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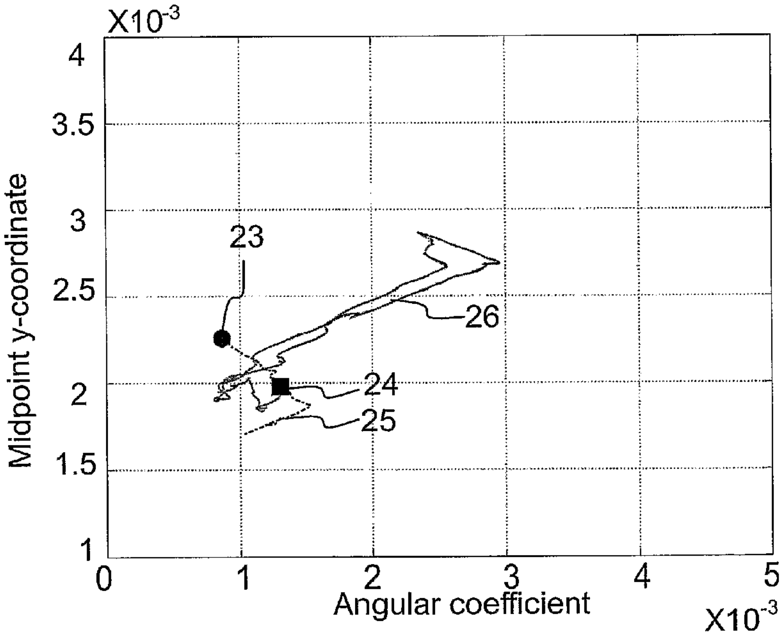
(54) **Title:** A METHOD AND A SYSTEM FOR MONITORING THE PERFORMANCE OF A PAPER OR PULP PRODUCTION PROCESS



(57) **Abstract:** A method and a system for monitoring the performance of a paper or pulp production process, which comprise the following steps: a) collecting data connected to at least one controllable variable (11) of the process from the process, b) removing from the process data collected in step a) at least one period that does not represent the normal operating state of the process, c) calculating from the process data received from step b) (12) with a moving calculation method a set of first data points, d) forming of the first data points calculated from step c) a set of second data points, which describe the cumulative coefficients of variation (COV), e) defining a first and a second limit value for the cumulative curve (14, 15) of the coefficients of variation (COV), which limit values define a line segment between them, f) defining for the line segment a parameter (23, 24) describing its slope and the y-coordinate of a point on the line between the limit values, in which point the line and a pre-selected cumulative number intersect, and presenting the parameter (23, 24) describing the slope of the line segment defined in step f) and the y-coordinate of the point defined between the limit values as a signal for deducing the performance of the process.

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A method and a system for monitoring the performance of a paper or pulp production process

Field of the invention

The invention relates to a method for monitoring the performance of a paper or pulp production process according to the preamble of the appended claim 1. The invention also relates to a system according to the preamble of claim 17.

Background of the invention

In paper and pulp production, performance evaluation, monitoring and fault analysis is a complex problem due to the multivariable and very interactive nature of the processes. The significance of process analysis for the profitability of a factory has increased activity in process analysis work as well as increased research for increasing the efficiency of process analysis products.

In paper or pulp production it is known to continuously (on-line) track the performance of a process by measuring controllable variables from the product being manufactured or the production process itself, on the basis of which variables trend lines or maps are created. This method is based on the visual examination of individual signals received from the measured variables. It is also known to calculate deviation values of the measured variables over certain time periods.

Generally speaking, indicators must be defined for evaluating the performance of a process. The indicator must be simple enough for it to be easy to understand, but still complex enough for presenting the performance of the process in a correct manner. It is difficult to define simple indicators due to the complexity of processes, especially due to their dynamics and the complex network of mutual relations. Time horizon and time resolution are critical factors from the point of view of evaluating performance, but they can also be utilized in order to receive further information.

