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Attorneys for GS CLEANTECH CORPORATION

UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA, SACRAMENTO DIVISION

| | |
|---|---|
| GS CLEANTECH CORPORATION,<br><br>Plaintiff,<br><br>v.<br><br>PACIFIC ETHANOL STOCKTON LLC<br><br>Defendant. | Case No.<br><br>**COMPLAINT FOR PATENT INFRINGEMENT**<br><br>**DEMAND FOR JURY TRIAL** |

Plaintiff, GS CleanTech Corporation, for its Complaint, does hereby, through its attorneys, allege as follows:

## I.
## THE PARTIES

1. Plaintiff, GS CleanTech Corporation (hereinafter "GS CleanTech"), is a Delaware corporation having its principal place of business at 1 Penn Plaza, Suite 1612, New York, New York 10119. GS CleanTech is a wholly-owned subsidiary of GreenShift Corporation (hereinafter "GreenShift"), a Delaware corporation having its principal place of business at 1 Penn Plaza, Suite 1612, New York, New York 10119.

2. Upon information and belief, Defendant Pacific Ethanol Stockton LLC (hereinafter

"PE Stockton") is a California limited liability company having its principal place of business at 3028 Navy Drive, Stockton, California 95206.

## II. JURISDICTION

3. This is a claim for patent infringement and arises under the patent laws of the United States, Title 35 of the United States Code. This Court has original jurisdiction over the subject matter of this claim under 28 U.S.C. §§ 1331 and 1338(a).

4. The Court has personal jurisdiction over PE Stockton because, upon information and belief and among other things, it resides in and/or directly, or indirectly through its agents, transacts business in this judicial District, has committed acts within this judicial District giving rise to this action and/or at least by offering to sell, selling, purchasing, and/or advertising the infringing products and/or placing them into the stream of commerce in such a way as to reach customers in this judicial District, and/or because it has sufficient minimum contacts with this judicial District. Requiring PE Stockton to respond to this action will not violate due process.

## III. VENUE

5. Upon information and belief, PE Stockton resides in this judicial District, directly, or indirectly through its agents, transacts business in this judicial District and/or has committed acts within this judicial District giving rise to this action. Venue is proper in this judicial District under 28 U.S.C. §§ 1391(b), (c) and 1400(b).

## IV. BACKGROUND FACTS

6. GS CleanTech is the owner by assignment of United States Patent No. 7,601,858, entitled "Method Of Processing Ethanol Byproducts And Related Subsystems," issued on October 13, 2009 (the " '858 patent"). A true and correct copy of the '858 patent is attached hereto as Exhibit A. The '858 patent issued from a patent application originally filed on May 5, 2005 as Serial No. 11/122,859 (the " '859 application") and published on February 23, 2006 as U.S. Patent Application Publication 2006/0041152. See Exhibit A. Both the '858 patent and the '859 application claim priority to GS CleanTech's first patent application related to its novel corn oil extraction methods and

systems, which was filed in August of 2004 as a provisional application (Serial No. 60/602,050) (the "'050 provisional application"). Id. The '858 patent and the '859 patent application are generally directed to the recovery of corn oil from the byproducts produced during the manufacture of ethanol from corn. Id.

7. GS CleanTech has standing to sue for infringement of the '858 patent because it owns all right, title and interest in and to the patents-in-suit, including the right to collect for past and future damages. GS CleanTech has suffered injury from Defendant's acts of patent infringement.

8. GS CleanTech invented a novel patented process to extract corn oil from the byproducts created during the manufacture of ethyl alcohol. This process is claimed in the '858 patent.

9. Recently, significant attention has been given to the production of ethyl alcohol, or "ethanol," for use as an alternative fuel. Ethanol not only burns cleaner than fossil fuels, but also can be produced using grains such as corn, which are abundant and renewable domestic resources.

10. In the United States, ethanol is typically produced from corn. Corn contains significant amounts of sugar and starch, which are fermented to produce ethanol.

11. A popular method of producing ethanol is known as "dry milling," whereby the starch in the corn is used to produce ethanol through fermentation. In a typical dry milling method, the process starts by grinding each kernel of corn into meal, which is then slurried with water into mash. Enzymes are added to the mash to convert the starch to sugar. Yeast is then added in fermentors to convert the sugar to ethanol and carbon dioxide. After fermentation, the mixture is transferred to distillation columns where the ethanol is evaporated and recovered as product, leaving an intermediate product called "whole stillage." The whole stillage contains the corn oil and the parts of each kernel of corn that were not fermented into ethanol.

12. Despite containing valuable corn oil, the whole stillage has traditionally been treated as a byproduct of the dry milling fermentation process and used primarily to supplement animal feed mostly in the form of a product called "dried distillers grains with solubles" (hereinafter "DDGS").

13. Prior to GS CleanTech's invention, efforts to recover the valuable corn oil from the whole stillage had not been successful in terms of efficiency or economy. A need therefore existed for

a more efficient and economical manner of recovering corn oil. GS CleanTech has filled that need with its novel and inventive process.

14. The inventors of the novel process, David Cantrell and David Winsness, completed feasibility testing with an early-stage corn oil extraction prototype in 2004 and demonstrated, for the first time, that efficient extraction of the corn oil trapped in the dry milling byproducts was economically feasible.

15. In August of 2004, the inventors filed the '050 provisional application directed to their novel corn oil extraction methods and systems. The patents-in-suit claims priority back to the '050 provisional application.

16. In one embodiment, GS CleanTech's patented method comprises initially processing the whole stillage by mechanically separating (such as by using a centrifugal decanter) the whole stillage into distillers wet grains and thin stillage, and then introducing the thin stillage into an evaporator to form a concentrated byproduct or "syrup." Prior to recombining the now concentrated syrup with the distillers wet grains, the syrup is introduced into a second mechanical separator, such as a second centrifuge, which is different from the centrifuge that mechanically separated the whole stillage into distillers wet grains and thin stillage. This second centrifuge separates corn oil from the syrup thereby allowing for the recovery of usable corn oil. The syrup that exits the centrifuge is then recombined with the distillers wet grain and dried in a dryer to form the DDGS. The corn oil that is extracted from the syrup can be used for various purposes such as feedstock for producing biodiesel.

17. After filing the '050 provisional application in 2004, the inventors of GS CleanTech's novel corn oil extraction method began to engage the ethanol manufacturing industry to explain and market the corn oil extraction method itself and the benefits to be had by ethanol manufacturers if they were to install these systems in their facilities. In fact, in 2005, the inventors invited ethanol manufacturers to a symposium to hear about the advantages of this method and about 30 percent of the industry attended.

18. Upon information and belief, PE Stockton has purchased and installed a corn oil separation system that infringes one or more of the claims of the patent-in-suit.

