



(51) International Patent Classification:

B01D 1/00 (2006.01) C12M 1/00 (2006.01)

B01D 3/00 (2006.01) B01D 1/26 (2006.01)

C12F 3/00 (2006.01)

(21) International Application Number:

PCT/US2020/016495

(22) International Filing Date:

04 February 2020 (04.02.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/805,526 14 February 2019 (14.02.2019) US

(71) Applicant: **BL TECHNOLOGIES, INC.** [US/US]; 5951 Clearwater Drive, Minnetonka, Minnesota 55343 (US).

(72) Inventors: **WALTER, Dan**; 5951 Clearwater Drive, Minnetonka, Minnesota 55343 (US). **ANDREWS, Aaron**; 5951 Clearwater Drive, Minnetonka, Minnesota 55343 (US).

(74) Agent: **FABRY, Michelle M.** et al.; Wegman Hessler, 6055 Rockside Woods Boulevard, Suite 200, Cleveland, Ohio 44131 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: USE OF CONDUCTIVITY AS A PROXY MEASURE FOR SOLIDS IN ETHANOL STILLAGE EVAPORATOR STREAMS

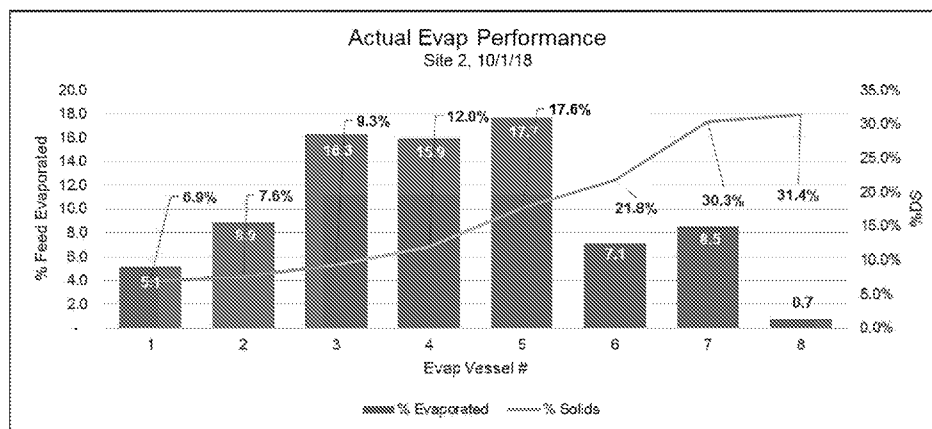


FIG. 1

(57) Abstract: A method for control and optimization of a stillage evaporation process, the method providing monitoring a conductivity of a stillage stream to obtain a conductivity value; correlating the conductivity value to a dry solids percentage (%DS) present in a stillage evaporator system to obtain an evaporator solids profile; and utilizing the evaporator solids profile to obtain a mass-balance solids profile of a stillage evaporator system to control and optimize a dry solids evaporation process.



Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

USE OF CONDUCTIVITY AS A PROXY MEASURE FOR SOLIDS IN ETHANOL STILLAGE EVAPORATOR STREAMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of Application Serial No. 62/805,526 filed February 14, 2019, the entirety of which is herein incorporated by reference.

FIELD OF INVENTION

[0002] The disclosed technology generally described hereinafter provides for a system and method for the control and optimization of a stillage evaporation process, and more specifically, using conductivity as a proxy measure of %DS in order to better manage load balances and optimize “Clean in Place” (CIP) processes of stillage evaporator systems.

BACKGROUND OF THE INVENTION

[0003] Currently, evaporator solids balance information is difficult to collect and/or measure, requiring two to four hours to measure resulting in ethanol producers using pre-determined “Clean in Place” (CIP) schedules to clean evaporator vessels on a pre-planned schedule and frequency with no regard to actual cleanliness conditions of any particular vessel. This can result in loss of system efficiency due to spending time cleaning a vessel that is not substantially fouled, rather than directing the effort to the most fouled vessel, if required. The impact on plant productivity and efficiency results in lower ethanol production and corn oil recovery due to the downtime associated with the CIP processes.