If a suitable indicator is found, the performance of the process can be defined with indicator parameters. It is, however, to be noted that despite the versatility of the indicator and the defined parameters the indicator describes performance in one way only. Because of this it is difficult to express the performance of a process and/or control with a simple indicator. Another important purpose for defining the performance of a process is reference analysis. Many factories wish to benchmark the performance of machines to the different machines in the same factory or in other factories producing the same paper grade. This is not an easy task, because the processes of different machines, as well as the measuring and control systems controlling and optimizing them differ from each other in many ways. The measuring and control systems are especially problematic, because the characteristics of measuring systems and signal processing may differ from each other significantly.

As a solution to these problems, it has been proposed to use the process itself as the reference value of the performance of the process in question. This also makes it possible to compare and monitor the on-line performance of the process. In order to detect problems created in the processes or process control systems or for defining improvements, reference behavior of the process is required. The conditions and the past performance of the process itself provide the best reference values for its current and future performance.

One such a method where the process itself is used as a reference value is disclosed in reference Nuyan, S., Nissinen, A., and Hietanen, V., 2004, New methods to improve effectiveness in process Analysis, Control Systems 2004, June 14-17, 2004, Quebec City, PQ, where cumulative COV distribution method (cCOVd = cumulative Coefficient of Variation distribution) is utilized in off-line monitoring of the performance of the process.

The cumulative COV method (COV, Coefficient of Variation) utilizes a sliding calculation method for calculating the deviation. The sliding calculation method divides into two steps. First, from the process data measured from the process within a desired time period T, for example during one day, are removed such periods that do not represent the normal operation of the process, but which are either disturbances caused consciously by the user or so-called normal transient states, which are not connected to the steady-state performance of the process. After this, deviation is calculated from the processed process data with a sliding calculation window. This takes place so that a window of a desired period of time, such as one hour, is taken from the processed process data. This window includes the process data from the time period in question, and standard deviation and mean value are calculated from it. A coefficient of variation is calculated from these values, which is standard deviation over mean value. Thus, one value is received from the data belonging to the area of the window. The thus calculated coefficient of variation is placed time-wise at the edge of the correct calculation window. After this the window is moved forward one sample and the calculation is repeated. This is repeated until the window has been slid over the entire calculation period T. From the thus received coefficients of variation a sliding COV trend as a function of time is formed, as well as a cumulative COV of the time period T, of which a cumulative COV curve (cCOVd curve) can be drawn. The cumulative COV curve is formed by arranging the points of the sliding COV curve in order of magnitude and by calculating the relative numbers of the coefficients of variation remaining below different numerical values and by scaling the x-axis between 0 to 100 %.

For off-line tracking of the process the cumulative COV curves are formed for several consecutive time periods T, in which case they can be compared and earlier deviations in the process can be detected.

A drawback of this method is that as such it is suitable only for off-line monitoring of the performance of the process and for detecting performance changes in the past. It cannot be used for on-line tracking of the process and corrective procedures, which would have a direct effect on the performance of the process, cannot be performed on the basis of it.

Summary of the invention

The purpose of the present invention is to provide a method utilizing cumulative COV, by means of which it is possible to monitor the performance of a paper or pulp production process on-line in real time.

To attain this purpose, the method according to the invention is primarily characterized in what will be presented in the characterizing part of the independent claim 1.

The system according to the invention, in turn, is primarily characterized in what will be presented in the characterizing part of the independent claim 17.

The other, dependent claims will present some preferred embodiments of the invention.

The invention is based on the idea that the sliding deviation of a controlled variable and its cumulative COV function is calculated continuously. The characteristics of a cumulative COV function are described by an approximation line, of which are defined two parameters: a parameter describing the slope of the line and the y-coordinate of the intersection point of the line and a pre-selected cumulative number. With these parameters the performance is shown as one point on a plane.

The method according to the invention utilizes the cumulative COV calculation method that is known as such, where the deviation of the variable to be controlled is calculated with a sliding window, a cumulative COV is formed of the deviation values and the cumulative COV function is shown by a graph. In the method according to the invention a line is defined between the limit values defined for the cumulative COV function, where the parameter describing the slope of the line and the y-coordinate of the intersection point of the line and a pre-selected cumulative number is defined and shown as a signal to the operator.