19. Upon information and belief, PE Stockton infringes, and will continue to infringe, one

or more claims of the patent-in-suit by using its corn oil separation system.

## V.
## COUNT I

**(Infringement of U.S. Patent No. 7,601,858)**

20. GS CleanTech repeats and realleges paragraphs 1-19, above, as though fully set forth herein.

21. PE Stockton infringes and will continue to infringe one or more of the claims of the '858 patent by, among other activities, practicing the claimed methods and/or processes.

22. PE Stockton's infringement has injured GS CleanTech, and GS CleanTech is entitled to recover damages adequate to compensate it for such infringement.

23. PE Stockton's infringement has been willful, deliberate, and objectively reckless.

24. PE Stockton's infringing activities have injured and will continue to injure GS CleanTech, unless and until this Court enters an injunction prohibiting further infringement and, specifically, enjoining further manufacture, use, sale, importation, and/or offer for sale of products or practice of any methods and/or processes that come within the scope of the claims of the '858 patent.

## VI.
## PRAYER FOR RELIEF

WHEREFORE, GS CleanTech respectfully asks this Court to enter judgment against PE Stockton and against its respective subsidiaries, successors, parents, affiliates, officers, directors, agents, servants and employees, and all persons in active concert or participation with it, granting the following relief:

1. The entry of judgment in favor of GS CleanTech and against PE Stockton;

2. A preliminary injunction prohibiting further infringement of the '858 patent;

3. A permanent injunction prohibiting further infringement of the '858 patent;

4. An award of damages adequate to compensate GS CleanTech for the infringement that has occurred, but in no event less than a reasonable royalty for the use made of the inventions of the '858 patent as provided in 35 U.S.C. § 284, together with prejudgment interest from the date the infringement began;

5. An award to GS CleanTech of all remedies available under 35 U.S.C. § 284;

6. An award to GS CleanTech of all remedies available under 35 U.S.C. § 285; and

7. Such other relief to which GS CleanTech is entitled under law, and any other and further relief that this Court or a jury may deem just and proper.

## VII.
## DEMAND FOR JURY TRIAL

Pursuant to Fed. R. Civ. P. 38(b), GS CleanTech demands a trial by jury on all issues so triable.

DATED: March 17, 2014

WILKE, FLEURY, HOFFELT,
GOULD & BIRNEY, LLP

By: Megan A Lewis
MEGAN A. LEWIS
Attorneys for
GS CLEANTECH CORPORATION

# EXHIBIT A


(12) **United States Patent**
**Cantrell et al.**

(10) **Patent No.: US 7,601,858 B2**
(45) **Date of Patent: Oct. 13, 2009**

(54) **METHOD OF PROCESSING ETHANOL BYPRODUCTS AND RELATED SUBSYSTEMS**

(75) Inventors: **David Fred Cantrell**, Lakemont, GA (US); **David J. Winsness**, Alpharetta, GA (US)

(73) Assignee: **GS Cleantech Corporation**, New York, NY (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 578 days.

(21) Appl. No.: **11/122,859**

(22) Filed: **May 5, 2005**

(65) **Prior Publication Data**

US 2006/0041152 A1 Feb. 23, 2006

**Related U.S. Application Data**

(60) Provisional application No. 60/602,050, filed on Aug. 17, 2004.

(51) **Int. Cl.**
*C11B 1/00* (2006.01)

(52) **U.S. Cl.** ..... 554/8

(58) **Field of Classification Search** ..... 554/8
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2,206,024 | A | 7/1940 | Brown |
| 2,216,904 | A | 10/1940 | Brown |
| 2,216,905 | A | 10/1940 | Brown et al. |
| 2,263,608 | A | 11/1941 | Brown |
| 2,446,913 | A | 8/1948 | Erlich |
| 2,524,718 | A | 10/1950 | Stark |
| 2,615,029 | A | 10/1952 | Rosten |
| 2,663,718 | A | 12/1953 | Strezynski |
| 3,721,568 | A | 3/1973 | Wilson |
| 3,950,230 | A | 4/1976 | Greenfield et al. |
| 4,341,713 | A | 7/1982 | Stolp et al. |
| 4,407,955 | A | 10/1983 | Muller et al. |
| 4,944,954 | A | 7/1990 | Strop et al. |
| 5,250,182 | A | 10/1993 | Bento et al. |
| 5,269,947 | A | 12/1993 | Baskis |
| 5,316,782 | A | 5/1994 | Zimlich, III |
| 5,662,810 | A | 9/1997 | Willgohs |
| 5,801,140 | A | 9/1998 | Langley et al. |
| 5,958,233 | A | 9/1999 | Willgohs |
| 5,998,641 | A | 12/1999 | Ganguli et al. |
| 6,146,645 | A | 11/2000 | Deckers et al. |
| 6,433,146 | B1 | 8/2002 | Cheryan |

(Continued)

OTHER PUBLICATIONS

Singh, et al., "Extraction of Oil from Corn Distillers Dried Grains with Solubles", 1998, Transactions of the ASAE, Bol. 41(6), pp. 1175 and 1176.*

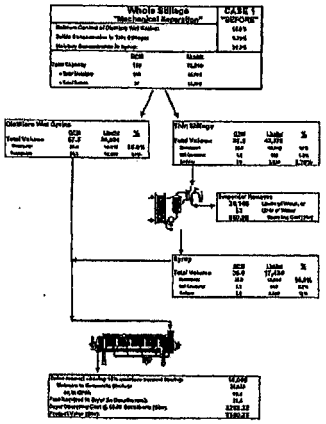
(Continued)

*Primary Examiner*—Deborah D Carr
(74) *Attorney, Agent, or Firm*—Cantor Colburn LLP

(57) **ABSTRACT**

In one aspect of the invention, a method recovers oil from a concentrated byproduct, such as evaporated thin stillage formed during a dry milling process used for producing ethanol. The method includes forming a concentrate from the byproduct and recovering oil from the concentrate. The step of forming the concentrate may comprise evaporating the byproduct. Further, the step of separating the oil from the concentrate may comprise using a centrifuge and, in particular, a disk stack centrifuge. Other aspects of the invention include related methods and subsystems for recovering oil from thin stillage.