[0004] Currently, coriolis meters are able to measure the actual mass flow of each evaporation vessel directly, where the actual flow rates and densities of the advancing liquor stream through the successive vessels as it concentrates can be provided. From these measurements, the mass-balance profile can be generated. However, utilization of this type of equipment would require substantially larger

investment due to the configuration needs and costs of such systems. Nine individual meters and associated piping consistent with meter installation requirements would be required. The relative cost of this equipment is nearly 10X of conductivity systems and the installation requirements are substantially greater as additional piping would very likely be required to provide the straight runs needed for such equipment.

[0005] Further, condensate flow measurements may also provide similar results, by measuring the mass balance across each evaporation vessel. However, the challenge with such an approach is the aggressive nature of process condensate and uneven real-time flow measurement capability of condensate flows from individual evaporation vessels.

[0006] Thus, the present technology overcomes the prior problems/issues discussed, and allows for the ethanol producer to better manage their stillage evaporator system to maximize the evaporation process efficiency with respect to final syrup stream %DS exiting the evaporation process, which will relate to a reduction in the total energy required to dry co-products that include the syrup stream.

SUMMARY OF THE INVENTION

[0007] The disclosed technology generally described hereinafter provides for a system and method control and optimization of a stillage evaporation process, and more specifically, a system and method for generating solids balance and evaporator load-performance data across a plurality of evaporator vessels within a stillage evaporation process.

[0008] In one aspect of the disclosed technology, a method for control and optimization of a stillage evaporation process is provided. The method comprising monitoring a conductivity of a stillage stream to obtain a conductivity value; correlating the conductivity value to a dry solids percentage (%DS) present in a stillage evaporator system to obtain an evaporator solids profile; and utilizing the evaporator solids profile to obtain a mass-balance solids profile of a stillage evaporator system to control and optimize an evaporation process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other features of the disclosed technology, and the advantages, are illustrated specifically in embodiments now to be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

[0010] FIG. 1 is a graph providing results of an illustrative embodiment of the disclosed technology;

[0011] FIG. 2 is a graph providing results of an illustrative embodiment of the disclosed technology;

[0012] FIG. 3 is a graph providing results of an illustrative embodiment of the disclosed technology;

[0013] FIG. 4 is a graph providing results of an illustrative embodiment of the disclosed technology; and

[0014] FIG. 5 is a graph providing results of an illustrative embodiment of the disclosed technology.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0015] The disclosed technology generally provides for a system and method for the control and optimization of a stillage evaporation process. The disclosed technology is directed towards monitoring the conductivity of stillage solid streams with a conductance monitor, and using this information to control and optimize the process evaporation, so as to optimize energy consumption and minimize fouling. The disclosed technology further provides for using conductivity as a proxy measure of %DS in order to better manage load balances and optimize “Clean in Place” (CIP) processes of stillage evaporator systems.

[0016] The disclosed technology, through routine analysis of stillage evaporator samples and the data obtained therein, determined a correlation of individual stillage stream conductivity to the corresponding % Dry Solids (%DS) of each sample across an eight (8) vessel double-effect evaporator system. It was determined the conductivity measurements provide a statistically accurate calculation of the %DS across all eight evaporator vessels. This data is then used to construct a mass-balance solids profile across an evaporator system that is used to effectively measure actual evaporation rates

within each vessel. Further, this information is used to support evaporator operation decisions regarding system cleanliness, hydraulic balance and provide predictive information to optimize “Clean in Place” (CIP) processes, such as CIP scheduling, vessel selection priority for CIPs, and/or the like.

[0017] By proving the correlation of conductivity to %DS, rapid results of evaporator solids profiles are generated such that, at any given time, the results will identify which vessels are underperforming with respect to evaporator duty. Further, with on-line conductivity instrumentation, real-time results of the solids profile, as well as more predictive performance expectations based on operating conditions and operating history through the use of multiple regression analysis of each evaporator vessel’s performance, are provided. In some embodiments, the real-time %DS profile across the stillage evaporator will support operational decision making based on these outcomes, which can result in (1) more effective evaporator vessel runs, and (2) increasing the final %DS based on cleanliness capability.

