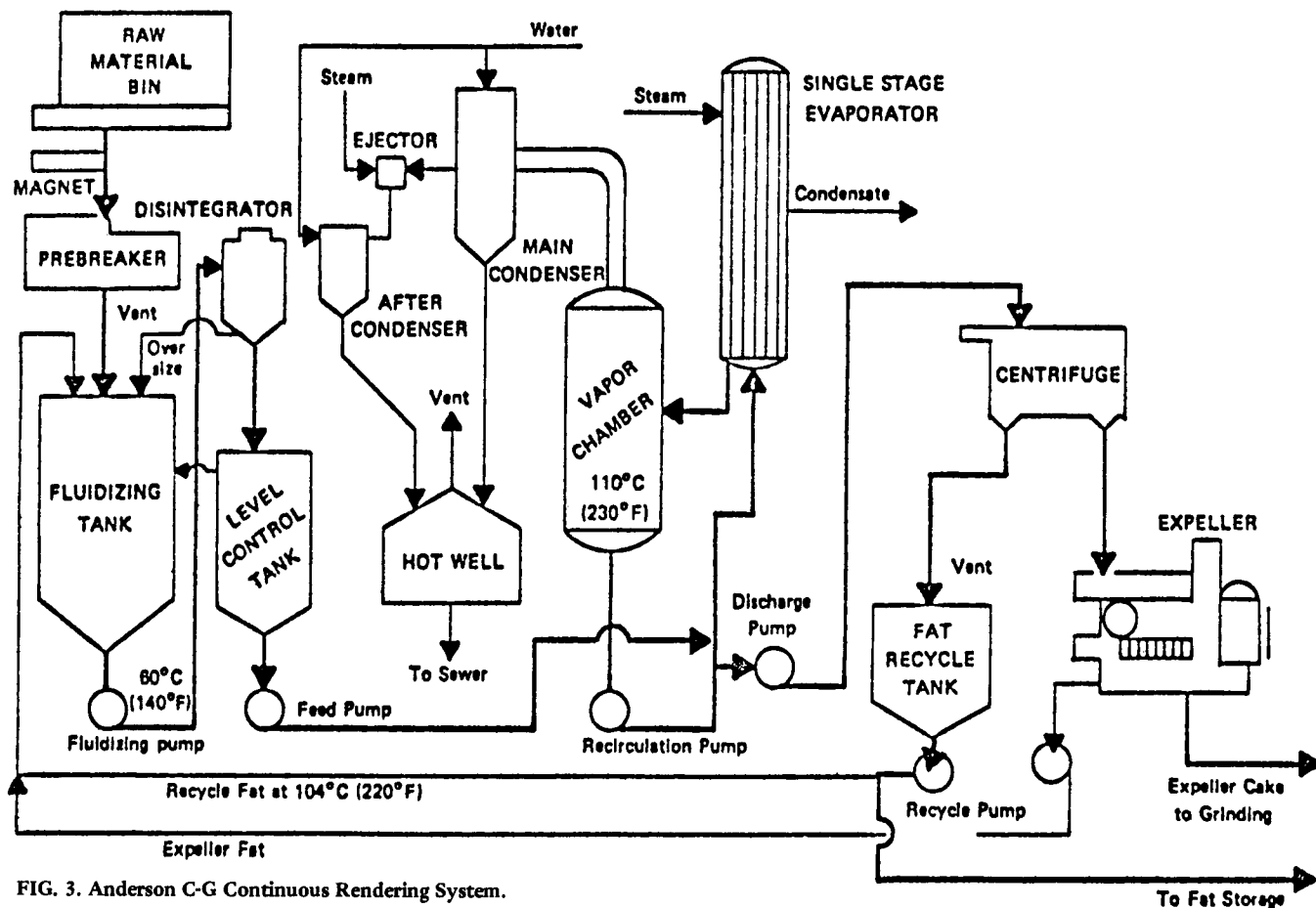


FIG. 3. Anderson C-G Continuous Rendering System.

and the slurry flows by gravity down through the tubes while steam is injected into the shell to provide heat for moisture evaporation. The water vapor is separated from the dried slurry in the vapor chamber, which is under a vacuum of 26 to 28 inches of mercury. The water vapor is condensed with a shell and tube condenser through which cooling water is circulated. Instead of a steam ejector system to provide the vacuum, a vacuum pump with electrical motor normally is used.