**16 Claims, 4 Drawing Sheets**



U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 6,761,914 | B2 | 7/2004 | Deckers et al. | |
| 2003/0093832 | A1 | 5/2003 | Szarka et al. | |
| 2003/0180415 | A1 | 9/2003 | Stiefel et al. | |
| 2004/0081654 | A1 | 4/2004 | Schryvers et al. | |
| 2004/0082044 | A1 | 4/2004 | Prevost et al. | |
| 2004/0087808 | A1* | 5/2004 | Prevost et al. | 554/9 |

OTHER PUBLICATIONS

Yokoyama, et al. "Liquid Fuel Production from Ethanol Fermentation Stillage" 1986, The Chemical Society of Japan, pp. 649-652.*
Minowa, T. et al., Oil Production form Buchwheat Stillage by Thermochemical Liquefactional, 1993, national Inst. for Resources and Environment, Ibaraki (Japan), STN, Abstract, NTIS database.*
Yokoyama, et al., "Liquid Fuel Production from Ethanol Fermentation Stillage," 1986, The Chemical Society of Japan, pp. 649-652.
"Disk Stack Centrifuge Technology," Alfa Laval website, www.alfalaval.com, Aug. 3, 2004.
N. Singh and M. Cheryan, Extraction of Oil from Corn Distillers Dried Grains with Solubles, Transactions of the ASAE, 1998, pp. 1775-1777, vol. 41(6).
Y. Dote et al., Liquefaction of Stillage from Ethanolic Fermentation and Upgrading of Liquefied Oil, Trans. Mat. Res. Soc. Jpn., 1994, pp. 285-288, vol. 18A.
(No Author Available), "Thermochemical Liquefaction", article by Wisconsin Biorefining Development Initiative, www.wisbiorefine.org, p. 1-4, undated.
International Search Report dated Mar. 11, 2008.
International Search Report dated Aug. 20, 2008.
Alfa Laval, "NS 934 DD Decanter," PFT00017EN 0207, PFT00018EN 0207, PFT00007EN 0207, 6 pags., 1999.
(No Author Available) "Thermochemical Liquefaction" article by Wisconsin Biorefining Development Initiative, www.wisbiorefine.org, pp. 1-4, undated, 2004.
(No Author Available), "Thermochemical Liquefaction", article by Wisconsin Biorefining Development Initiative, www.wisbiorefine.org, pp. 1-4, undated, 2004.
Mcintyre, Craig., "Measurement solutions for Ethanol Producers", A white paper by Endress+Hauser, Inc., Copyright 2003, pp. 1-10.
Jacques et al. "The Alcohol Textbook" 3rd Edition, published 1999, Part 1 of 4 Parts, 53 pgs.
Jacques, et al., "The Alcohol Textbook", 3rd Edition, published 1999, Part 2 of 4 Parts, 50 pgs.
Jacques, et al., "The Alcohol Textbook", 3rd Edition, published 1999, Part 3 of 4 Parts, 50 pgs.
Jacques, et al., "The Alcohol Textbook", 3rd Edition, published 1999, Part 4 of 4 Parts, 42 pgs.

* cited by examiner

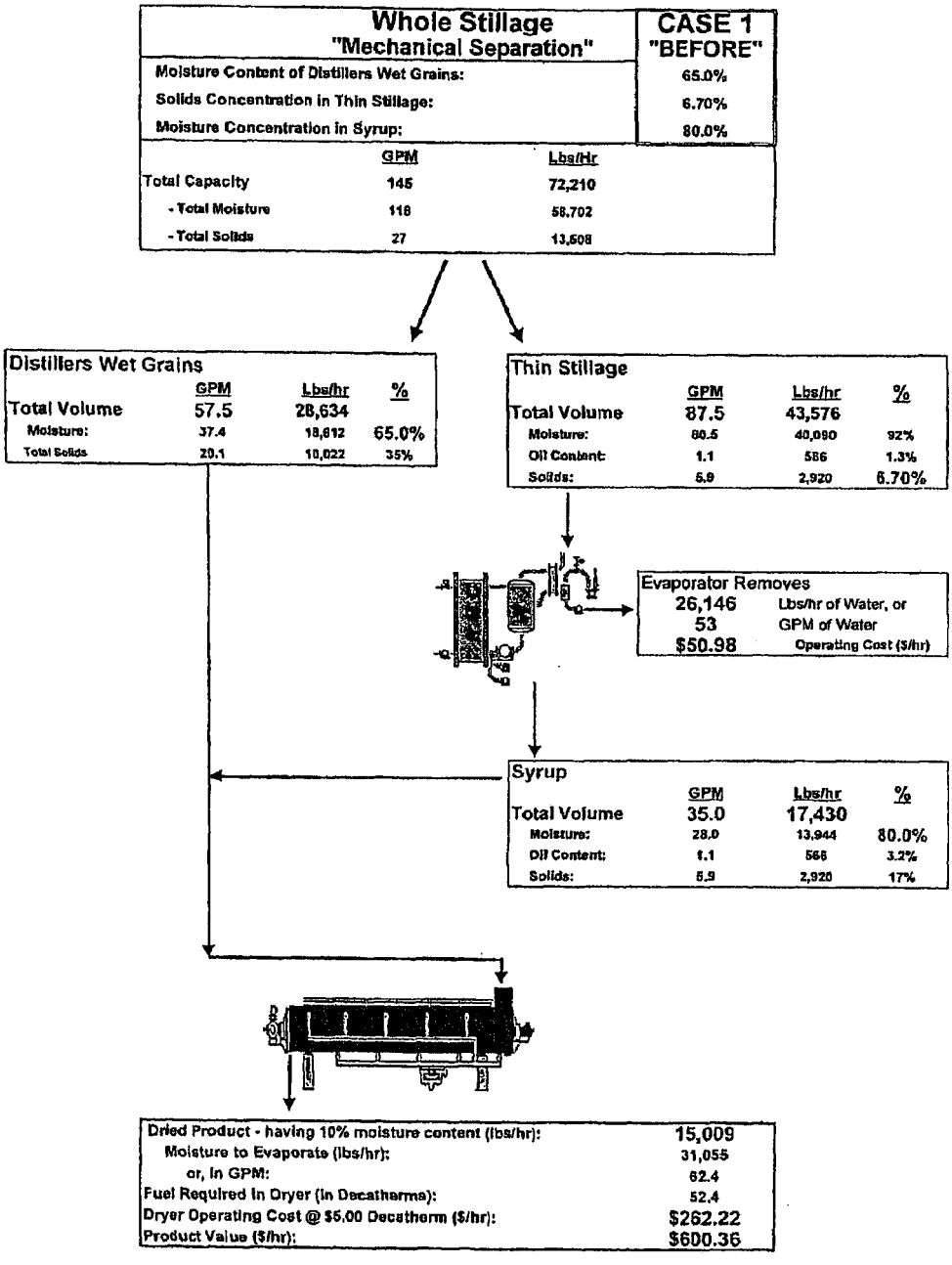

Whole Stillage
"Mechanical Separation"
CASE 1
"BEFORE"
Moisture Content of Distillers Wet Grains: 65.0%
Solids Concentration in Thin Stillage: 6.70%
Moisture Concentration in Syrup: 80.0%
GPM Lbs/Hr
Total Capacity 145 72,210
- Total Moisture 118 58,702
- Total Solids 27 13,508
Distillers Wet Grains
GPM Lbs/hr %
Total Volume 57.5 28,634
Moisture: 37.4 18,612 65.0%
Total Solids 20.1 10,022 35%
Thin Stillage
GPM Lbs/hr %
Total Volume 87.5 43,576
Moisture: 80.5 40,090 92%
Oil Content: 1.1 586 1.3%
Solids: 5.9 2,920 6.70%
Evaporator Removes
26,146 Lbs/hr of Water, or
53 GPM of Water
$50.98 Operating Cost ($/hr)
Syrup
GPM Lbs/hr %
Total Volume 35.0 17,430
Moisture: 28.0 13,944 80.0%
Oil Content: 1.1 568 3.2%
Solids: 5.9 2,920 17%
Dried Product - having 10% moisture content (lbs/hr): 15,009
Moisture to Evaporate (lbs/hr): 31,055
or, in GPM: 62.4
Fuel Required in Dryer (in Decatherms): 52.4
Dryer Operating Cost @ $5.00 Decatherm ($/hr): $262.22
Product Value ($/hr): $600.36

