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(54) Predictive maintenance system for a filling machine

Prädiktives Wartungssystem für eine Füllmaschine

Système de maintenance prédictif pour une machine de remplissage

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Description

[0001] The present invention relates to a predictive system and method for a filling machine, designed for filling containers with a product, in particular for predictive fault analysis and maintenance.

[0002] In the field of bottling of a liquid, in particular a food product, in containers, like glass bottles or aluminum cans, a system is known comprising a feed line for feeding a succession of empty bottles to a filling machine, in turn comprising a filling rotating wheel (so called "carousel"), carrying a number of filling units.

[0003] The filling units are mounted to rotate continuously about a longitudinal axis, engage the empty bottles, fill the bottles with the product, and then feed the bottles to a capping machine, which is connected to the filling machine by at least one transfer wheel and closes the bottles with respective caps.

[0004] Figure 1 schematically shows a known filling machine, denoted as a whole with 1, for filling liquid into containers 2, for example glass bottles or aluminum cans.

[0005] Filling machine 1 comprises a conveying device, including a carousel 4, which is mounted to rotate continuously (anticlockwise in Figure 1) about a substantially vertical longitudinal axis A.

[0006] The carousel 4 receives a succession of empty containers 2 from an input wheel 5, which is coupled to carousel 4 at a first transfer station 6 and is mounted to rotate continuously about a respective vertical longitudinal axis B, parallel to axis A.

[0007] The carousel 4 releases a succession of filled containers 2 to an output wheel 8, which is coupled to carousel 4 at a second transfer station 9 and is mounted to rotate continuously about a respective vertical longitudinal axis C, parallel to axes A and B.

[0008] Filling machine 1 comprises a number of filling units 10, which are equally spaced about axis A, are mounted along a peripheral edge of carousel 4, each in a corresponding slot or seat 11 of the carousel 4, and are moved by the same carousel 4 along a path P extending about axis A and through transfer stations 6 and 9.

[0009] Each filling unit 10 is designed to receive at least one container 2 to be filled, and to perform, during its rotation along path P, a number of filling operations according to a filling "recipe", in order to fill the container 2 with a desired fluid or combination of fluids (e.g. in case of carbonated liquids).

[0010] The filling unit 10 is configured to engage the container 2, at an opening of a neck 2' thereof, and includes one or more fluidic conduits (not shown), which are designed to selectively couple the container 2 to one or more feed devices.

[0011] Each filling unit 10 also comprises at least one flow regulator device (not shown), designed to define one or more filling passages communicating with the opening of the container 2, and including at least a filling valve, operable to selectively open the filling passage(s) during filling of the container 2.

[0012] Each filling unit 10 is moreover provided with an electronic board (not shown), including suitable circuitry to control its operation, and operatively coupled to a supervisor unit 14 of the filling machine 1, e.g. including a PLC (Programmable Logic Controller). Supervisor unit 14 also provides an HMI (Human Machine Interface) towards an operator, including suitable input and display means, in order to allow the operator to check and control the operation of the filling machine 1.

[0013] The Applicant has realized that known filling machines (e.g. of the type shown in Figure 1) may suffer from some drawbacks concerning the occurrence of faults in the filling units during their operation; faults may indeed occur in constituent elements of the same filling units (e.g. in the filling valves), due to the wearing effect of time and/or due to defects or malfunctions.

[0014] When faults occur, correct filling of the containers may be impaired; for example, a container may only be partially filled in a filling unit, with the consequence that the same container has to be discarded after quality checks.

[0015] Generally, maintenance of the filling units in the filling machine is based on a total number of working hours or working cycles performed by the same filling units; constituent elements are replaced, when a preset upper threshold is reached for these operating parameters.

[0016] However, such a maintenance solution is not wholly satisfactory, since it may lead to constituent elements of the filling machine being replaced while still in a proper operating condition, or to sudden and unforeseen faults occurring in constituent elements, having not reached the preset threshold number of working hours or cycles yet, with the consequence of unplanned stops for the filling machine.

[0017] Also known from US-2007/107801-A1 is an automated system for predictive maintenance of a filling machine as defined in the preamble of claim 1.

[0018] The aim of the present invention is consequently to solve, at least in part, the problems previously highlighted, and in general to provide an improved solution for monitoring the correct operation of a filling machine and for maintenance thereof.

[0019] According to the present invention, a system and a method are thus provided, as defined in the appended claims.

[0020] For a better understanding of the present invention, preferred embodiments thereof are now described, purely by way of a non-limiting example, with reference to the attached drawings, wherein:

- Figure 1 shows schematically a known filling machine;
- Figure 2 is a schematic block diagram of a maintenance system according to the present solution;
- Figure 3 is a schematic representation of the content

of a central database in the system of Figure 2;

- Figure 4 is a flowchart of operations performed in the system of Figure 2;
- Figures 5 to 7 show plots relating to the performance of the filling machine, provided by the system of Figure 2;
- Figure 8 shows exemplary data that may be provided by the system of Figure 2.

[0021] One aspect of the present solution provides an automated and computerized system for monitoring the operation of filling units in a filling machine, and for predicting faults in view of a predictive maintenance. As will be discussed in detail, each filling unit is continuously monitored, by acquiring operating parameters during its operation, and a predictive algorithm is executed based on the acquired operating parameters, in order to predict the occurrence of faults, and schedule maintenance or replacement for the same filling unit before the faults occur.

[0022] Figure 2 shows an automated predictive maintenance system according to the present solution, denoted as a whole with 20, which is operatively coupled to a filling machine 1 in a manufacturing plant; for example, filling machine 1 may be made as discussed with reference to figure 1, so that same reference numerals are used again to denote similar elements.

[0023] System 20 includes an image acquisition unit 22, e.g. a CCD camera or similar device, arranged at the filling machine 1, in such a manner as to be able to read a univocal coded sign 23, e.g. a so called "datamatrix", a QR code, a barcode, placed on each filling unit 10 of the filling machine 1. For example, image acquisition unit 22 is fixed to a supporting structure 24, facing the carousel 4 of the filling machine 1.

[0024] System 20 further includes a control module 25, provided with a processing unit 26, such as a CPU, a controller or a microcontroller, suitably programmed in order to be able to execute the operations that will be discussed in detail in the following.

[0025] Control module 25 is provided with a first interface 27, operatively coupled to the processing unit 26, and configured to provide wired or wireless communication with the image acquisition unit 22, in order to allow the processing unit 26 to receive data acquired by the same image acquisition unit 22.

[0026] In particular, processing unit 26 is provided with information regarding the association between each seat 11 of the filling machine 1 and the specific filling unit 10, which occupies the same seat 11. As will be clarified in the following, these information allow to closely monitor the performance of the filling units 10 in relation to the position along the carousel 4, and to properly schedule maintenance and replacement of those specific filling units 10 that are considered to be liable to faults.

[0027] Moreover, control module 25 is provided with a second interface 28, operatively coupled to supervisor module 14 of the filling machine 1, and configured to provide wired or wireless communication therewith, so as to acquire specific operating data relating to the operation of filling units 10, during execution of each filling recipe or each filling cycle.