The performance calculated from the past of the process itself functions as a reference when assessing the current performance. The performance can be benchmarked, for example, to the performance from, for example, the past 24 hours, the past week, the past month, or any other time of optimum operation of the process. This provides a clear idea on what the current performance is in comparison to the past.

An advantage of the invention is that it provides a systematic approach for performing real-time process analysis in the production process of paper or chemical pulp. It provides new information on the bottlenecks, limitations and reference values of the performance of the process. This, in turn, is utilized when setting the limits of the performance of the process and when searching control targets from the process. Knowing the weaknesses of machines used in different applications, i.e. in manufacturing different grades of paper is an irreplaceable advantage for operators in their everyday work.

With the method according to the invention it is possible to show in a simple manner information on the level of deviations of desired process variables, of the development of deviation and on how the deviations relate to the previously detected performance. It is possible to show even large numbers of plane graphs on the same display and the system can be constructed as hierarchical. Thus, from the collection view it is possible to access graphs on a lower level quickly, from which graphs the development of deviations, as well as the actual process data can be seen. In addition, the invention facilitates the long-term visualization, monitoring and assessment of the process.

Brief description of the drawings

In the following, the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 shows schematically a paper production process where the invention can be applied,

Figs. 2a and 2b	show calculation-horizon-specific graphs,
Figs. 3a and 3b	show other calculation-horizon-specific graphs, where the length of the calculation horizon is different from graphs 2a and 2b,
Fig. 4	shows a cumulative COV curve,
Fig. 5	shows a planar graph used in monitoring the performance of a process,
Fig. 6	shows a qualitative latticed graph used in monitoring the performance of a process, and
Fig. 7	shows a control unit in a schematic view.

Detailed description of the invention

In this description and claims the term controllable variable refers to a directly or indirectly controllable variable in an industrial process, such as the production process of paper or pulp. The controllable variable can be a variable that can be directly measured from the process, on the basis of which it is possible to control the process. Thus, the controllable variable can be a characteristic of an end product, for example paper, such as, for example, basis weight, moisture or thickness, or a characteristic of paper or pulp, such as, for example, consistency. It may also be any measurable variable of a paper machine, such as running speed of the machine, the rotation speed of wires or felts, or controllable variables of headbox. It may also be some deviation variable, such as, for example, the flow of retention agent in the pulp section, in which case the deviation of the deviation variable of the flow control of an individual retention agent is monitored. An indirectly controllable variable is a variable, which cannot be directly measured or adjusted, but which is monitored or adjusted by means of other measured variables having an effect on the variable in question. Such a variable is, for example, retention, which is adjusted, for example, on the basis of consistency measurement of white water.

Figure 1 is a schematic view showing a paper machine 1. For the sake of clarity, figure 1 does not show the actual pulp section of the paper machine 1, where the paper pulp fed to the paper machine is prepared of one or more fiber raw materials and different fillers and additives. The paper machine 1 comprises a headbox 2, from where the paper pulp is fed to the wire section 3, where a paper web W is formed of the pulp on the wire 4. The paper web W is led to the press section 5 and from there further to the drying section 6. From the drying section 6 the web W is directed to the reel-up 7. Before the reel-up 7 in the direction of movement of the web W is placed a measurement frame 8, which measurement frame 8 contains measurement means in a reciprocating or fixed measurement carriage, which means are used to measure quality variables of a finished paper web. The paper machine may also comprise other parts, such as, for example, a surface-size press, a calender and a coating unit, which are not shown in figure 1 for the sake of clarity. There may also be several measurement frames 8 placed at suitable locations in the paper machine to measure the quality variables of the manufactured paper web. Measurement sensors may be placed in connection with other parts of the paper machine as well, which measurement sensors are not shown in the figure for the sake of clarity, but which measure variables connected to the operation of the part in question and/or the quality of the finished product. The paper production process is controlled on the basis of the measured variables.