*Fig. 1*

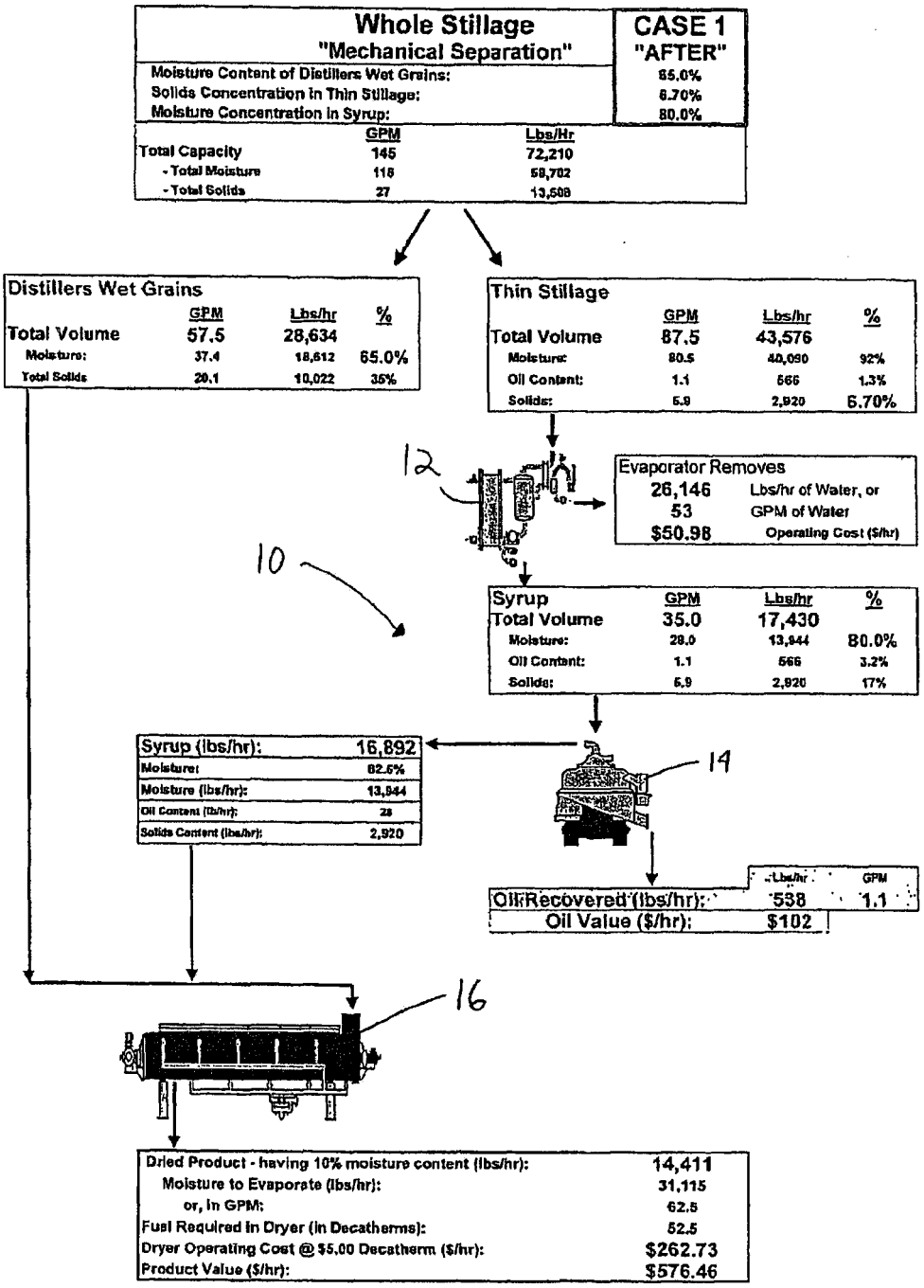

Whole Stillage
"Mechanical Separation"
CASE 1
"AFTER"
Moisture Content of Distillers Wet Grains: 65.0%
Solids Concentration in Thin Stillage: 6.70%
Moisture Concentration in Syrup: 80.0%
GPM Lbs/Hr
Total Capacity 145 72,210
- Total Moisture 118 58,702
- Total Solids 27 13,508
Distillers Wet Grains
GPM Lbs/hr %
Total Volume 57.5 28,634
Moisture: 37.4 18,612 65.0%
Total Solids 20.1 10,022 35%
Thin Stillage
GPM Lbs/hr %
Total Volume 87.5 43,576
Moisture: 80.5 40,090 92%
Oil Content: 1.1 566 1.3%
Solids: 5.9 2,920 6.70%
12
Evaporator Removes
26,146 Lbs/hr of Water, or
53 GPM of Water
$50.98 Operating Cost ($/hr)
10
Syrup GPM Lbs/hr %
Total Volume 35.0 17,430
Moisture: 28.0 13,944 80.0%
Oil Content: 1.1 566 3.2%
Solids: 5.9 2,920 17%
Syrup (lbs/hr): 16,892
Moisture: 82.6%
Moisture (lbs/hr): 13,944
Oil Content (lb/hr): 28
Solids Content (lbs/hr): 2,920
14
Lbs/hr GPM
Oil Recovered (lbs/hr): 538 1.1
Oil Value ($/hr): $102
16
Dried Product - having 10% moisture content (lbs/hr): 14,411
Moisture to Evaporate (lbs/hr): 31,115
or, in GPM: 62.5
Fuel Required in Dryer (in Decatherms): 52.5
Dryer Operating Cost @ $5.00 Decatherm ($/hr): $262.73
Product Value ($/hr): $576.46