[0028] In detail, according to a particular aspect of the present solution, the acquired operating data include at least the following operating parameters:

Filling Time (FT), i.e. the time required for complete filling of a container 2 by the filling unit 10, with a desired quantity of liquid;
Tail time (TT), i.e. the time interval between the arrival of an electric closing command at the filling unit 10 and mechanical closing thereof;
KT, i.e. a dimensionless parameter related to the stability of the closing time value, determined based on a number (e.g. five) of past filling operations;
FFC, i.e. a filling counter, measured by a flow meter, relating to the filled quantity of liquid.

[0029] These operating parameters have been found by the Applicant to provide a reliable monitoring of the operating state of the filling units 10; it is clear, however, that other parameters may be used, in addition to, or substitution of, the above cited operating parameters.

[0030] Moreover, control module 25 acquires, through second interface 28, general operating data relating to the operations of each filling unit 10, and in particular relating to the number of working hours, working cycles performed, number of liters of filled liquid, number of CIP - Cleaning in Place - processes undergone by the same filling unit; as it is known, during a CIP process, dummy bottles are coupled to the filling units 10 and a sanitizing liquid is flown through the filling machine, in order to perform cleaning thereof.

[0031] Control module 25 may also include a display and user interface unit 29, coupled to processing unit 25, allowing an operator to interact with the same control module 25 and to display information (e.g. data and/or plots).

[0032] System 20 also includes a storage unit 30, operatively coupled to control module 25 and storing a central database DB.

[0033] Central database DB includes a number of records, each related to a different filling unit 10, whose univocal coded sign 23 has been identified via image acquisition unit 22.

[0034] In detail, and as shown in Figure 3, each record 32 of central database DB includes:

a first field 32a, storing the coded sign 23 of the corresponding filling unit 10;
a second field 32b, storing characterization data for the filling unit 10, e.g. data corresponding to the above cited operating parameters, filling time FT, tail time TT, KT, FFC, acquired during a characterization operation performed after manufacturing, or refurbishing/reconditioning, of the filling unit 10 and suit-

ably certified (e.g. by the manufacturer). These characterization data (which are shown schematically in Figure 3, with two letters for the name and two numbers for the value thereof) are suitably received at the storage unit 30, e.g. via a wireless data communication channel;

a third field 32c storing an univocal identifier of the filling machine 1 where the filling unit 10 is being mounted, and the information relating to the seat 11 of the filling machine 1 where the same filling unit 10 is installed;

a fourth field 32d storing both the general (schematically denoted as "A") and the specific (schematically denoted as "B") operating data, related to the filling operations performed by the filling unit 10, as will be detailed in the following.

[0035] While image acquisition unit 22 is required to be located at the site of the filling machine 1, the physical location of both the control module 25 and the storage unit 30 is independent from the site of the same filling machine 1, and may be local or remote with respect thereto; also, the specific location of the control module 25 may differ from the location of the storage unit 30.

[0036] Moreover, control module 25 may be provided with an own storage memory (not shown in Figure 2), storing a replica of the whole, or a part of, central database DB, which may be conveniently synchronized and linked to the same central database DB (in any known manner, here not discussed in detail).

[0037] In a possible embodiment, a portable electronic apparatus (not shown), such as a PDA, a laptop, a smartphone, a tablet, with wireless data communication capability, may also communicate with the storage unit 30 through an internet connection and a web interface, in order to access the stored data for further analysis or processing.

[0038] An operator may interact with both control module 25 and, in case, the above portable electronic apparatus, to access data stored in the central database DB, and e.g. display information or plots of relevant data and information.

[0039] Operation of system 20 is now discussed, with reference also to Figure 4.

[0040] Control module 25 continuously monitor operation of each filling unit 10 in the filling machine 1, as shown in step 40.

[0041] In particular, during each filling cycle (i.e. at each filling of a container 2 by a filling unit 10), control module 25 acquires filling operating parameters (both the general and the specific operating parameters previously discussed).

[0042] Control module 25 then processes, at step 42, the acquired data in order to check if the filling unit 10 is working properly.

[0043] According to a particular aspect of the present solution, control module 25 executes a suitable comparison between the acquired operating parameters for each filling unit 10 and the characterization data for the same filling unit 10 stored in the central database DB, and between the same acquired operating parameters and the operating parameters acquired for the other filling units 10 of the whole filling machine 1, in order to determine if the operation of the filling unit 10 deviates from its standard, normal, operation and/or from the operation of the other constituent elements of the filling machine 1. Control module 25 is able to retrieve from central database DB in storage unit 30 any data that may be required for the above comparative analysis.

[0044] It is clear that many alternative specific solutions may be envisaged for this evaluation; generally, if the operation of the filling unit 10 is found to differ from an expected operating mode more than a given threshold, then operation for the filling unit 10 is found to be "anomalous" of "faulty".

[0045] If the control module 25 determines, at step 44, that the operation of the filling unit 10 is "normal", i.e. in line with what was expected based on the characterization data and the operation of the other constituent elements of the filling machine 1, then a normal monitoring mode is followed, step 45, according to which acquired operating data are stored in the central database DB, with a first preset storage frequency, for example once a day.

[0046] Control module 25 updates in the related field of the record 32 in the central database DB the general operating data, relating to the number of working hours, number of working cycles performed, number of liters of filled liquid, number of CIP processes performed by each filling unit 10.

[0047] Moreover, control module 25 stores in the related field of the record 32 in the central database DB the specific operating data for the filling units 10, determined during the monitoring time interval pertaining to the current storage operation (i.e. during the time interval elapsed since the last storage operation).

[0048] In particular, control module 25 calculates, for each filling unit 10, the average of the relevant operating parameters (e.g. filing time FT, tail time TT, KT, FFC), which have been acquired during the monitoring time interval.

[0049] Control module 25 further determines, for the same relevant parameters, machine-average values, as the average calculated on the filling units 10 of the whole filling machine 1 (in particular, as the average of the average values for the various filling units 10, computed after each machine cycle); control module 25 also calculates, for each filling unit 10, the deviation σ of the value of the respective relevant parameters with respect to the determined machine-average values.

[0050] When computing the above machine-average values, filling machine 1 is considered as a "batch", as a single entity including the various filling units 10; this may be advantageous to provide to the operator overall information regarding the operation of the whole machine.

[0051] The specific operating data that are stored in

the central database DB, at each storage operation, are therefore the average values of the relevant operating parameters calculated for the various filling units 10, associated to the deviation σ with respect to the machine-average values, and the same machine-average values (wit the result of a considerable saving in the occupation of storing resources).

[0052] If instead control module 25 determines, at above step 44, that the operation of the filling unit 10 is "anomalous", i.e. not as expected, then an anomaly monitoring mode is followed, at step 46, according to which acquired operating data are stored in the central database DB with a second storage frequency, higher than the first storage frequency, for example once every hour or half an hour.

[0053] The value of the second storage frequency may also vary dynamically, based on the amount of deviation of the determined operating condition from the "normal" state, or progressively with time after the determination of the anomalous operating condition is made.