The measurement results measured by the measurement frame 8, as well as the measurement results received from other measurement sensors are transmitted to the control unit 9 via cables 8'. The control unit 9 controls the calculation process and it comprises the necessary means for forming the parameters to be presented for monitoring the performance of the production process of paper or pulp. The measurement results can be transmitted to the control unit 9 wirelessly as well, in which case a transmitter for transmitting the measurement results is arranged in connection with the measurement frame 8 and other measurement sensors, and a receiver is arranged in the control unit 9 for receiving measurement results. A user interface 10 is connected to the control unit 9, by which user interface the operator can monitor the process and its performance. The control unit 9 and the means comprised by it are described later in connection with figure 7.

The user interface 10 is a terminal, for example a display. The display can be a fixed display, a flat panel display or a personal, portable display device. It is also possible to use an image reflected on a substrate as a display. The user interface may also comprise means for presenting audio signals.

Figures 2 to 5 show graphs formed to assist in illustrating the method according to the invention. They can also be presented in a user interface of the production process of paper and pulp, such as, for example, on a computer display. The user interface can be built hierarchical so that only planar graphs illustrating performance and calculated from different process areas are shown in the same display. Figure 5 shows such a planar graph. From the display according to figure 5 it is possible to move to view graphs on a lower level, which present the actual calculation results from the tracked signal.

The example shown in figures 2 to 5 illustrates an application, where the performance of a paper machine is monitored by oven dry weight measured from the paper being manufactured over two different time periods, i.e. horizons: one and five days backwards from the present moment.

Figures 2a and 2b show calculation graphs for a time period of five days, i.e. time horizon T. Figures 3a and 3b show calculation graphs for the one day time horizon. The time horizons in question are used for calculating cumulative deviation data. The x-axis of the graphs in figures 2a, 2b, 3a and 3b is the time axis, which is hours backwards from the present moment. The y-axis in figures 2a and 3a is the unit of the monitored variable in question. In addition, the length of the calculation window used is marked in the figures with a vertical line 35. The length of the window is the same as the time-wise distance between the line 35 and zero point. In the case of figures 2a, 2b, 3a and 3b the calculation window is the time period of one hour backwards from the present moment. The length of the calculation window can be selected according to the application. The graph shown in figure 2a shows raw and processed data of the oven dry weight of the paper received from the measurement equipment over five days. The graph shown in figure 3a shows the raw and processed data for one day received from the same measurement equipment.

Figures 2a and 3a show the process data retrieved from each calculation horizon, which data is shown in the graphs with a dashed line and marked with number 11. The calculation needed in connection with monitoring the performance of the process is performed at desired time intervals, for example every two minutes, when all the calculation results are updated. When the desired period of time has passed from the previous calculation cycle, the measurement data necessary in the new calculation cycle is retrieved for the calculation module. The calculation horizon is defined with two parameters, one of which discloses the length of the calculation horizon, for example one day, and the other parameter provides the offset of the end moment of the calculation period backwards from the present moment. This way it is possible to calculate, for example, deviation data from two consecutive days and compare these to each other. The data retrieved for the calculation module can be retrieved in so-called increment form, i.e. new data in relation to the previous cycle is required from only such a time period as the time difference between the calculation cycles is. At the same time, unnecessary data is removed from the data structure of the calculation module itself.

After the data retrieval data processing is performed, i.e. validation on the basis of desired calculation conditions. From the point of view of performance tracking it is substantial to detect if critical changes take place in the status of the process or control. In order to detect these, such disturbance periods that do not describe the normal operation of the process or are caused by the user himself must be removed from the data. Such time periods include, for example, break situations, transients following breaks and set value changes made by the user, which always result in transient states. The data remaining after the process is shown with a solid line in the graph in figure 2a and 3a and marked with number 12. When reviewing figures 2a and 3a it is to be noted that the process data retrieved from each calculation horizon, the so-called raw data that is marked with dashed line 11, extends over the entire calculation horizon. In the presentation of this example the validated data after the process is marked with a solid line 12. The raw data 11 in the graph is the data removed in the calculation.