*Fig. 2*

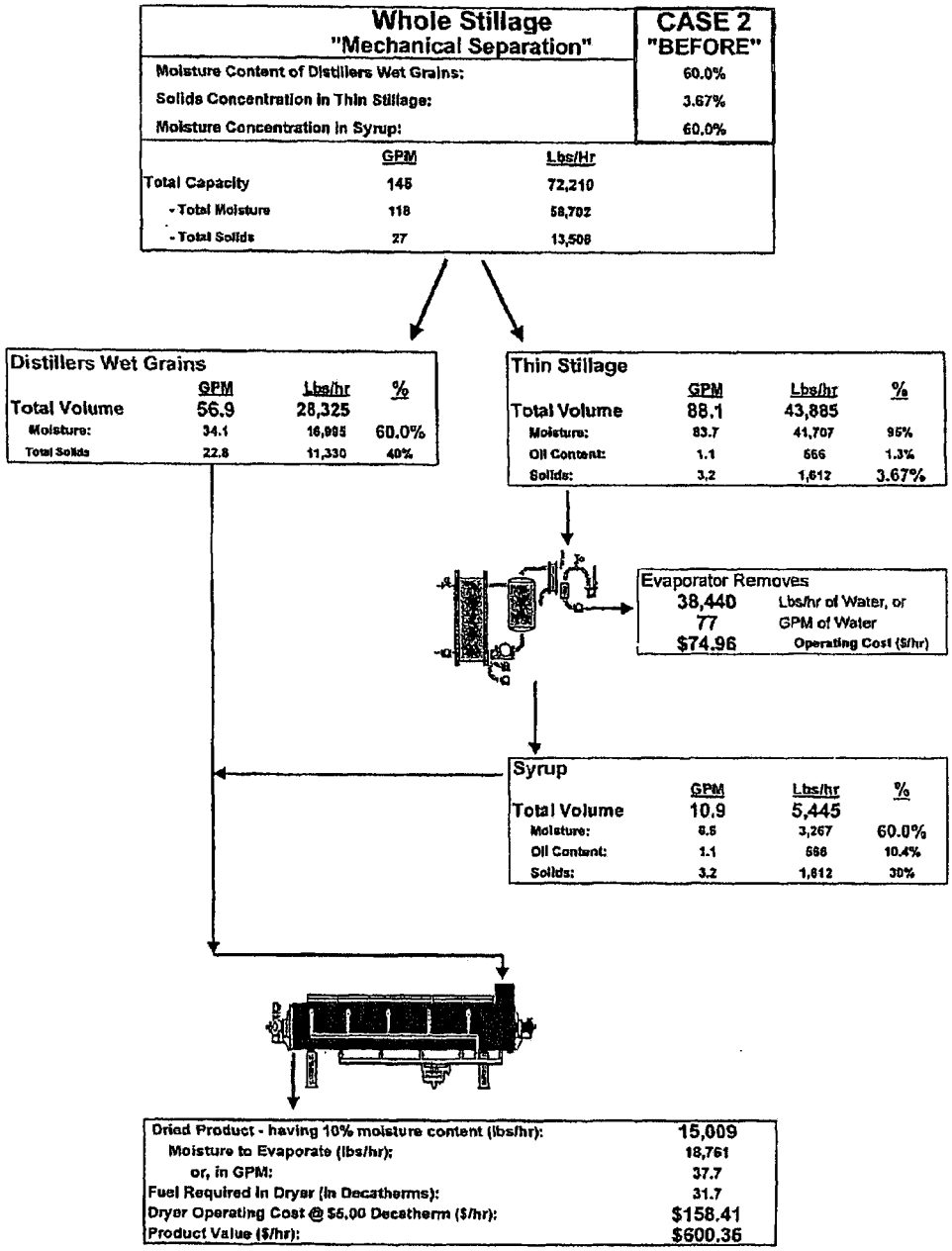

Whole Stillage
"Mechanical Separation"
CASE 2
"BEFORE"
Moisture Content of Distillers Wet Grains: 60.0%
Solids Concentration in Thin Stillage: 3.67%
Moisture Concentration in Syrup: 60.0%
GPM Lbs/Hr
Total Capacity 145 72,210
- Total Moisture 118 58,702
- Total Solids 27 13,508
Distillers Wet Grains
GPM Lbs/hr %
Total Volume 56.9 28,325
Moisture: 34.1 16,995 60.0%
Total Solids 22.8 11,330 40%
Thin Stillage
GPM Lbs/hr %
Total Volume 88.1 43,885
Moisture: 83.7 41,707 95%
Oil Content: 1.1 566 1.3%
Solids: 3.2 1,612 3.67%
Evaporator Removes
38,440 Lbs/hr of Water, or
77 GPM of Water
$74.96 Operating Cost ($/hr)
Syrup
GPM Lbs/hr %
Total Volume 10.9 5,445
Moisture: 6.6 3,267 60.0%
Oil Content: 1.1 566 10.4%
Solids: 3.2 1,612 30%
Dried Product - having 10% moisture content (lbs/hr): 15,009
Moisture to Evaporate (lbs/hr): 18,761
or, in GPM: 37.7
Fuel Required in Dryer (in Decatherms): 31.7
Dryer Operating Cost @ $5.00 Decatherm ($/hr): $158.41
Product Value ($/hr): $600.36