[0054] In any case, the general effect is that of achieving a more accurate monitoring of the filling units 10, when doubts about their correct operation arise.

[0055] Moreover, after the "anomalous" state determination, control module 25 is configured to process the acquired data with a predictive algorithm, at step 48, in order to predict possible occurrence of a fault or a malfunction, so that suitable alarms may be activated and suitable control actions performed (such as refurbishment or replacement of the faulty filling unit).

[0056] To this end, control module 25 is configured to execute any suitable predictive strategy, based on the acquired data relating to the operating parameters of the filling units 10, and in particular based on: the performance of each filling unit 10, considered independently, and/or in connection with the operation of the whole filling machine 1 and/or with the stored characterization data for the same filling unit 10; the deviation of the operation of each filling unit 10 with respect to the average operation of the other filling units 10 in the filling machine 1; the wearing state of the same filling unit 10, determined based on the information about the working cycles and hours already performed.

[0057] Control module 25 is thus configured to monitor the state of degradation of the filling units 10, with the passing of time and filling cycle by filling cycle, so as to timely and reliably predict the occurrence of possible faults, and also to determine the causes of the malfunction.

[0058] The control module 25 also suggests, at step 49, a suitable time to execute maintenance of the filling machine 1, in order to avoid errors and malfunctions, and particularly the number and positions (in terms of the occupied seats 11) of the filling units 10 that are to be replaced in the filling machine 1.

[0059] The same control module 25 is also able to suggest a replacement unit for each filling unit 10 that is to be replaced, in the form of a list, the so called "rotation kit". For example, a list of replacement filling units 10, whose data are present in the central database DB and whose characteristic may suite the operation of those to be replaced, is suggested to the operator, in view of the scheduled maintenance operation.

[0060] It is to be noted that after replacement of a filling unit 10, monitoring of the operation of the new filling unit 10 is resumed, populating a new record 32 in the central database DB.

[0061] Moreover, after a replaced filling unit 10 is refurbished and then newly installed in a different filling machine 1, or in a different seat 11 of the same filling machine 1, the operation of the same filling unit 10 is again monitored and the operating data stored in the central database DB, in association with the univocal identifier of the same filling unit 10.

[0062] As previously discussed, an operator may interact with control module 25 (or other portable electronic apparatus accessing the central database DB and running suitable software programs), to access data stored in the central database DB, and e.g. display information or plots.

[0063] Figure 5 shows an exemplary plot relating to the filling time FT for a filling unit 10, showing the progressive lengthening of the same filling time.

[0064] The plot shows a first region of normal operation, denoted with R_1, followed by a region of anomalous operation, denoted with R_2, where frequency of storage operations is intensified, to closely monitor wearing of the component (as shown by the filling time FT crossing threshold TH). The plot also shows the filling unit 10 returning to a normal operating condition, after maintenance has been performed, at region denoted with R_3.

[0065] Figure 6 shows a further plot, which may be displayed by control module 25, showing, in a histogram format, minimum, maximum and average values for the filling time FT of a given filling unit 10, compared to average values for the other filling units 10 in the filling machine 1.

[0066] Figure 7 shows still a further plot, which may be generated by the control module 25, allowing a direct and immediate visual perception of the operating condition of the filling units 10 in the filling machine 1, with respect to monitored parameters filling time FT and tail time TT.

[0067] In detail, each filling unit 10 is represented as a "ball", in a two-dimensional plot where average filling time FT values are represented along the x axis, and average tail time TT values are represented along the y axis. Ball color denotes the deviation σ for the filling time FT, while the ball dimension (i.e. its radius) denotes the deviation σ for the tail time TT, with respect to the machine-average values. Moreover, the number associated to each ball refers to the particular seat 11 where the related filling unit 10 is placed. In this exemplary representation, balls with deeperhue color and greater size indicate a possible malfunction of the related filling units 10.

[0068] Numerical values for the relevant operating parameters (in this case, filling time FT and tail time TT)

may also be easily obtained, for each of the depicted balls (as shown in Figure 7 for ball number 29).

[0069] Moreover, Figure 8 shows information that may be displayed by control module 25, including values for the filling time FT and tail time TT operating parameters.

[0070] In detail, for each storing operation (whose time is denoted at the left of the displayed area), values computed on all the filling units 10 in the filling machine 1 are displayed (in other words, considering the filling machine 1 as a "batch", as a single entity): in particular, an average value, a minimum value and a maximum value are displayed for each relevant operating parameter.

[0071] Conveniently, as also shown in the same Figure 8, a "batch" may be exploded to get specific information about each filling unit 10 in the filling machine 1, with respect to the same considered operating parameters, at the particular storing operation, in particular relating to the deviation with respect to the machine-average values and the characterization values.

[0072] The advantages that the described solution allows to achieve are clear from the foregoing description.

[0073] In any case, it is again underlined that unexpected faults and stop of the filling machine 1 may be avoided, thanks to the continuous monitoring and predictive maintenance provided by the disclosed automated system.

[0074] Accordingly, important issues associated to waste (e.g. not totally filled) containers and to unforeseen stops may be avoided during the operation of the filling machine 1.

[0075] Each filling unit 10 in the filling machine 1 is fully exploited, as long as its operation remains within the boundaries of a normal operating condition, independently from the number of working hours or cycles already performed (in other words, a filling unit 10 is not replaced based only on the working lifetime, but based on its actual functionality, determined from actual measurements of relevant operating parameters).

[0076] Moreover, since only a minimum portion of the acquired data is stored in the central database DB (with the storing frequency being incremented only when an anomalous operation is detected), requirements associated to the storing capacity are less stringent.

[0077] Moreover, historical trends may be easily generated from the data stored in the central database DB, in order to further improve quality assessment of the operation of the filling machine 1, and prediction of future faults and malfunctions.

[0078] Finally, it is clear that modifications and variations may be applied to the solution described and shown.

[0079] For example, it is clear that the discussed solution may advantageously envisage different and/or additional relevant operating parameters to be monitored during the filling operations.

[0080] Moreover, further analysis of the acquired data may be performed to detect anomalous operations and to predict faults and malfunctions of the filling units 10 in the filling machine 1.

Claims

1. An automated system (20) for predictive maintenance of a filling machine (1), including a number of filling units (10) designed to engage at least one respective container (2) to carry out filling thereof with a filling product,
comprising a control module (25), operatively coupled to the filling machine (1) and configured to:

acquire operating data relating to the performance of the filling units (10) during the filling operations; and
process the acquired operating data to predict the occurrence of a fault in one or more of the filling units (10), and further comprising a storage unit (30) storing a database (DB) and operatively coupled to the control module (25); each record (32) of the database (DB) being related to a filling unit (10) of the filling machine (1) and storing a subset of the acquired operating data for the filling unit (10), said control module (25) being configured to process the acquired operating data to determine a normal or anomalous operating state of the filling unit (10); **characterized in that** the control module (25) is configured to cause storing of the subset of acquired operating data at a first storing frequency, in case a normal operating state is determined, and at a second storing frequency, in case an anomalous operating state is determined, the second operating frequency being higher than the first operating frequency.