Figure 3 shows a single stage evaporator system. Currently, two-stage and even three-stage systems are operated to obtain improved steam economy, especially for raw material with a higher moisture content. For a two-stage system, the water vapor evaporated from the second stage serves as the heating medium for the first stage. This results in the use of about 0.7 pounds of steam per pound of moisture evaporated.

The slurry of fat and "cooked" material is pumped from the evaporator to the centrifuge, which removes a substantial part of the fat. This fat is collected in a tank and is recycled back to the fluidizing tank. The solids discharged from the centrifuge are conveyed to the expellers or screw presses for additional separation of fat.

A central control panel is provided for the operator to consolidate the instruments required for process control. Level indications and controls are provided to stabilize the flows through the fluidizing and other process tanks and also for the vapor chamber of the evaporator. Evaporator vacuum and temperature also is monitored. Equipment speed settings, motor ampere readings and start-stop push-buttons also are located at the panel.

New Continuous Systems with Reduced Energy Usage

In the past few years, considerable effort has been spent on

developing new rendering systems that utilize the cooking vapors from either a batch cooker system or a continuous rendering system to obtain further moisture removal. Most of this new rendering technology has evolved in Europe, where energy costs have been significantly higher than in the U.S.

The Stord Bartz Waste Heat Dewatering (WHD) System is manufactured by Stord Bartz A/S, Bergen, Norway. It is illustrated by Figure 4. The Stord Bartz WHD system consists of a preheater, twin screw press and evaporator system. It usually is installed in conjunction with an existing rendering system.

Raw material is screw conveyed as usual from the raw material bin over an electromagnet and fed to either a prebreaker or hogor for coarse grinding. This ground material passes through the preheater, which is a horizontal, steam-jacketed, cylindrical vessel with a rotating shaft and agitator to move the material through the vessel continuously and to improve heat transfer. The temperature of the raw material in the preheater is controlled and may range from 140 to 180 F, depending upon the type of raw material being processed. This heating step is necessary to melt the fat and condition the animal fibrous tissue properly for the subsequent pressing operation.

The twin screw press consists of intermeshing, counter-rotating, twin screws moving inside a press cage assembly. It includes a perforated screen through which the liquid is pressed and a series of vertical support plates to secure the perforated screen in place. The perforated screen with heavy backing plate is constructed to follow the contour of the rotating flights of the twin screws. The feed material fills the free space between the screws and the press cage. At the feed end, the twin screws are constructed with a lower diameter shaft and deeper flights to provide a larger

RENDERING ANIMAL BY-PRODUCT MTLs.