Coefficients of variation COV are calculated from the processed data, which coefficients are shown as function of time, i.e. COV trend in the graphs of figures 2b and 3b and marked with number 13. The COV's are calculated with a sliding calculation method, with a window of a desired length. In the examples of figures 2a, 2b, 3a, 3b the calculation window is one hour. Calculation of COV's takes place so that the calculation window is moved over the processed data in the calculation horizon. This can be illustrated so that the calculation window is thought to be moved over the curves 12 of the graphs in figures 2a and 3a. One data point, i.e. coefficient of variation, is defined at the point of each movement of calculation window, which coefficient of variation is the standard deviation of the data within the window over the mean value of the data within the window. The time stamp of the right edge of the calculation window, i.e. the latter edge time-wise, is provided as the time coordinate of this relative coefficient of variation. If there are rejected time periods within the calculation window, no result for the time-wise location of the calculation window in question is provided from the sliding calculation. The coefficients of variation form a first set of data points, which can be presented as a COV trend, i.e. coefficient of variation curve 13. The newest point of the COV trend 13 time-wise is calculated from the data limited by the line 35 and zero point. Presenting the COV trend to the operator in a user interface is not necessary from the point of view of calculation, but from the point of view of examining performance they are a substantial part of interpreting the other graphs presented in the user interface.

Cumulative COV graphs, which are shown in figure 4, are formed of the first sets of data points formed above. This takes place so that all the accepted COV's received from the calculation horizon are arranged in an order of magnitude according to their numerical value and the relative numbers of the COV's remaining below different numerical values are calculated. Another set of data points is formed from the relative numbers of the COV's as a function of the COV value. Graphically this means that the COV values are plotted in an ascending order and the x-axis is scaled between zero and one hundred. The curve 14 shown in figure 4 shows the cumulative COV curve of the five day calculation horizon and curve 15 the one day calculation horizon. The unit of the x-axis is percentage from the cumulative COV. The y-axis is a numerical value of COV, which is a non-qualitative number.

Next, a first and a second limit value are defined for the cumulative COV curve. It is possible to define as limit values any two numbers that are unequal and between 0 and 100. In this example 20% is defined as the first limit value and 80% as the second limit value. The lower one of the limits means that 20% of all calculation horizon COV remains below the COV numerical value in question. On the other hand, only 20% of the results of the COV calculation exceed the numerical value of the 80% upper limit.

If desired, these limit values can also be illustrated in the graphs of figures 2b and 3b, as has been done in the present example. A straight line 16 is drawn in the graphs of figures 2b and 3b, which describes the 80% limit value for the COV trend points within the visible calculation horizon. Curve 17 describes the past values of the 80% limit of the COV trend from past points of time. The 20% limit value of the calculation moment is marked with a straight line 18 and its past trend with a curve 19.

In cumulative graphs 14 and 15, also the latest result provided by the COV calculation is shown by symbol 20. In other words, the y-coordinate of the location of the symbol 20 is the COV value calculated from the data of the calculation window of the length of the last hour. With the color of the symbol it is possible to provide information on the magnitude of deviation, for example so that when certain limit values are exceeded, the color of the symbol changes. If desired, the symbol is not shown at all, for example when no acceptable value is available from the COV calculation.

If desired, it is possible to provide the reliability of the COV calculation in the graph, for example by a line type of a cumulative graph. If, for example, the COV calculation has provided more points than 70 % of the maximum amount, the cumulative graph can be presented as a solid line. Decreased reliability of calculation can be shown, for example, by using different line types or colors.

The form of the cumulative COV provides a great deal of information on the nature of deviation of the variable being examined. The slope of the cumulative graph shows the fluctuations in performance during the calculation horizon. A high cumulative slope may suggest that the calculation horizon includes good and bad periods from the point of view of performance. A gently sloping middle part of the cumulative graph is, in turn, typical for such calculation horizon data where the performance has been approximately the same all the time. The y-direction plane of the cumulative graph shows the average deviation level within the calculation horizon. A clear step shape in the cumulative function is a sign that the calculation horizon includes either several time periods, when the deviation level is clearly larger than the other area, or a clear increase has taken place in the deviation level a short time ago. The latter is visible so that the location of the step moves to the left in the figure as time passes.