2. The system according to claim 1, wherein the control module (25) is configured
to execute a predictive algorithm to predict the fault of the one or more filling units (10), and
to process the operating data acquired for a given filling unit (10) in relation to corresponding operating data acquired for other filling units (10) in the filling machine (1), in order to determine a normal or anomalous operating state of the given filling unit.

3. The system according to claim 1 or 2, wherein the control module (25) is configured
to process the operating data acquired for the given filling unit (10) in relation to characterization data for the given filling unit (10), in order to determine a normal or anomalous operating state thereof, and
to calculate a deviation (σ) of the operating state of the given filling unit (10) with respect to the other filling units (10) in the filling machine (1) and/or with respect to the characterization data.

4. The system according to any of the preceding claims, wherein the control module (25) is configured to schedule a maintenance operation of the filling ma-

chine (1) and provide a list of faulty filling units (10) to be subjected to maintenance and said system further comprising;
an image acquisition unit (22), configured to image the filling units (10) of the filling machine (1) to read an univocal coded sign (23) associated to each of the filling units (10),
a storage unit (30) storing a database (DB) and operatively coupled to the control module (25); each record (32) of the database (DB) being related to a filling unit (10) of the filling machine (1) and storing a subset of the acquired operating data for the filling unit (10) and the univocal coded sign (23) associated to the same filling unit (10).

Patentansprüche

1. Automatisiertes System (20) zum prädiktiven Warten einer Füllmaschine (1), die eine Anzahl von Fülleinheiten (10) enthält, die gestaltet sind, mit mindestens einem jeweiligen Behälter (2) in Eingriff zu gelangen, um dessen Füllen mit einem Füllprodukt auszuführen,
das ein Steuermodul (25) umfasst, das betriebstechnisch an die Füllmaschine (1) gekoppelt ist und konfiguriert ist:

Betriebsdaten, die sich auf die Leistung der Fülleinheiten (10) während der Füllvorgänge beziehen, zu erfassen; und
die erfassten Betriebsdaten zu verarbeiten, um das Auftreten eines Fehlers in einer oder mehreren der Fülleinheiten (10) vorauszusagen, und das ferner eine Speichereinheit (30) umfasst, die eine Datenbank (DB) speichert und betriebstechnisch an das Steuermodul (25) gekoppelt ist; wobei sich jede Aufzeichnung (32) der Datenbank (DB) auf eine Fülleinheit (10) der Füllmaschine (1) bezieht und eine Untergruppe der erfassten Betriebsdaten für die Fülleinheit (10) speichert, wobei das Steuermodul (25) konfiguriert ist, die erfassten Betriebsdaten zu verarbeiten, um einen normalen oder anomalen Betriebszustand der Fülleinheit (10) zu bestimmen; **dadurch gekennzeichnet, dass** das Steuermodul (25) konfiguriert ist, das Speichern der Untergruppe der erfassten Betriebsdaten mit einer ersten Speicherfrequenz, falls ein normaler Betriebszustand bestimmt wird, und mit einer zweiten Speicherfrequenz, falls ein anomaler Betriebszustand bestimmt wird, zu bewirken, wobei die zweite Betriebsfrequenz höher als die erste Betriebsfrequenz ist.

2. System nach Anspruch 1, wobei das Steuermodul (25) konfiguriert ist,
einen prädiktiven Algorithmus auszuführen, um den Fehler der einen oder der mehreren Fülleinheiten (10) vorauszusagen, und
die für eine gegebene Fülleinheit (10) erfassten Betriebsdaten in Beziehung zu entsprechenden für andere Fülleinheiten (10) in der Füllmaschine (1) erfassten Betriebsdaten zu verarbeiten, um einen normalen oder anomalen Betriebszustand der gegebenen Fülleinheit zu bestimmen.

3. System nach Anspruch 1 oder 2, wobei das Steuermodul (25) konfiguriert ist,
die für die gegebene Fülleinheit (10) erfassten Betriebsdaten in Beziehung zu Charakterisierungsdaten für die gegebene Fülleinheit (10) zu verarbeiten, um einen normalen oder anomalen Betriebszustand von ihr zu bestimmen, und
eine Abweichung (σ) des Betriebszustands der gegebenen Fülleinheit (10) in Bezug auf die anderen Fülleinheiten (10) in der Füllmaschine (1) und/oder in Bezug auf die Charakterisierungsdaten zu berechnen.

4. System nach einem der vorhergehenden Ansprüche, wobei das Steuermodul (25) konfiguriert ist, einen Wartungsvorgang der Füllmaschine (1) einzuplanen und eine Liste von fehlerhaften Fülleinheiten (10) zu liefern, die der Wartung zu unterziehen sind, und wobei das System ferner umfasst:

eine Bilderfassungseinheit (22), die konfiguriert ist, die Fülleinheiten (10) der Füllmaschine (1) abzubilden, um ein eindeutiges codiertes Zeichen (23), das jeder der Fülleinheiten (10) zugeordnet ist, zu lesen,
eine Speichereinheit (30), die eine Datenbank (DB) speichert und betriebstechnisch an das Steuermodul (25) gekoppelt ist; wobei sich jede Aufzeichnung (32) der Datenbank (DB) auf eine Fülleinheit (10) der Füllmaschine (1) bezieht und eine Untergruppe der erfassten Betriebsdaten für die Fülleinheit (10) und ein eindeutiges codiertes Zeichen (23), das derselben Fülleinheit (10) zugeordnet ist, speichert.

Revendications

1. Système automatique (20) de maintenance prédictive d'une machine de remplissage (1), comprenant un nombre d'unités de remplissage (10) conçues pour engager au moins un récipient respectif (2) pour réaliser le remplissage de celui-ci avec un produit de remplissage,
comprenant un module de commande (25) qui est couplé de façon opérationnelle à la machine de remplissage (1) et est configuré pour:

acquérir des données de fonctionnement relati-

ves à la performance des unités de remplissage (10) pendant les opérations de remplissage; et traiter les données de fonctionnement acquises afin de prédire l'occurrence d'une défaillance dans une ou plusieurs des unités de remplissage (10), et comprenant en outre une unité de stockage (30) stockant une base de données (DB) et couplée de façon opérationnelle au module de commande (25); chaque registre (32) de la base de données (DB) étant associé à une unité de remplissage (10) de la machine de remplissage (1) et stockant un sous-ensemble des données de fonctionnement acquises pour l'unité de remplissage (10), ledit module de commande (25) étant configuré pour traiter les données de fonctionnement acquises afin de déterminer un état de fonctionnement normal ou anormal de l'unité de remplissage (10);
caractérisé en ce que le module de commande (25) est configuré pour entraîner le stockage du sous-ensemble de données de fonctionnement acquises à une première fréquence de stockage, dans le cas où un état de fonctionnement normal est déterminé, et à une deuxième fréquence de stockage, dans le cas où un état de fonctionnement anormal est déterminé, la deuxième fréquence de fonctionnement étant plus élevée que la première fréquence de fonctionnement.