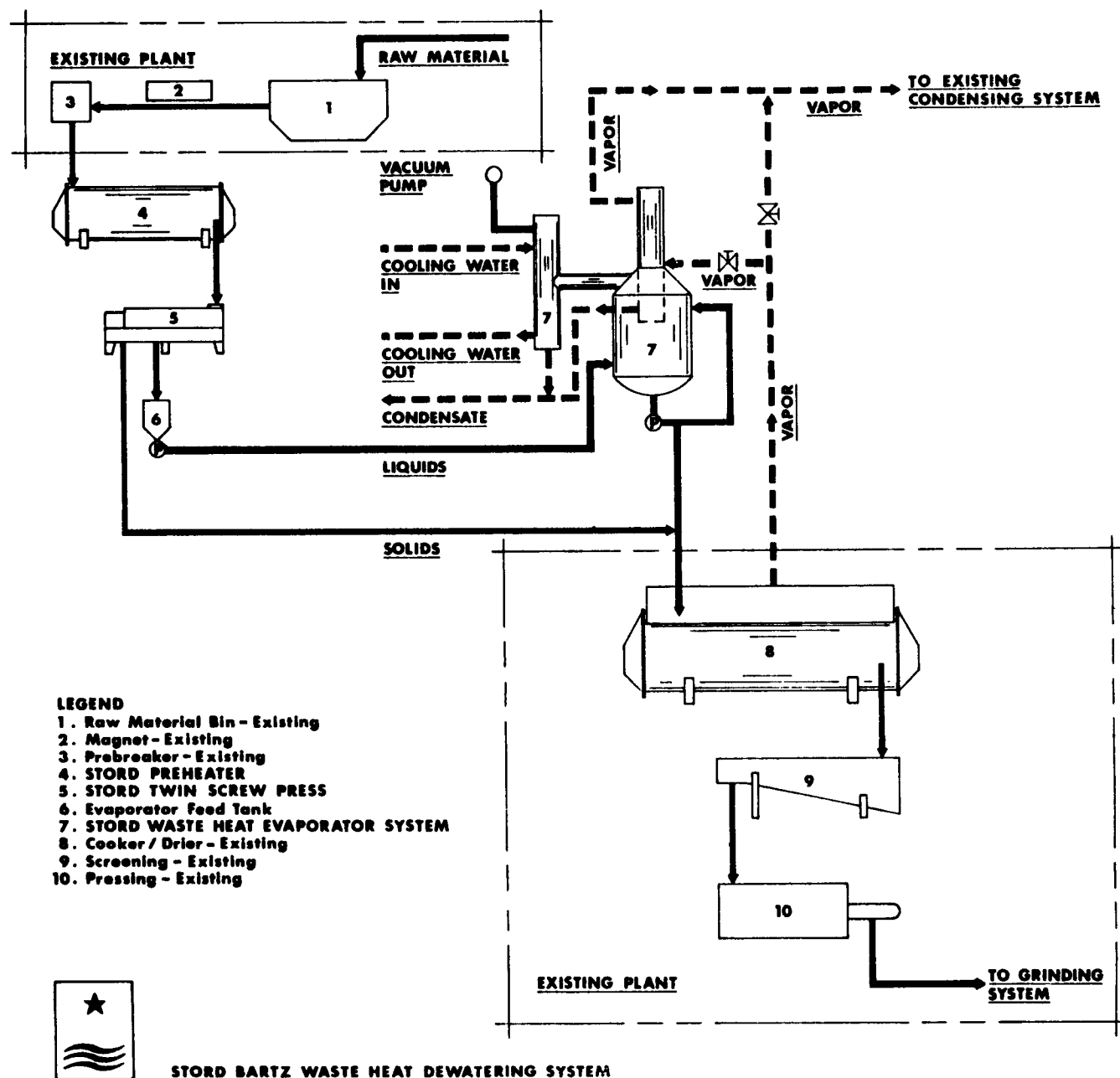


FIG. 4. Stord Bartz WHD System.

volume of space. As the press screws rotate, this space decreases and the material is submitted to a steadily increasing pressure to squeeze out the liquid through the perforated screen.

The twin screw press separates the heated and ground raw material into two phases, a presscake of solids containing fat and moisture, and a liquid containing mostly the melted fat and water. The solids are screw conveyed to the existing cooker or drier, which is steam heated to remove the moisture. Final separation of the fat from the solids is completed with a screw press.

Liquid from the twin screw press is pumped from the feed tank to the evaporator, which consists of a tubular heat exchanger mounted vertically and integral with the vapor chamber. The vapors from the existing cooker or drier provide the heating medium for evaporation. The liquid pumped to the evaporator enters at the top of the heat exchanger and flows by gravity downward through the tubes discharging into the vapor chamber which is maintained under a vacuum of 24 to 26 inches of mercury pro-

vided by a vacuum pump. The water vapor from the vapor chamber is condensed with a shell and tube condenser through which cooling water is circulated.