The invention utilizes these characteristics connected to the form of the cumulative COV graph so that an approximation line is drawn for the cumulative graph, which line travels between the first and second limit values of the cumulative graph. From this line it is possible to define a parameter describing its slope and a y-coordinate for the point where the line and some cumulative value pre-selected from between the first and the second limit values, i.e. the cumulative number intersect. The cumulative number is some number selected on the x-axis from between 0 and 100%. It is selected between the above-defined first and second limit values. The parameter describing the slope of the line can be, for example, the angular coefficient of the line, or if fixed limit values are used in the calculation, it can be, for example, the difference Δy between the y-coordinates of the end points of the line. Thus, two parameters are provided, from which it is easy to conclude the general level of performance, and the possible deviation of performance. These two parameters can also be easily shown as a point on a plane, as will be pointed out later.

In this example the approximation lines 21 are drawn between the 20% and 80% limits of the cumulative curves 14 and 15. 50% cumulative number is selected as the coordinates of the y-point. In evaluating performance, the angular coefficient of line 21 and its y-coordinate at the point where the line 21 and the 50% cumulative number intersect are used.

In addition in the graph of figure 4 a limit value has been drawn with a dashed line 22, which describes a good performance of the process, when the measured and adjusted variable is the oven dry weight of the paper being manufactured. As can be seen from the figure, in this example only 20 % of the process run time has remained below this line within the time horizon of one day.

The above-mentioned parameters can be presented to the operator in the user interface in various ways. The signal shown to the operator can be a curve generated on the basis of the parameters of the line, a column graph, a color scale, a text that is spoken or shown in the user interface, or an acoustic signal. In the present example the signal is shown as a point in the planar graph, where the parameters of the line approximations of the cumulative graphs of the COV trends calculated from two different calculation horizons are drawn, i.e. the parameter describing the slope of the line and the y-coordinate of that point, where the line and a pre-selected cumulative number intersect, on a plane. This graph is shown in figure 5. The y-axis of the graph is the y-coordinate of the intersection point of the line approximation and the selected accumulation number, and the x-axis is the angular coefficient of the line approximation. The parameters of the line provided by the one-day calculation horizon are marked with a circle 23 and the corresponding five-day parameters are marked with a square 24.

COV calculation is performed continuously in the control unit 9. Calculation samples, i.e. raw data is collected from the process at certain, predetermined intervals, for example every five seconds. Each raw data sample is processed calculatorily according to the above-presented procedure. As time passes the points 23 and 24 move on the plane according to the calculation results. In order to provide a clear idea on how the points 23 and 24 have moved on the plane in time as the calculation progresses, their paths are drawn in the graph, the time-wise length of which paths is the same as the length of the calculation horizon being used. The paths describe the development of the deviation of process variables in the selected calculation horizons. In the figure the path of the circle 23 is shown with curve 25 and the path of the square with curve 26.

In the above-described example the parameters describing the performance of the process had been calculated with two different calculation horizons in relation to the variable being controlled and the points received from this calculation have been placed in the same planar graph. This way the development of the state of the process can be easily benchmarked in real-time while the process is running. Naturally, it is possible to calculate and describe the position and path of more controllable variables as well with a planar graph. Naturally, it is possible to calculate and describe the position and path of one or more controllable variables with only one or more than two calculation horizons.

From the mutual locations and movement of the points as a function of time it is now easy to conclude how the average level of the performance has developed with different calculation horizons and which direction they are headed. Figure 6 shows a representation of the performance of a process, which can be utilized in evaluating the performance of the process.