2. Système selon la revendication 1, dans lequel le module de commande (25) est configuré pour:

exécuter un algorithme prédictif afin de prédire la défaillance de la ou des unité (s) de remplissage (10) ; et
traiter les données de fonctionnement acquises pour une unité de remplissage donnée (10) par rapport à des données de fonctionnement correspondantes acquises pour d'autres unités de remplissage (10) dans la machine de remplissage (1), dans le but de déterminer un état de fonctionnement normal ou anormal de l'unité de remplissage donnée.

3. Système selon la revendication 1 ou la revendication 2, dans lequel le module de commande (25) est configuré pour:

traiter les données de fonctionnement acquises pour l'unité de remplissage donnée (10) en relation avec des données de caractérisation pour l'unité de remplissage donnée (10), dans le but de déterminer un état de fonctionnement normal ou anormal de celle-ci; et
calculer un écart (σ) de l'état de fonctionnement de l'unité de remplissage donnée (10) par rapport aux autres unités de remplissage (10) dans la machine de remplissage (1) et/ou par rapport aux données de caractérisation.

4. Système selon l'une quelconque des revendications précédentes, dans lequel le module de commande (25) est configuré de manière à programmer une opération de maintenance de la machine de remplissage (1) et à fournir une liste d'unités de remplissage défaillantes (10) devant faire l'objet d'une maintenance, et ledit système comprenant en outre:

une unité d'acquisition d'image (22) configurée pour imager les unités de remplissage (10) de la machine de remplissage (1) afin de lire un signe codé univoque (23) qui est associé à chacune des unités de remplissage (10),
une unité de stockage (30) stockant une base de données (DB) et couplée de façon opérationnelle au module de commande (25); chaque registre (32) de la base de données (DB) étant associé à une unité de remplissage (10) de la machine de remplissage (1) et stockant un sous-ensemble des données de fonctionnement acquises pour l'unité de remplissage (10) et le signe codé univoque (23) associé à la même unité de remplissage (10).