The basic concept of the Stord Bartz WHD system is to use the waste heat in the vapors from the existing cooker to evaporate the moisture from the liquid removed by pressing the raw material, thus converting the existing plant into a two-stage evaporation system. It is essential to balance the operation of this system so that there are sufficient vapors available from the existing cooker to evaporate the moisture from the pressed liquid. Operation of the preheater and twin screw press requires adjustment for different types of raw material with varying moisture content in order to achieve proper balance of this system.

In addition to reducing fuel costs with less steam demand by 30 to 40%, the operation of the Stord Bartz WHD system in conjunction with the existing cooker system is capable of increasing production throughput by 75%. A major U.S. renderer has installed and currently is operating two of these systems.

The Dupps/Myren Rendering System is similar in principle to the Stord Bartz WHD system previously described.

This system was jointly developed by the Dupps Company in Germantown, Ohio and Myrens Verksted A/S, in Oslo, Norway.

The Dupps/Myren system also features a preheater, twin screw press and evaporator system operated under vacuum. Also, it includes the multicoil dryer to process the press-cake solids for moisture removal. The multicoil unit consists of a rotor forming the heat transfer surface and a stainless steel housing. The rotor is constructed of numerous parallel sets of coils attached to a rotating shaft with steam inlet. Each set of coils contains a number of concentric pipe rings.

A pilot plant system has been operated in a U.S. renderer's plant to obtain basic design data for scaling up to a plant scale production system. Currently, such a system is being designed for installation in a U.S. rendering plant.

The Anderson TM-1 Rendering System is manufactured by the Anderson International Corp., Cleveland, Ohio. This system was developed in Holland five years ago in a rendering plant that utilizes the vapors from an existing batch cooker system to pre-dry the raw material by means of a single stage evaporator system.

The TM-1 system follows the same basic flow pattern as the Anderson C-G system. The raw material from the prebreaker is mixed with the recycled fat in the fluidizing tank. This material is fine ground by the disintegrators and fed to the evaporator. The material is pre-dried in the evaporator using the cooker vapors as the heating medium, and then is pumped to the fat separator which removes the partially dried solids from the fat recycled to the fluidizing tank. The solids are conveyed to the existing cooking system for final moisture removal.

The TM-1 system includes the following improvements over the conventional Anderson C-G system:

- The tubular heat exchanger is installed inside the vapor chamber to save space, and the heat exchanger tubes are increased to a 2-inch diameter to accept larger particles. The evaporator height is reduced to save electrical power for the recirculation pump.
- The Reitz disintegrator screen opening is increased from 3/8 to 5/8 inches to reduce electrical power and maintenance.
- The fat separator consists of a stationary curved screen for removing the recycled fat from the pre-dried solids. The screen requires no electrical power and much less maintenance than the centrifuge it replaces.
- A computerized monitoring and control system for maintaining the key process variables within predetermined operating limits.