[0018] By monitoring the actual individual vessel evaporation rate (based on vessel cleanliness), decisions on when to CIP any given vessel can be managed to extend the time to optimum for the respective vessel. This will reduce the CIP frequency for many of the evaporator vessels that may not exhibit the same level of fouling as other vessels, and may also increase the CIP frequency of those vessels that do exhibit higher fouling rates. In either case, the time and effort required for CIP processes are directed to where the most cleanliness benefit will be realized.

[0019] The purpose of the stillage evaporator is to concentrate the stillage solids level, such that the final liquor can be applied to other solids streams that comprise Dried Distillers Grains with Solubles (DDGS), a valuable co-product of the ethanol process. The DDGS solids moisture content market requirement is 10-12% moisture. At a typical syrup moisture content of 65%-70% exiting the evaporator system, additional energy is required to produce a marketable DDGS coproduct. The evaporator removes moisture using half the energy (double effect) that will be required in down-stream DDGS dryer systems. Therefore, increasing the %DS (i.e. reducing the moisture content) in the evaporator system effluent syrup will decrease the energy requirement down-stream, resulting in reduced manufacturing/operating costs required

to produce the DDGS. This is not done today in current processes due to the increased risk on evaporator performance the higher %DS syrup level will have on increased fouling. By more effectively managing the total evaporator cleanliness, this risk is reduced and increasing/maintaining higher %DS results.

[0020] The cost and simplicity of the conductivity measurement as in the present technology, allows the producer to effectively measure their system performance with a robust real-time conductivity analyzer array to optimize the benefits described above. It also provides real performance data to measure improvements to the evaporation process that are realized through the use of on-line deposit control agents, CIP additives, and other adjunct treatments designed to make such improvements. In contrast to the disclosed technology, with such adjunct treatments used with current processes, actual impact is difficult to prove due to the myriad variables of the stillage evaporator system.

[0021] In some embodiments, the method and process described herein may include measuring the actual mass balances across the eight evaporator vessels, including the %DS mass balance described herein, measuring of the resulting condensate or vapor generated by the evaporation processes, density measurements of the liquor streams, or the like.

EXAMPLES

[0022] The present invention will be further described in the following examples, which should be viewed as being illustrative and should not be construed to narrow the scope of the disclosed technology or limit the scope to any particular embodiments.

[0023] Multiple analyses of two separate stillage evaporator system % Dry Solids (%DS) profiles have been run and compared to corresponding specific conductance measurements. The charted data was used to develop a mathematical (exponential) trend formula with an R2 greater than 0.98. The results of this correlation are then used in a mass balance formula for the evaporator system to generate a solids balance and evaporator load-performance data across all evaporator vessels. Ultimately this data will be generated using on-line instrumentation and providing real-time data.

[0024] The results of testing also identified the need for individual site-based correlation formulae that, while different from site to site, have been proven to provide the statistically significant accuracy for each respective site.

[0025] Table 1 provides data obtained from the disclosed technology, wherein the calculation parameter for $y=[\text{constant}]e^{(\text{multiplier} \times X)}$, where the constant value is 0.0228, and the multiplier is 0.00012257.

TABLE 1

Site	Date	Conductivity	Measured %DS	Calculated %DS	% error
2	4-Jun	8870	7.0%	6.8%	-3.1%
2	4-Jun	9357	8.0%	7.2%	-10.3%
2	4-Jun	10770	9.1%	8.5%	-6.1%
2	4-Jun	12010	10.4%	9.9%	-4.2%
2	4-Jun	13060	11.4%	11.3%	-0.8%
2	4-Jun	15740	16.3%	15.7%	-3.7%
2	4-Jun	18970	26.5%	23.3%	-12.1%
2	27-Aug	8733	6.7%	6.6%	-1.0%
2	27-Aug	9511	7.3%	7.3%	-0.5%
2	27-Aug	9920	8.0%	7.7%	-3.8%
2	27-Aug	10610	8.6%	8.4%	-2.9%
2	27-Aug	12610	11.1%	10.7%	-3.5%
2	27-Aug	14700	14.0%	13.8%	-1.6%
2	27-Aug	16810	18.5%	17.9%	-3.1%
2	27-Aug	18890	26.8%	23.1%	-13.7%
2	27-Aug	20760	37.2%	29.0%	-21.9%
2	18-Sep	8929	6.5%	6.8%	4.6%
2	18-Sep	9488	6.9%	7.3%	6.4%
2	18-Sep	9741	7.6%	7.5%	-0.4%
2	18-Sep	10790	9.3%	8.6%	-7.9%
2	18-Sep	12910	12.0%	11.1%	-7.3%
2	18-Sep	15190	17.6%	14.7%	-16.8%
2	18-Sep	17630	21.8%	19.8%	-9.2%
2	18-Sep	20450	30.3%	28.0%	-7.8%
2	18-Sep	22160	31.4%	34.5%	9.8%
2	1-Oct	8798	6.5%	6.7%	2.9%
2	1-Oct	9786	6.9%	7.6%	10.3%
2	1-Oct	10330	7.6%	8.1%	7.0%
2	1-Oct	11800	9.3%	9.7%	4.2%
2	1-Oct	13960	12.0%	12.6%	5.4%
2	1-Oct	16760	17.6%	17.8%	0.9%
2	1-Oct	18880	21.8%	23.1%	5.8%
2	1-Oct	21190	30.3%	30.6%	0.9%
2	1-Oct	21450	31.4%	31.6%	0.6%