In figure 6 the above-described xy-plane is divided into quarters A, B, C and D, which describe the performance of the process. It may change significantly during the calculation horizon. For example, if the angular coefficient increases when the horizon is moved, the point moves to the right on the plane, in which case variations of performance within the calculation horizon increase and the process can be described as more unstable than before. Upward movement of the point shows that the average performance drifts to a level that is poorer than the previous one.

It is also possible to present on the plane a point from some fixed calculation horizon, which does not move with real time. This type of time period can be selected, for example, from such time frame where the performance of the control has been detected being excellent and which thus represents the performance of the process at its best.

It is possible to form a summary of the overall state of the process and the development of deviations on different process areas by collecting several planar graphs from the parameters of approximation lines on the same display. With these it is easy and quick to detect on which process areas the deviations have begun to increase if there are problems. This way, those process areas whose operation should be examined more closely can be quickly located, either from the lower plane graphs or by means of normal process analysis.

The reliability of calculation is one calculated parameter. If rejected time periods are located within the sliding calculation window, this causes breaks in the calculation of COV trend as well. In order to evaluate the reliability of calculation, the relative portion of COV trend points of the maximum amount within the calculation period is calculated. This variable describing reliability can be presented in the graphics shown in the user interface by, inter alia, different line types.

The invention can also be applied for calculating on-line alarms relating to deteriorating process trends, developing performance problems or quality of the end product and disturbances having a negative effect on it.

The control unit 9 comprises means for performing the operations of the method according to the invention. Figure 7 shows more closely a control unit 9, which includes means 27 to 32 for calculating and defining the parameters necessary for monitoring the performance of the process. The steps of the above-described method can be performed by a program, for example a micro processor. The means can be composed of one or more micro processors and the application software comprised by them. In this example, there are several means, but the different steps of the method can also be performed in a single means.

The control unit 9 comprises collection means 27, which collect the process data measured by the measuring devices 8 or the measurement sensors. The collection means 27 can also comprise means for processing the collected process data. The control unit also includes first means 28, i.e. validation means, which remove from the process data measured by the measuring devices 8 those time periods, which do not represent the normal operation state of the process, and second means 29, i.e. calculation means for first data points, which means calculate with a sliding calculation method a set of first data points, i.e. coefficients of variation (COV) from the process data received from the first means 28. Further, the control unit 9 includes third means 30, i.e. formation means for second data points, which means form a set of second data points from the first data points calculated in the second means 29, which data points describe the cumulative curve of the coefficients of variation (COV).

In addition, the control unit 9 comprises fourth means 31, i.e. limit value determining means, which determine a first and a second limit value for the cumulative curve of the coefficient of variation (COV), which first and second limit values define a line between them, as well as fifth means 32, which define a parameter for the line describing its slope, and the y-coordinate of the intersection of the cumulative number selected from between any first and second limit value of the line and the line.

The means 27 to 32 included by the control unit perform the procedures defined for the means 27 to 32 again within certain time intervals, in which case the location of the point in the plane is updated. The user interface 10 shows both the parameter describing the slope of the line, and the y-coordinate of the intersection point of the cumulative number selected between any first and second limit value of the line and the line as a signal, as well as the updated point as a different updated signal, in which case changes in the signal can be detected. From the signal and its change it is possible to conclude the performance of the process and changes in the performance within time.

The invention is not intended to be limited to the embodiments presented as examples above, but the invention is intended to be applied widely within the scope of the inventive idea as defined in the appended claims.

Claims

1. A method for monitoring the performance of a paper or pulp production process, which method comprises the following steps:

a) collecting data connected to at least one controllable variable of the process from the process,
b) removing from the process data collected in phase a) at least one period that does not represent the normal operating state of the process,
c) calculating from the process data received from phase b) with a sliding calculation method a set a first data points,
d) forming of the first data points calculated from phase c) a set of second data points, which describe the cumulative COV coefficients of variation (COV),

characterized in that

e) a first and a second limit value are defined for the cumulative curve of the coefficients of variation (COV), which limit values define a line between them,
f) a parameter describing its slope is defined for the line and a y-coordinate of a point on the line between the limit values, in which point the line and a pre-selected cumulative number intersect, and
g) the parameter describing the slope of the line defined in phase f) and the y-coordinate of the point defined between the limit values is presented as a signal for deducing the performance of the process.