*Fig. 3*

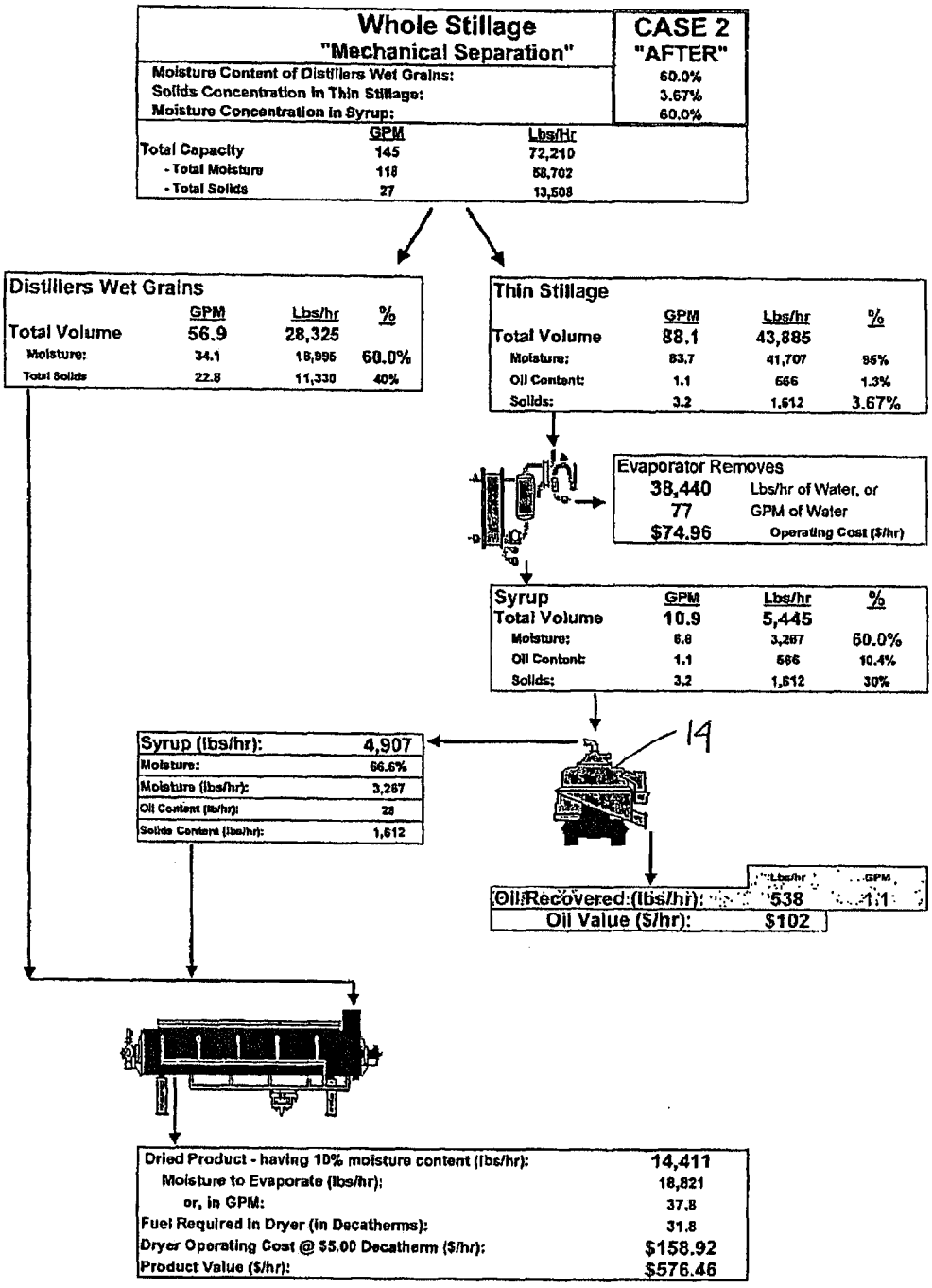

Whole Stillage
"Mechanical Separation"
CASE 2
"AFTER"
Moisture Content of Distillers Wet Grains: 60.0%
Solids Concentration in Thin Stillage: 3.67%
Moisture Concentration in Syrup: 60.0%
GPM Lbs/Hr
Total Capacity 145 72,210
- Total Moisture 118 58,702
- Total Solids 27 13,508
Distillers Wet Grains
GPM Lbs/hr %
Total Volume 56.9 28,325
Moisture: 34.1 16,995 60.0%
Total Solids 22.8 11,330 40%
Thin Stillage
GPM Lbs/hr %
Total Volume 88.1 43,885
Moisture: 83.7 41,707 95%
Oil Content: 1.1 566 1.3%
Solids: 3.2 1,612 3.67%
Evaporator Removes
38,440 Lbs/hr of Water, or
77 GPM of Water
$74.96 Operating Cost ($/hr)
Syrup GPM Lbs/hr %
Total Volume 10.9 5,445
Moisture: 6.6 3,267 60.0%
Oil Content: 1.1 566 10.4%
Solids: 3.2 1,612 30%
Syrup (lbs/hr): 4,907
Moisture: 66.6%
Moisture (lbs/hr): 3,267
Oil Content (lb/hr): 28
Solids Content (lbs/hr): 1,612
14
Lbs/hr GPM
Oil Recovered:(lbs/hr): 538 1.1
Oil Value ($/hr): $102
Dried Product - having 10% moisture content (lbs/hr): 14,411
Moisture to Evaporate (lbs/hr): 18,821
or, in GPM: 37.8
Fuel Required in Dryer (in Decatherms): 31.8
Dryer Operating Cost @ $5.00 Decatherm ($/hr): $158.92
Product Value ($/hr): $576.46

*Fig. 4*

# METHOD OF PROCESSING ETHANOL BYPRODUCTS AND RELATED SUBSYSTEMS

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 60/602,050, filed Aug. 17, 2004, the disclosure of which is incorporated herein by reference.

## COPYRIGHT STATEMENT



## TECHNICAL FIELD

The present invention relates generally to recovering oil and, more particularly, to recovering oil from a byproduct of the dry milling process used to form ethanol.

## BACKGROUND OF THE INVENTION

Over the past thirty years, significant attention has been given to the production of ethyl alcohol, or "ethanol," for use as an alternative fuel. Ethanol not only burns cleaner than fossil fuels, but also can be produced using grains such as corn, which are of course renewable resources. At present, approximately sixty-nine "dry milling" plants in the United States produce over two billion gallons of ethanol per year. Additional plants presently under construction are expected to add over four hundred million gallons to this total in an effort to meet the current high demand.

As noted in the foregoing discussion, a popular method of producing ethanol is known as "dry milling," and in the United States is typically practiced using corn. As is well known in the industry, the dry milling process utilizes the starch in the corn or other grain to produce the ethanol through fermentation, and creates a waste stream comprised of byproducts termed "whole stillage" (which may be further separated into products known as distillers wet grains and "thin stillage"). Despite containing valuable oil, this whole stillage has for the most part been treated as waste and used primarily to supplement animal feed (mostly in the form of distillers dried grains with solubles (DDGS), which is created by evaporating the thin stillage, recombining the resulting concentrate or syrup with the distillers wet grains, and drying the product to have a low moisture content; see, e.g., U.S. Pat. Nos. 5,662,810 and 5,958,233, the disclosures of which are incorporated herein by reference).

Efforts to recover the valuable oil from this byproduct have not been successful in terms of efficiency or economy. For example, one approach involves attempting to separate the oil from the thin stillage before the evaporation stage, such as using a centrifuge. However, spinning the thin stillage at this stage does not produce usable oil, but rather merely creates an undesirable emulsion phase requiring further processing. Moreover, the volume of thin stillage present is generally 2 to 10 times greater than the syrup, which requires considerable capital to purchase the number of centrifuges required. Together, these obstacles make attempts to recover oil from thin stillage highly inefficient and uneconomical.

U.S. Pat. No. 5,250,182 (the disclosure of which is incorporated herein by reference) describes the use of filters for removing substantially all solids and recovering lactic acid and glycerol from the thin stillage without the need for evaporation. Despite eliminating a step in the conventional process, the proposal results in a more complicated arrangement requiring multiple filtration steps. Wholesale elimination of the evaporator in the vast majority of existing plants is also unlikely and otherwise uneconomical. Filters, and especially the microfiltration and ultrafiltration types proposed in this patent, are also susceptible to frequent plugging and thus disadvantageously increase the operating cost. For these reasons, the filtration process proposed in this patent has not gained widespread commercial acceptance.