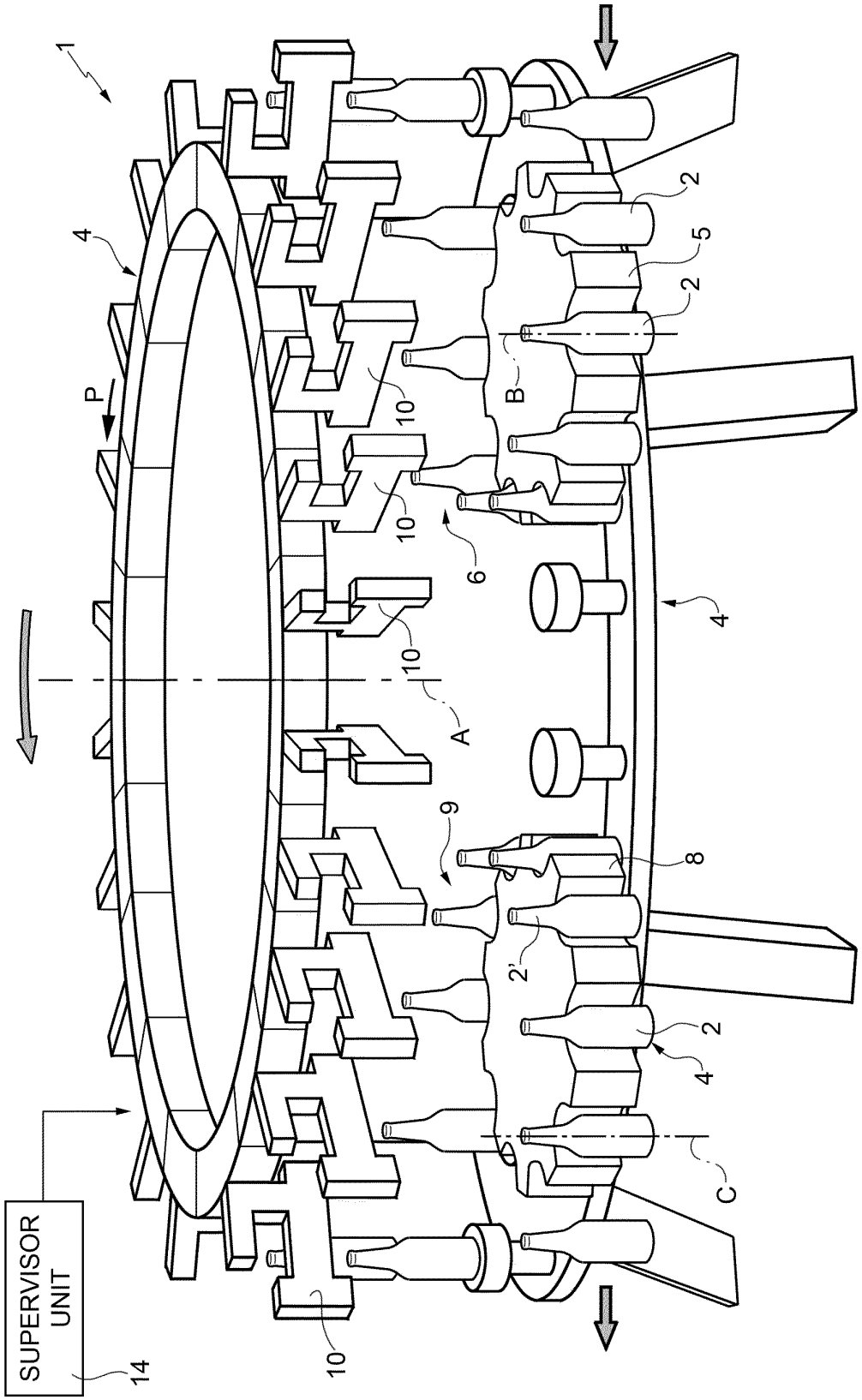


FIG. 1

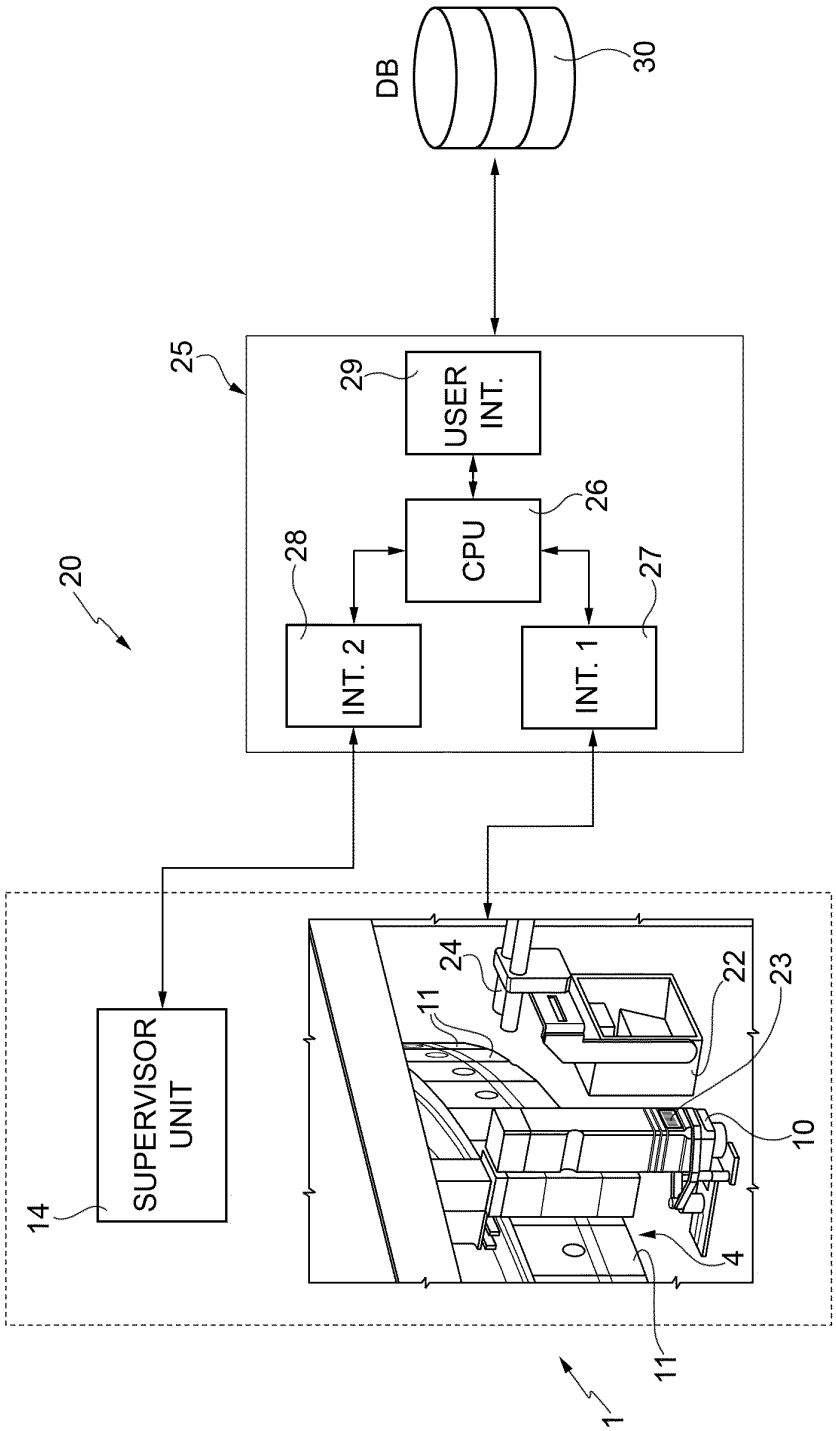

DB
30
25
29
USER INT.
26
CPU
28
27
INT. 2
INT. 1
20
SUPERVISOR UNIT
14
24
22
23
11
10
4
11
1

FIG. 2

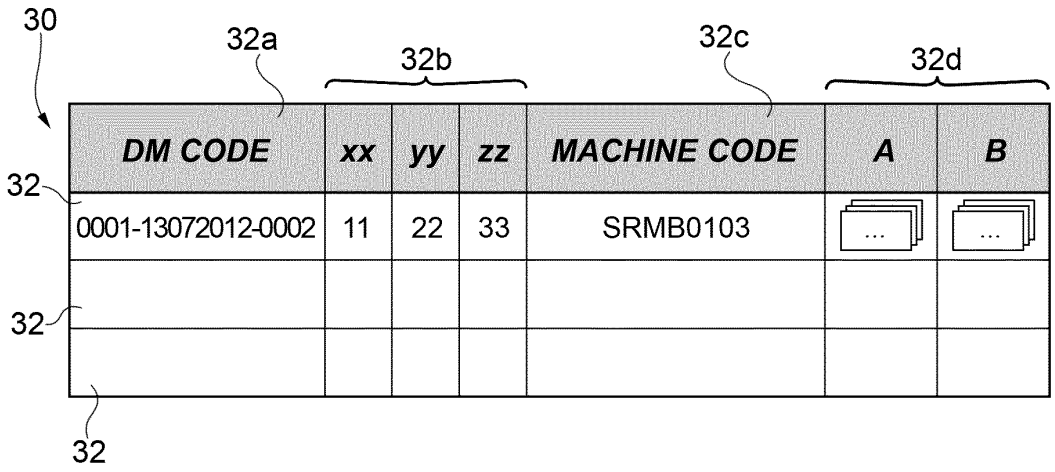

30
32a
32b
32c
32d
DM CODE
xx
yy
zz
MACHINE CODE
A
B
32
0001-13072012-0002
11
22
33
SRMB0103
...
...
32
32

FIG. 3

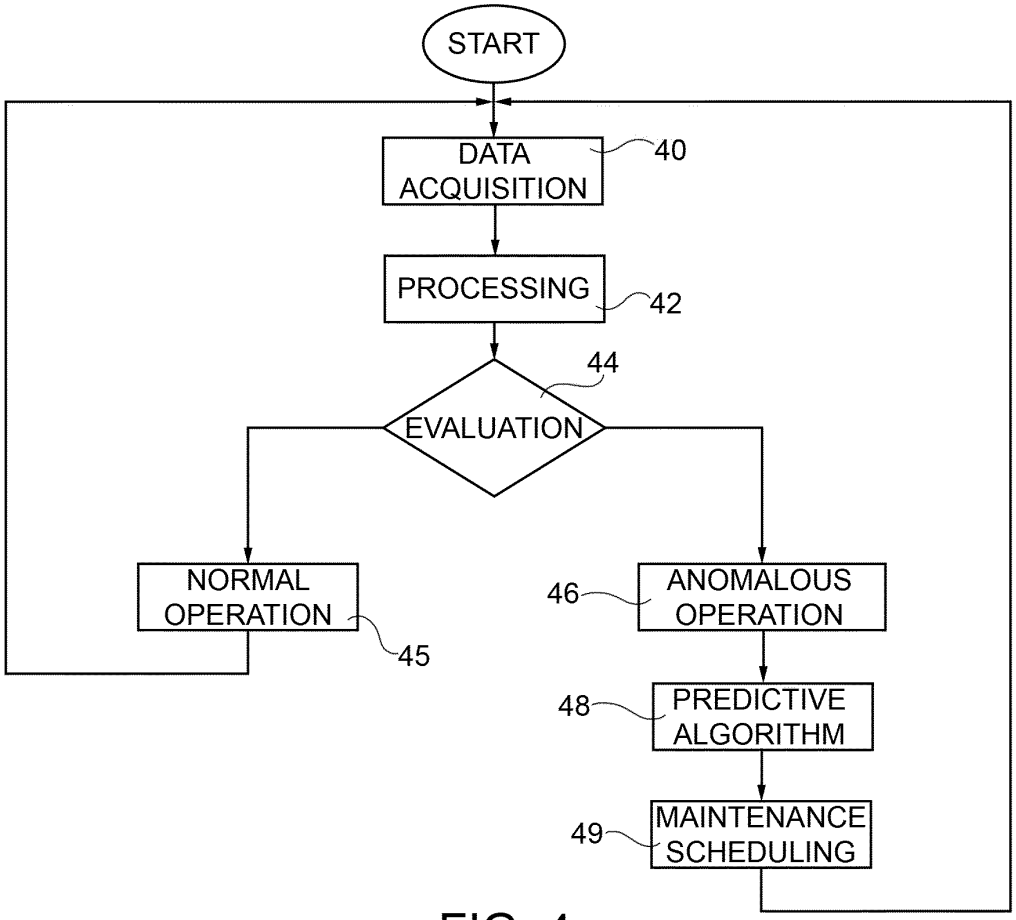

START
DATA ACQUISITION
40
PROCESSING
42
44
EVALUATION
NORMAL OPERATION
45
46
ANOMALOUS OPERATION
48
PREDICTIVE ALGORITHM
49
MAINTENANCE SCHEDULING