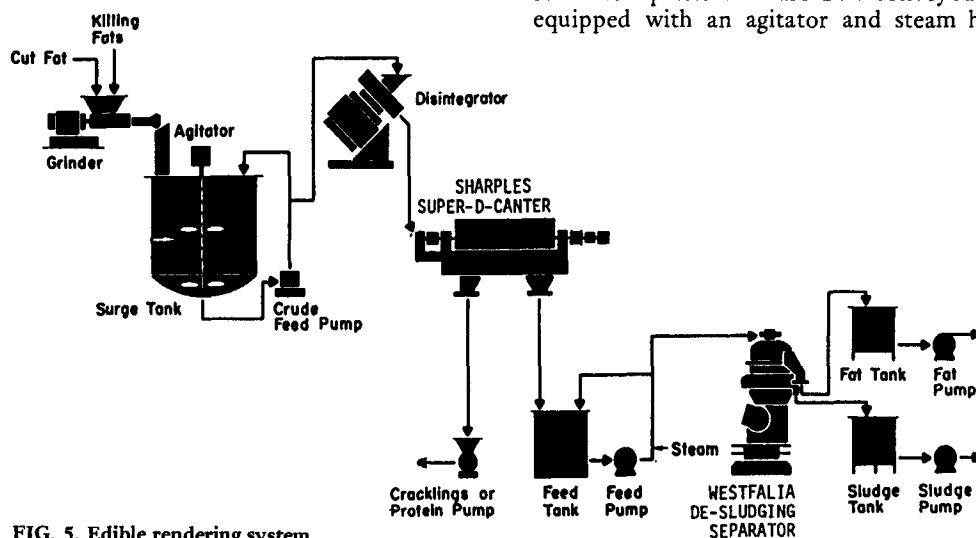


FIG. 5. Edible rendering system.

The TM-1 System is rated to reduce fuel costs with less steam demand by 40% and is capable of increasing the production throughput up to 80% for an existing cooker system. Currently, TM-1 systems have been installed and are in operation in two U.S. rendering plants.

EDIBLE RENDERING

Edible rendering is synonymous with continuous rendering of animal fatty tissue to produce an edible lard or tallow that is light in color, bland in taste and low in FFA. Maximum fat quality is maintained by a minimum exposure of the fat to heat, usually no more than 200 F for a period of 30 minutes or less. It is only necessary to melt the fat in the raw material and raise the temperature to a sufficient level to achieve the two stages of centrifugal separation.

There are two alternatives for rendering edible fat. First, an edible protein product can be produced where the melted fat temperature is maintained below 120 F to obtain an edible protein of acceptable quality. This is known as the low temperature option for continuous edible rendering. The second or high temperature option consists of heating the melted fat to 180-210 F before separating the protein solids fraction from the melted fat. Although a more complete separation of fat from protein is obtained at the higher temperature, the protein fraction must be sold as an inedible product. The edible protein product has a much higher value than the inedible protein.

This presentation describes the Sharples Trim-R Process and includes both the low and high temperature options. However, other continuous edible rendering systems are available. For example, Sullivan Systems, Inc. (subsidiary of Alfa-Laval) in Larkspur, California manufactures the Centriflow System for the production of edible lard or tallow.

The Sharples Trim-R Edible Fat Processing System is manufactured by the Sharples Division of the Pennwalt Corp., Warminster, Pennsylvania. This system is illustrated by Figure 5. It makes no distinction between low temperature operation to produce an edible protein and high temperature operation to produce an inedible protein.

A typical edible fat rendering system that uses the low temperature option is described. The beef fat trimmings from USDA-inspected meat production plants contain 11-13% fat, 62-64% moisture and 19-21% protein solids. The system operates 20 hours per day and processes 200,000 pounds of beef fat trimmings to produce edible beef tallow and partially defatted beef fatty tissue (PDBFT).

Fat trimmings are ground through a Weiler grinder with 5/16-inch plates and are belt conveyed to the melt tank equipped with an agitator and steam heated jacket. The

melted fatty tissue at 110 F is pumped to a Reitz disintegrator with rotating hammers and a perforated screen containing 3/8-inch openings. Essentially complete rupturing of the fat cells is accomplished to facilitate separation of the protein solids from the melted fat in the Sharples Super-D-Canter.