Accordingly, a need exists for a more efficient and economical manner of recovering oil from a byproduct containing it, such as thin stillage created during the dry milling process used to produce ethanol.

## SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, a method of processing a concentrated byproduct of a dry milling process for producing ethanol, such as by using corn, is disclosed. In its most basic form, the method comprises recovering oil from the concentrated byproduct.

In one embodiment, the byproduct comprises thin stillage, and the method includes the step of evaporating the thin stillage to form a concentrate. The recovering step may further comprise separating the oil from the concentrate using a disk stack centrifuge. Preferably, the recovering step comprises: (1) providing the concentrated byproduct at a temperature of between about 150 and 212° F. and, most preferably, at a temperature of about 180° F.; and/or (2) providing the concentrated byproduct having a pH of between about 3 and 6 and, most preferably, between about 3.5 and 4.5. Additionally, it is preferred that the concentrated byproduct have a moisture content greater than 15% by weight, more preferably a moisture content greater than 50% and less than 90% and, most preferably, a moisture content between about 60-85%. The step of recovering the oil from the concentrated byproduct produces syrup, and the method may further include the step of recovering oil from the syrup.

In accordance with another aspect of the invention, a more specific method of processing concentrated thin stillage created by a dry milling process for producing ethanol, such as from corn, is disclosed. The method comprises recovering oil from the concentrated thin stillage having a moisture content of less than about 90% by weight.

In one embodiment, the recovering step comprises separating the oil from the concentrate using a disk stack centrifuge. The method may further include the step of drying the concentrate after the removing step.

In accordance with still another aspect of the invention, a method of recovering oil from thin stillage is disclosed. The method comprises evaporating the thin stillage to create a concentrate having a moisture content of greater than 15% by weight and less than about 90% by weight. Oil is then recovered by centrifuging the concentrate, preferably using a disk stack centrifuge.

In accordance with yet another aspect of the invention, a method of processing whole stillage is disclosed. The method comprises recovering thin stillage including oil and solids from the whole stillage, concentrating the thin stillage including the solids, and recovering oil from the concentrate.

In one embodiment, the step of recovering the thin stillage includes using a separator selected from the group consisting of a press, extruder, a decanter centrifuge, and a screen centrifuge. The concentrating step may comprise processing the thin stillage to a temperature of between about 150 and 212° F., a pH of between about 3 and 6, and a moisture content of

less than 90%. The step of recovering oil comprises separating the oil from the concentrate using a centrifuge. The recovering and concentrating steps may be performed in a continuous fashion. The method may further include drying the concentrate after recovering oil.

In accordance with a further aspect of the invention, a subsystem for use in a system for producing ethanol by dry milling and creating thin stillage as a byproduct is disclosed. The subsystem comprises an evaporator for evaporating the thin stillage to form a concentrate, and a centrifuge for receiving the concentrate and recovering oil therefrom. Preferably, the concentrate has a moisture content of less than about 90% by weight, and the centrifuge is a disk stack type.

Still a further aspect of the invention is a subsystem for use in a system for producing ethanol by dry milling and creating thin stillage as a byproduct. The subsystem comprises an evaporator for evaporating the thin stillage to form a concentrate and means for recovering oil from the concentrate. In one embodiment, the recovering means comprises a centrifuge and, most preferably, a disk stack centrifuge.

Yet a further aspect of the invention is the combination of a concentrate formed from thin stillage including oil and a centrifuge for removing at least a portion of the oil from the concentrate. Preferably, the concentrate has a moisture content of greater than 15% by weight and less than about 90% by weight, and the centrifuge is a self-cleaning bowl type of disk stack centrifuge, a nozzle bowl disk stack centrifuge, or a horizontal centrifugal decanter

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially schematic flow chart illustrating the processing of co-products formed during the ethanol extraction process;

FIG. **2** is a partially schematic flow chart illustrating the recovery of oil from a syrup formed by evaporating the thin stillage;

FIG. **3** is a schematic view similar to FIG. **1**; and

FIG. **4** is a schematic view similar to FIG. **2**.

## DETAILED DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a method recovers oil from a byproduct resulting from the production of ethanol using a dry milling technique (which is extensively described in the above-referenced '182 patent). The byproduct, known as "thin stillage," is recovered by separating the distillers wet grain from the "whole stillage" leftover after fermentation is complete. As is known in the art, this mechanical separation may be accomplished using a press/extruder, a decanter centrifuge, or a screen centrifuge. Moisture is then removed from the unfiltered thin stillage to create a concentrate or syrup, such as through evaporation. Advantageously, usable oil is then easily recovered from this concentrated form of the byproduct through relatively simple mechanical processing, without the prior need for multiple stages of filtration or other expensive and complicated undertakings.

In one embodiment, oil is recovered from the concentrate by passing it through a centrifuge and, in particular, a disk stack centrifuge (and most preferably a self-cleaning bowl type). Preferably, the concentrate fed to the disk stack centrifuge is at a temperature of between about 150 and 212° F. (and ideally 180° F.) and a pH of between about 3 and 6 (ideally between about 3.5 and 4.5). As a result of the preceding evaporation step, the concentrate has a moisture content of greater than 15% and less than about 90%, more preferably



between 30% and about 90%, and ideally about 60-85% by weight. Under these process conditions, the disk stack centrifuge is able to separate the oil in usable form from the concentrate in an efficient and effective manner, despite the relatively high level of solids present (which may be recovered from the centrifuge in a continuous or intermittent fashion, depending on the particular process conditions).

Besides creating usable oil, the concentrate or syrup recovered from the disk stack centrifuge is considered more valuable. This is because the post-evaporation processing to recover or remove the oil improves the efficiency of the drying process used on the combined concentrate syrup and distillers wet grains. A stable, flowable product for supplementing animal feed results, which thus further complements the value of the oil recovered.

Two examples are presented below to demonstrate the efficacy of the above-described method.

## EXAMPLE 1

Reference is made to FIGS. **1** and **2** to illustrate schematically a first example demonstrating the efficacy of the present method.

FIG. **1** represents one technique for processing whole stillage resulting from dry milling corn to create distillers dried grains with solubles. The whole stillage leftover after deriving the ethanol is mechanically separated into distillers wet grains (approx. 35% solids) and thin stillage (approx. 6.7% solids), such as by using a centrifugal decanter. The thin stillage is then introduced to an evaporator to create a syrup having a moisture content of approximately 80% by weight and about 17% solids by weight. The syrup is then recombined with the distillers wet grains, introduced to a drum dryer, and dried to reduce the overall moisture content to approximately 10% by weight. An estimated total value of the resulting distillers dried grains with solubles is $600.36 per hour.