[0026] While embodiments of the disclosed technology have been described, it should be understood that the present disclosure is not so limited and modifications may be made without departing from the disclosed technology. The scope of the disclosed technology is defined by the appended claims, and all devices, processes, and methods that come within the meaning of the claims, either literally or by equivalence, are intended to be embraced therein.

CLAIMS

1. A method for control and optimization of a stillage evaporation process, the method comprising:
 - monitoring a conductivity of a stillage stream to obtain a conductivity value;
 - correlating the conductivity value to a dry solids percentage (%DS) present in a stillage evaporator system to obtain an evaporator solids profile; and
 - utilizing the evaporator solids profile to obtain a mass-balance solids profile of a stillage evaporator system to control and optimize an evaporation process.
2. The method as recited in claim 1, wherein the mass-balance solids profile is further used to measure an evaporation rate within a plurality of evaporation vessels.
3. The method as recited in claim 2, wherein the evaporation rate is used to identify and control performance of the plurality of evaporator vessels.

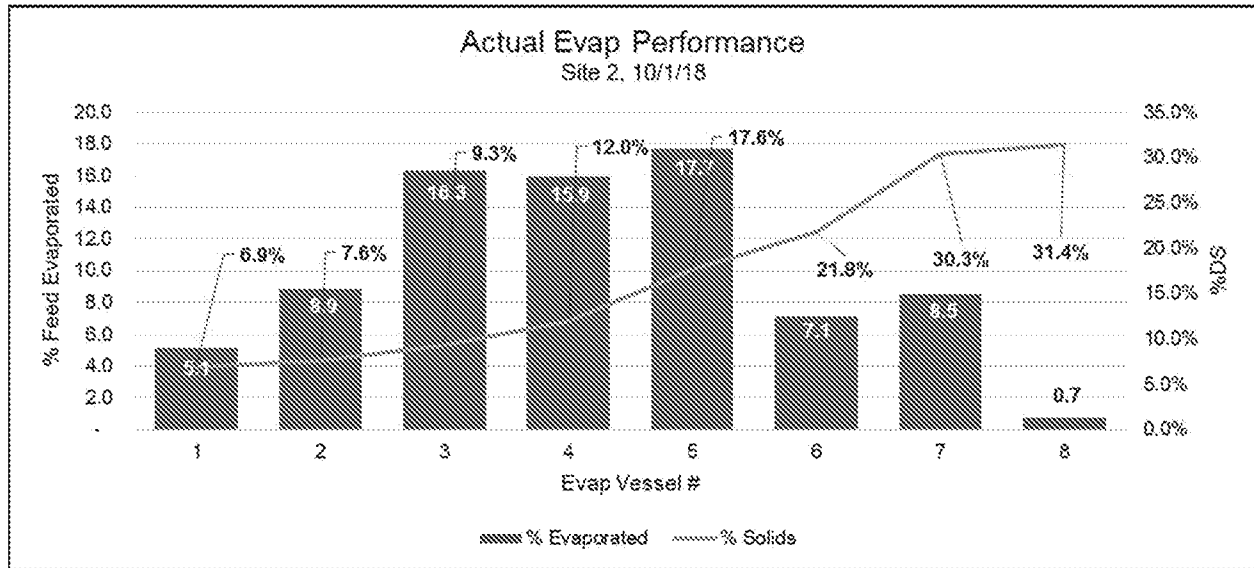


FIG. 1

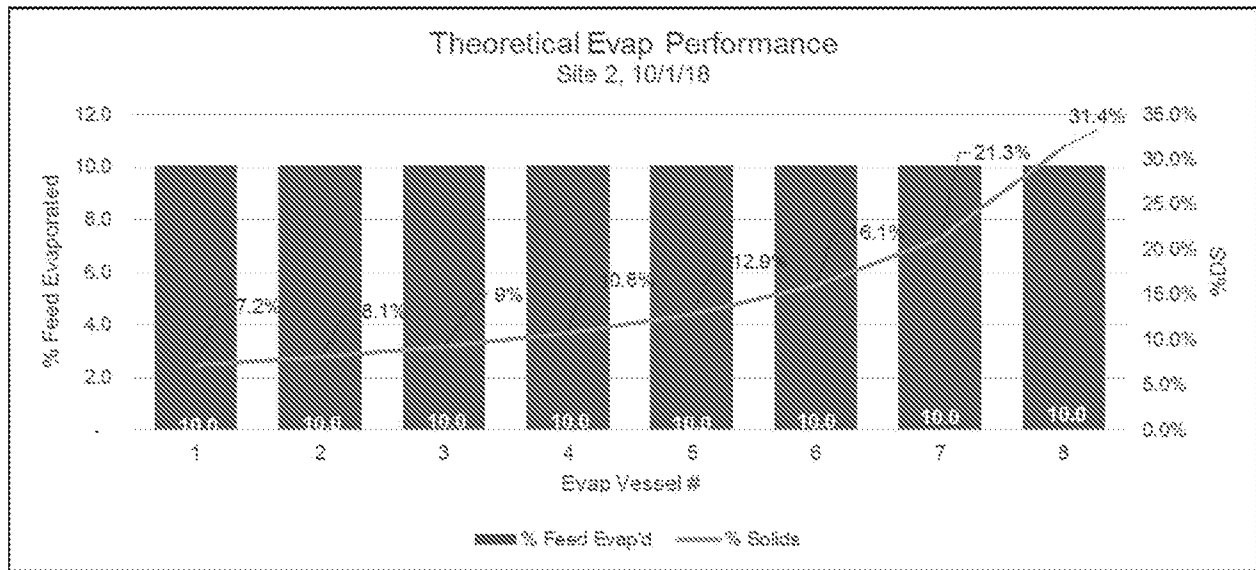


FIG. 2

3/5

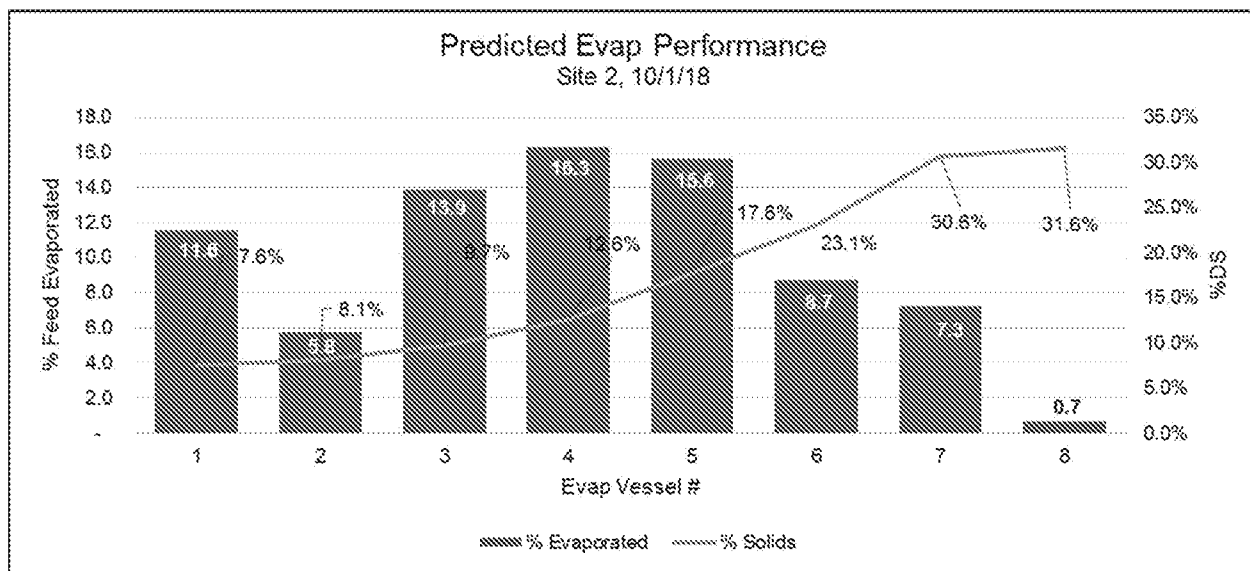


FIG. 3