FIG. 4

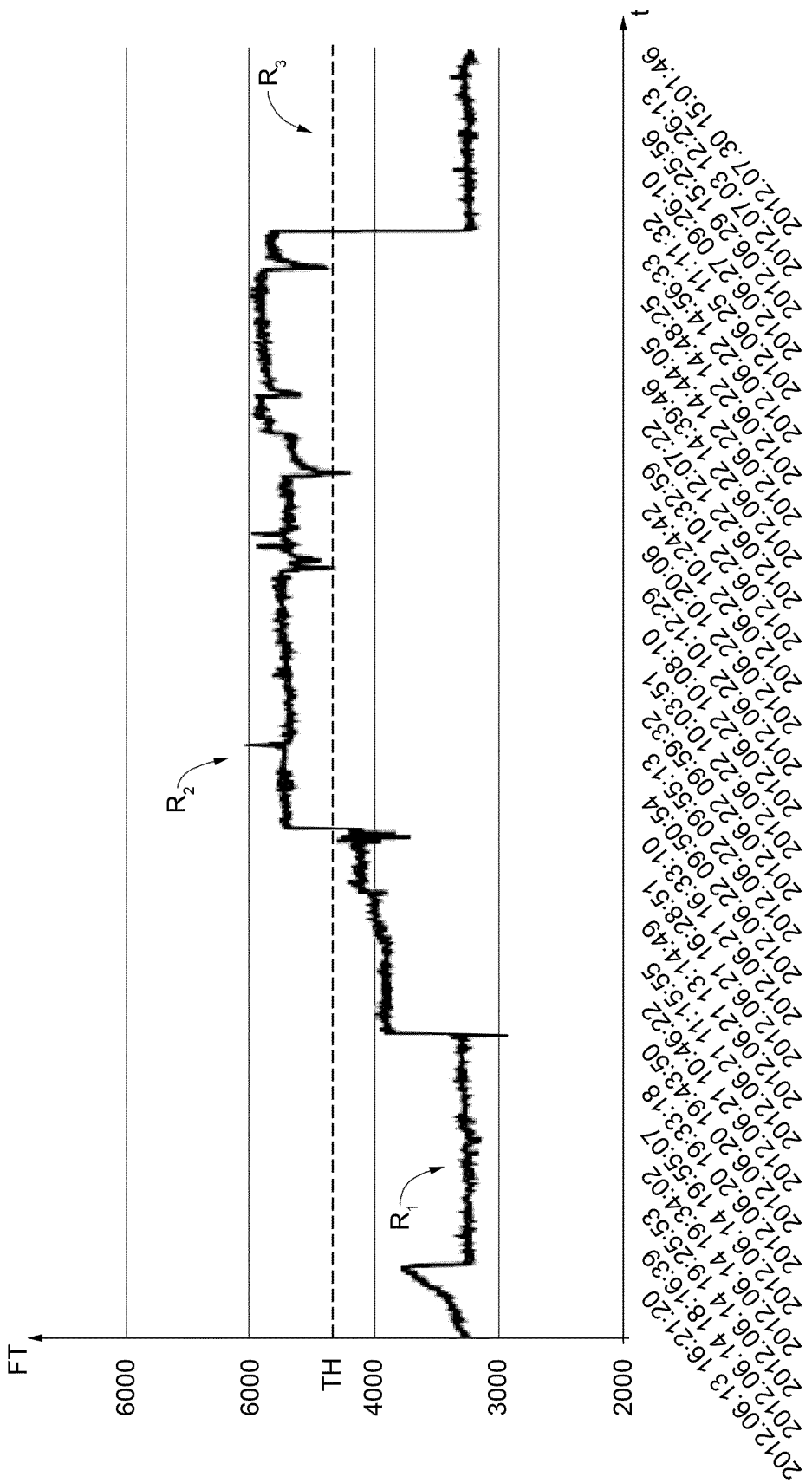

FT
6000
6000
TH
4000
3000
2000
R_1
R_2
R_3
t
2012.06.13 16:21:20
2012.06.14 18:16:39
2012.06.14 19:25:53
2012.06.14 19:34:02
2012.06.20 19:55:07
2012.06.20 19:33:18
2012.06.21 10:43:50
2012.06.21 10:46:22
2012.06.21 11:15:55
2012.06.21 13:14:49
2012.06.21 16:28:51
2012.06.22 16:33:10
2012.06.22 09:50:54
2012.06.22 09:55:13
2012.06.22 09:59:32
2012.06.22 10:03:51
2012.06.22 10:08:10
2012.06.22 10:12:29
2012.06.22 10:20:06
2012.06.22 10:24:42
2012.06.22 10:32:59
2012.06.22 12:07:22
2012.06.22 14:39:46
2012.06.22 14:44:05
2012.06.22 14:48:25
2012.06.25 14:56:33
2012.06.27 11:11:32
2012.06.29 09:26:10
2012.07.03 15:25:56
2012.07.30 12:26:13
2012.08.01 15:01:46