The Super-D-Canter consists of a rotating horizontal solid bowl or cylinder inside which a helical screw conveyor rotates in the same direction but at a slightly lower speed. The solids discharge end of the bowl is fitted with a truncated conical section or "beach." The liquid discharge end of the bowl is equipped with an adjustable weir which determines the liquid depth in the bowl. The fat slurry is fed through a stationary nozzle inside the rotating bowl. Centrifugal separating forces ranging up to 3000 times the forces of gravity cause the solids to be thrown against the cylindrical wall of the bowl. The liquid of lesser density forms a concentric inner ring inside the bowl. The solids are removed by the screw conveyor, which pushes them up the "beach" out of the liquid layer, discharging them from the bowl. The clarified liquid is removed continuously as it overflows the adjustable weir to discharge from the bowl.

The edible protein discharged from the Super-D-Canter centrifuge at 110 F, compared to 180 F for inedible protein, is much higher in fat content and has a plastic consistency which requires more critical control of the differential speed between the rotating bowl and screw conveyor. When the Super-D-Canter is operated with the low temperature option, it normally is provided with variable speed control for both the rotating bowl and screw conveyor.

The edible protein is cooled rapidly to 10 F by spreading it onto a rotating drum whose surface is chilled by means of ammonia refrigeration. The edible protein is scraped off the drum as a sheet which is chopped into small squares for packaging. This rapid chilling of the PDBFT product minimizes excessive growth of bacteria.

The melted fat from the Super-D-Canter contains moisture and a small percentage of solids or fines. A second stage centrifuge is required to "polish" the edible fat. The Westfalia De-Sludging Separator manufactured by Westfalia Separator AG, Oelde, West Germany (represented in the U.S. by Centrico, Inc. in Northvale, New Jersey) is used for this purpose.

However, before being fed to the second stage centrifuge, the melted fat is first passed through a shell and tube heat exchanger which is steam heated to raise the fat temperature to 200 F. This is necessary to reduce the viscosity of the liquid sufficiently to achieve the desired separation.

The Westfalia De-Sludging Separator consists of a series of conical shaped discs rotating about a vertical axis inside

the bowl. The feed enters through the center shaft and is distributed at the bottom of the bowl. The fat, being lighter in density, tends to rise, passing upward as thin layers past adjacent discs. Due to centrifugal force, a sludge layer of water and protein fines tends to build up in the "sludge space" located outboard from the discs and inside the outer periphery of the bowl. The Westfalia unit is equipped with a "self-thinker" internal sensor that measures the volume of sludge buildup within the bowl and automatically actuates discharge ports around the periphery to discharge the sludge, while operating at full speed.

The polished edible fat discharges from the top of the bowl and is pumped to fat storage. The sludge discharged from the centrifuge is usually pumped or transported to an inedible rendering plant.

A central control panel is provided to consolidate the process controls. Temperature and level indications and controls for the melt tank, a temperature indication and control for the heat exchanger outlet and an indication of the production rate are located at the control panel. Also included are the start-stop pushbuttons for the motors. Each of the pumps is provided with varispeed drives to be able to adjust their pumping rates.

The high temperature option of the Sharples Trim-R Process to produce an inedible protein merely involves a change in the piping to and from the heat exchanger. The melted fat from the Reitz disintegrator is diverted to the heat exchanger and then to the Super-D-Canter. This allows the melted fat to be heated to 180-210 F for improved separation of the protein from the fat in the Super-D-Canter. The inedible protein solids discharged from the centrifuge are conveyed or transported to an inedible rendering plant.

All equipment and piping in contact with the edible fat or protein is constructed of 304 type stainless steel with a suitable food grade finish. The piping is provided with quick opening connections for quick disassembly and cleaning. Likewise, both centrifuges and the heat exchanger are capable of being "cleaned in place" in order to comply with the sanitary standards established by the USDA Food Safety and Inspection Service (Meat and Poultry Inspection Program).

As mentioned before, the edible rendering plant described operates 20 hours per day and uses the remaining four hours for plant cleanup and sanitizing. The USDA-FSIS requires such a cleanup after 24 hours of operation. Hot boiling water with a detergent is circulated from the melt tank through the entire system. Then, a sanitizing solution with a final rinse is used.