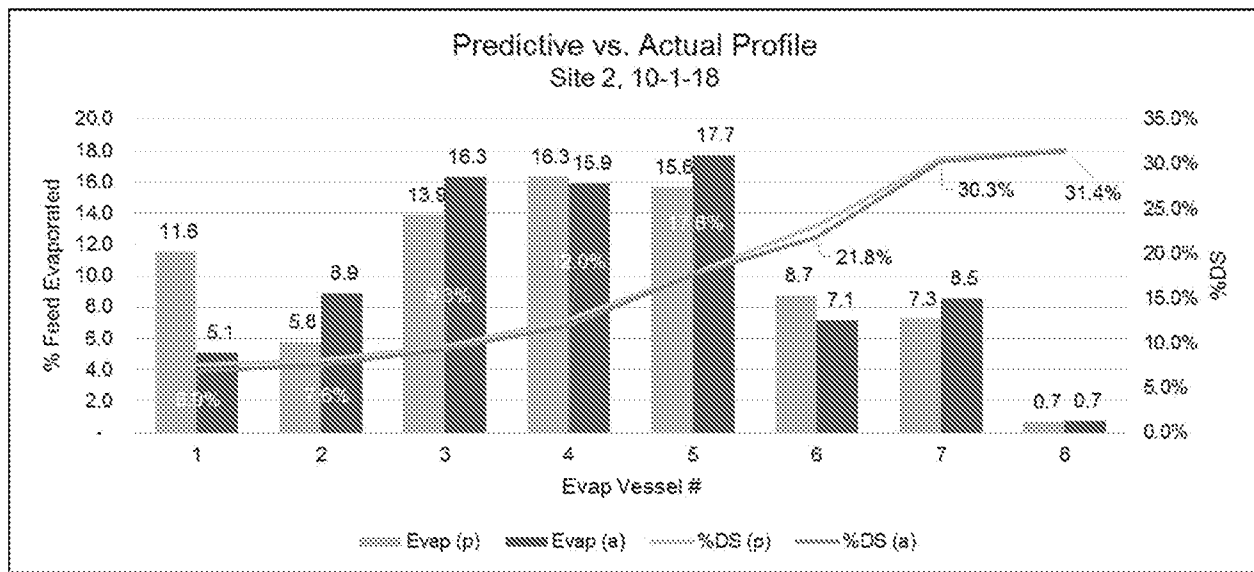


FIG. 4

5/5

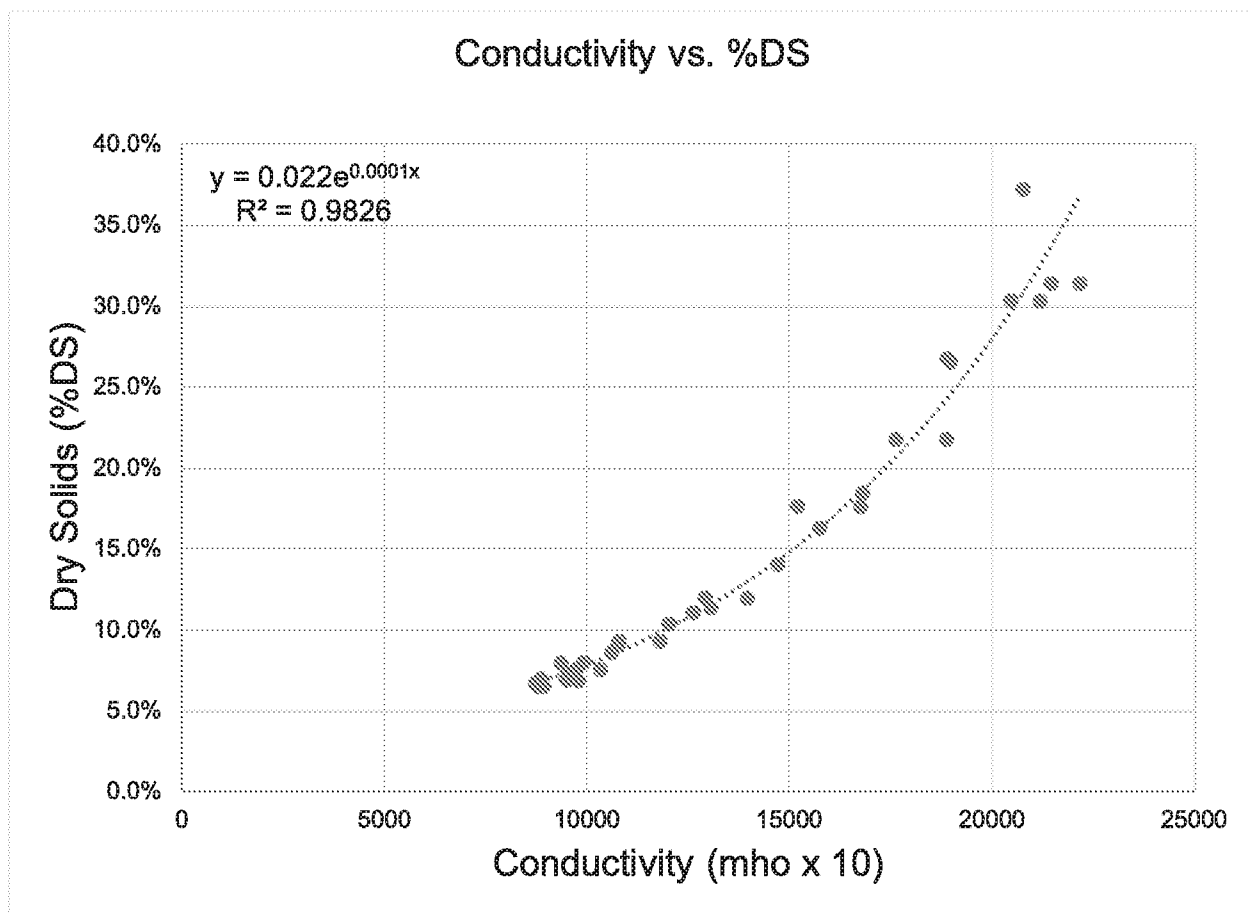


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2020/016495

A. CLASSIFICATION OF SUBJECT MATTER INV. B01D1/00 B01D3/00 C12F3/00 C12M1/00 B01D1/26 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B01D C12M C12F C12P A23K G05D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8 103 385 B2 (MACHARIA MAINA A [US]; MAXWELL DONALD MELVIN [US] ET AL.) 24 January 2012 (2012-01-24) figure 2 column 1, lines 7-10 column 5, lines 1-5 column 7, lines 35-38 column 9, lines 47-67 -----	1-3
A	US 2008/103747 A1 (MACHARIA MAINA A [US] ET AL) 1 May 2008 (2008-05-01) figure 4 paragraphs [0142], [0174], [0180] -----	1-3
A	US 2015/152372 A1 (KOHL SCOTT D [US] ET AL) 4 June 2015 (2015-06-04) figure 2 paragraphs [0052], [0115] - [0117] -----	1-3
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
19 May 2020		10/06/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer
		Van Ganswijk, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2020/016495

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8103385	B2	24-01-2012	NONE
US 2008103747	A1	01-05-2008	NONE
US 2015152372	A1	04-06-2015	BR 112013002972 A2 07-06-2016
		CA 2799409 A1 09-02-2012	
		EP 2600957 A1 12-06-2013	
		US 2011283602 A1 24-11-2011	
		US 2012051980 A1 01-03-2012	
		US 2013165678 A1 27-06-2013	
		US 2015152372 A1 04-06-2015	
		WO 2012018421 A1 09-02-2012	