FIG. **2** represents the inventive method and a related subsystem **10** for implementing it. Initial processing of the whole stillage is done in the same fashion, and the mechanically separated thin stillage is delivered to the evaporator **12** forming part of the subsystem **10**. The resulting concentrate or syrup having a moisture content of approximately 80% by weight and a solids content of approximately 17% by weight is delivered to a disk stack centrifuge **14**, and preferably a "solids ejecting" one, such as an Alfa Laval Model No. AFPX 510, AFPX 513, or AFPX 617 or equivalent device. At an infeed rate of approximately 35 gallons per minute, this centrifuge **14** recovers usable oil at a rate of 538 pounds per hour and produces syrup having a having a moisture content of 82.5% by weight, but with far less oil in view of the preceding recovery step.

Recombining the syrup (which is substantially free of oil) from the centrifuge **14** with the distillers wet grains and drying in a drum dryer **16** to a moisture content of 10% by weight results in a product having a value of $576.46 per hour. However, the 538 pounds per hour of oil recovered has a product value of approximately $102 per hour. Accordingly, the total product value using the inventive method is $678.46 per hour, which is approximately 12% greater than the $600.36 per hour product value resulting from use of the conventional set-up shown in FIG. **1**. Moreover, removal of the majority of the oil before the drying step makes the process more efficient, and results in an estimated energy savings of approximately 10%, or $26.27 per hour. As a result, product value per hour ($678.46) less the estimated dryer operat-

ing cost ($236.46 per hour with the 10% savings) and less the estimated evaporator operating cost ($50.98 per hour) is about $391.02 per hour.

## EXAMPLE 2

Reference is made to FIGS. 3 and 4, which illustrate a prophetic comparison between one processing method and the inventive method. The set-up is essentially the same as shown in FIGS. 1 and 2, but a more effective centrifugal decanter is used than the one used in Example 1. As a result, the syrup introduced to the disk stack centrifuge **14** would have a moisture content estimated at 60% by weight. While this does not impact the product value figures, the syrup from the centrifuge **14** has a moisture content of only 66.6% by weight, as compared to 82.5% by weight in Example 1. As a result, the cost per hour of drying this syrup when combined with the distillers wet grains to achieve an end product having a moisture content of less than 10% is only $158.92, or approximately 40% less. Assuming a savings in dryer efficiency of 10%, the product value per hour ($678.46) less the estimated dryer operating cost ($143.03 per hour) and less the estimated evaporator operating cost ($74.96 per hour) is $460.46 per hour. This represents an approximate 15% increase over the corresponding value calculated for Example 1.

As should be appreciated, the above-described method and subsystem of the preferred embodiment essentially require the addition of a centrifuge downstream of the evaporator in the conventional system for processing thin stillage (which centrifuge may thus be considered a "means for" recovering oil from thin stillage). Accordingly, instructions on how to implement the above-described method (including the optimum process variables) may be provided along with a centrifuge for use in an ethanol plant for forming the novel subsystem **10** disclosed herein. Such instructions result in the most efficient implementation of the method, as compared to the situation where the scientists or engineers at the plant must experiment with the centrifuge to determine the optimum process conditions required to achieve a favorable result.

The foregoing description provides illustration of the inventive concepts. The descriptions are not intended to be exhaustive or to limit the disclosed invention to the precise form disclosed. Modifications or variations are also possible in light of the above teachings. For example, the syrup recovered from the centrifuge may be evaporated and processed again in a further effort to recover oil before drying. Moreover, in addition to a self-cleaning bowl type of disk stack centrifuge, a nozzle bowl disk stack centrifuge would work as a means for recovering oil from the concentrate, as would a horizontal centrifugal decanter (which may be especially beneficial when the moisture content of the concentrate is less than 50% by weight) or other like devices for separating oil from a substance including suspended solids. Moreover, besides corn, the present invention may have utility with any other grain used in a dry milling process for producing ethanol, such as for example, milo. The embodiments described above were chosen to provide the best application to thereby enable one of ordinary skill in the art to utilize the inventions in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention.

The invention claimed is:

**1**. A method of recovering oil from thin stillage, the method comprising, in sequence:



evaporating the thin stillage to remove water and form a concentrated byproduct; and

recovering oil from the concentrated byproduct by heating and mechanically processing the concentrated byproduct to separate the oil from the concentrated byproduct, wherein the concentrated byproduct has a moisture content of greater than 30% and less than 90% by weight.

**2**. The method of claim **1**, wherein the mechanical processing comprises separating the oil from the concentrated byproduct using a disk stack centrifuge.

**3**. The method of claim **1**, wherein the recovering step is performed on the concentrated byproduct at a temperature of between about 150 and 212° F.

**4**. The method of claim **1**, wherein the recovering step is performed on the concentrated byproduct at a temperature of about 180° F.

**5**. The method of claim **1**, wherein the recovering step is performed on the concentrated byproduct having a pH of between about 3 and 6.

**6**. The method of claim **1**, wherein the recovering step is performed on the concentrated byproduct having a pH of between about 3.5 and 4.5.

**7**. The method of claim **1**, wherein the concentrated byproduct has a moisture content between about 60-85%.

**8**. A method of recovering oil from thin stillage, comprising, in sequence: evaporating the thin stillage to create a concentrate having a moisture content of greater than 30% by weight and less than about 90% by weight; and centrifuging the concentrate to recover oil.

**9**. The method according to claim **8**, wherein the step of centrifuging the concentrate comprises using a disk stack centrifuge.

**10**. A method of processing whole stillage, comprising: recovering thin stillage from the whole stillage, the thin stillage including oil and solids; concentrating the thin stillage including the solids to produce a thin stillage concentrate, wherein the thin stillage concentrate has a moisture content of greater than 30% and less than 90% by weight; and recovering oil from the concentrate by a process consisting essentially of heating and mechanically processing the concentrate to separate the oil from the concentrate.

**11**. The method of claim **10**, wherein the step of recovering the thin stillage includes using a separator selected from the group consisting of a press, extruder, a decanter centrifuge, and a screen centrifuge.

**12**. The method of claim **10**, wherein the concentrating step comprises processing the thin stillage to a temperature of between about 150 and 212° F., a pH of between about 3 and 6.

**13**. The method of claim **10**, wherein the step of recovering oil comprises separating the oil from the concentrate using a centrifuge.

**14**. The method of claim **10**, wherein the recovering and concentrating steps are performed in a continuous fashion.

**15**. The method of claim **10**, further including the step of drying the concentrate after the step of recovering the oil.

**16**. In a method for processing corn to produce ethanol and concentrated thin stillage, the improvement comprising the step of recovering a product consisting essentially of oil from the concentrated thin stillage by heating and mechanically processing the concentrated thin stillage to separate the oil from the concentrated thin stillage.

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