FIG. 5

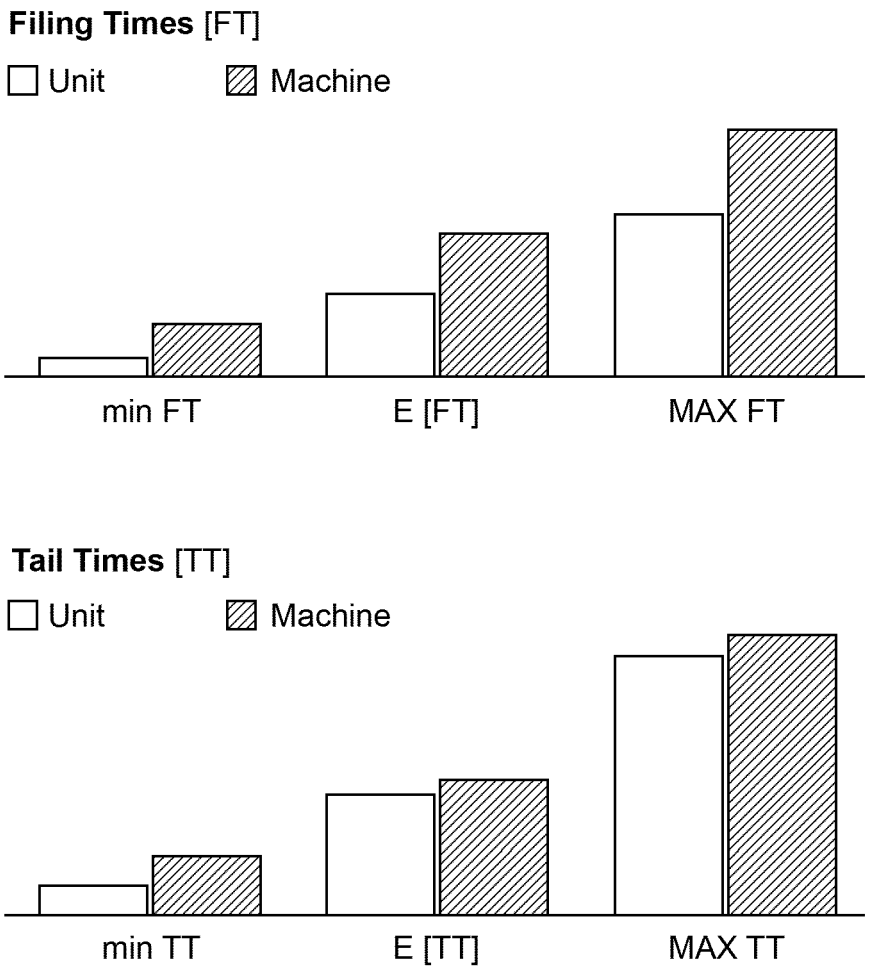

Filing Times [FT]
Unit
Machine
min FT
E [FT]
MAX FT
Tail Times [TT]
Unit
Machine
min TT
E [TT]
MAX TT

FIG. 6

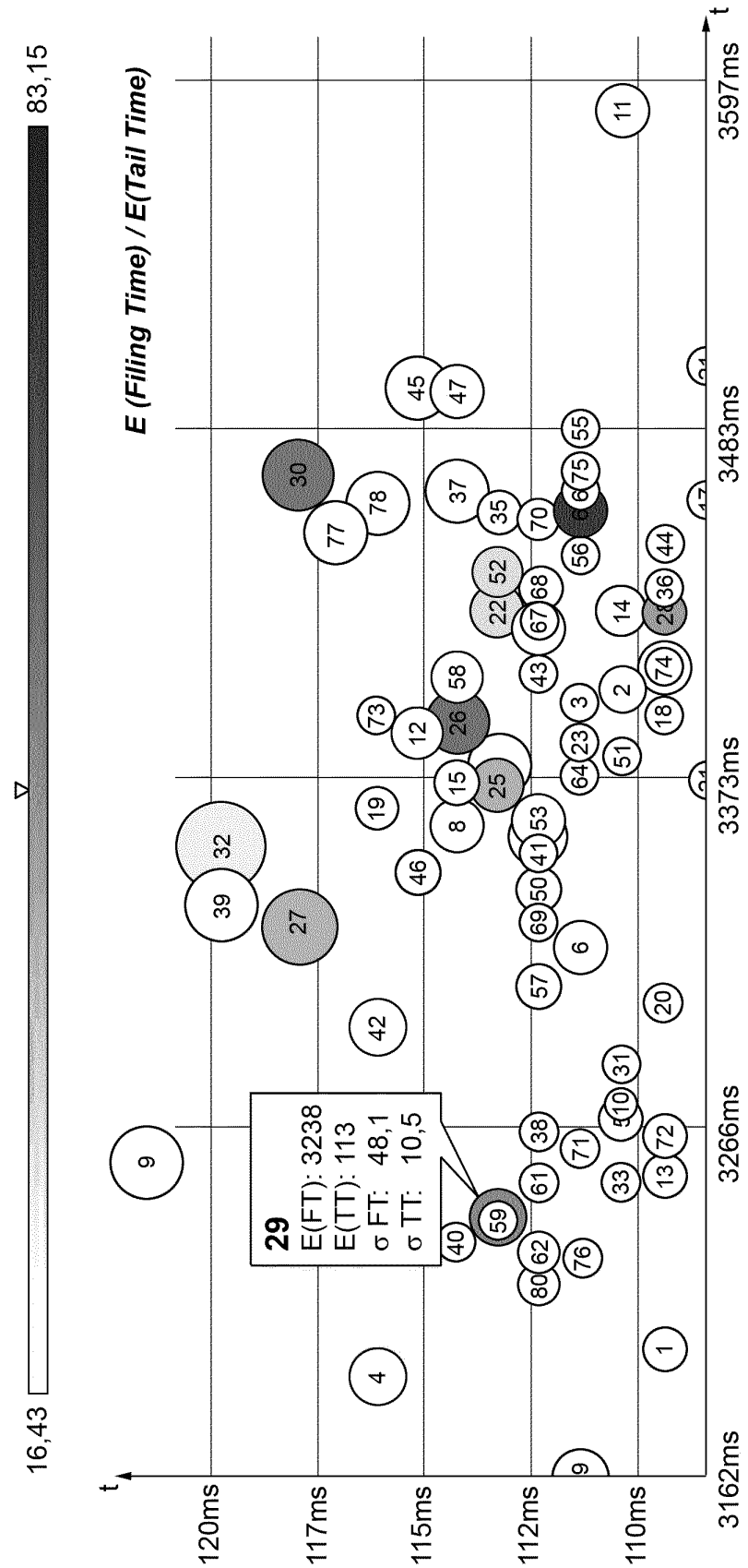

16,43
83,15
E (Filing Time) / E(Tail Time)
t
120ms
117ms
115ms
112ms
110ms
3162ms
3266ms
3373ms
3483ms
3597ms
29
E(FT): 3238
E(TT): 113
σ FT: 48,1
σ TT: 10,5

FIG. 7

Filing Batch

TIME	OK	AVG FT	MIN FT	MAX FT	AVG FFC	MIN FFC	MAX FFC	AVG TT	MIN TT	MAX TT	AVG TFC	MIN TFC	MAX TFC
2012.06.22 16:54:02	80	3409	3165	4845	504	503	506	114	99	154	10	7	12
2012.06.22 16:53:55	80	3391	3145	4843	504	503	506	112	99	143	10	7	12
2012.06.22 16:53:48	80	3397	3150	4848	504	503	506	113	98	143	10	7	12
2012.06.22 16:53:41	80	3422	3176	4927	504	503	506	114	99	165	10	7	12
2012.06.22 16:53:33	80	3374	3124	4819	504	503	506	112	88	132	10	7	12

⋮

Filing Batch Details

TIME	OK	FT	FT Δ	SET	FFC	Δ	TT	TT	TFC	TFC Δ
27	1	4927	-1505	505	504	-1	99	15	7	3
59	1	4846	-1424	505	504	0	110	4	8	2
68	1	3762	-340	505	504	-1	110	4	9	1
55	1	3648	-226	505	504	-1	110	4	9	1
16	1	3641	-219	505	504	-1	110	4	10	0
42	1	3595	-173	505	504	-1	110	4	9	1
11	1	3590	-168	505	504	0	110	4	10	0

⋮

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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