2. The method according to claim 1, **characterized** in that phases a) to f) are performed again within set interval, the signal is updated and the change of the signal is presented in a user interface.

3. The method according to claim 1, **characterized** in that the first data points are coefficients of variation, which describe the coefficient of variation curve formed with a sliding calculation method.

4. The method according to claim 1, **characterized** in that at least one directly or indirectly controllable variable of the process is measured continuously from the process.

5. The method according to claim 1, **characterized** in that measured process data is collected continuously.

6. The method according to claim 1, **characterized** in that a pre-determined time horizon is used in collecting and processing process data measured from the process, which time horizon has at least a defined length, which is backwards from the present moment.

7. The method according to claim 1, **characterized** in that the first and second limit value of the cumulative curve of the coefficients of variation (COV) are defined between 0 and 100% so that the limit values are unequal.

8. The method according to claim 1, **characterized** in that angular coefficient of the line is used as the parameter describing the slope of the line.

9. The method according to claim 1, **characterized** in that the first and second limit value of the cumulative curve of the coefficients of variation (COV) are defined as fixed and the difference Δy of the y-coordinates of the end points of the line are used as a parameter describing the slope of the line.

10. The method according to claim 1, **characterized** in that the first data points are calculated by a sliding calculation method so that:

- a calculation window of a desired length is selected,
- the standard deviation of the data within the window over the mean value of the data within the window is calculated,
- the calculation window is moved over the data processed in the calculation horizon,
- the calculation is performed again.

11. The method according to claim 1, **characterized** in that a set of second data points is formed by arranging the coefficients of variation (COV) in the order of magnitude and the relative amounts below different numeric values are calculated.

12. The method according to any of the preceding claims 1 to 11, **characterized** in that at least two cumulative curves of coefficients of variation (COV) with different time horizons are defined simultaneously.

13. The method according to any of the preceding claims 1 to 12, **characterized** in that the signals defined for different time horizons are shown in the same user interface.

14. The method according to claim 1, **characterized** in that the controllable variable is a variable that can be measured or calculated in the process for producing paper or pulp, on the basis of which variable it is possible to control the process.

15. The method according to claim 1, **characterized** in that the signal shown in phase f) is one of the following: a curve generated on the basis of the parameters of the line, a column graph, a color scale, a text that is spoken or shown in the user interface, or an acoustic signal.

16. The method according to claim 1, **characterized** in that the parameter describing the slope of the line defined in phase f) and the y-coordinate of the point defined between the limit values are presented as a point in the plane.

17. A system for monitoring the performance of a process for producing paper or chemical pulp, which system comprises:

- measurement devices (8) for measuring process data relating to at least one controllable variable of the process,
- collection means (27) for collecting process data relating to an controllable variable of the process,
- a user interface (10) for presenting signals relating to monitoring the performance of the process, and
- a control unit (9), which control unit (9) comprises

a) first means (28) arranged to remove from the collected process data at least one period that does not represent the normal operation state of the process,
b) second means (29) arranged to calculate with a sliding calculation method a set of first data points from the process data received from the first means (28),
c) third means (30) arranged to form a set of second data points from the first data points calculated in the second means (29), which second data points describe the cumulative curve of the coefficients of variation (COV),

characterized in that
in addition, the control unit (9) comprises

- fourth means (31) arranged to define a first and a second limit value for the cumulative curve of the coefficients of variation (COV), which limit values define a line between them,
- fifth means (32) arranged to define a parameter describing its slope for the line, and the y-coordinate of some point on the line between the limit values, in which point the line and a pre-selected cumulative number intersect,

and that the user interface is arranged to present the parameter describing the slope of the line and the y-coordinate of the point defined on the line between the limit values as a signal for concluding the performance of the process.

18. The system according to claim 17, **characterized** in that the means (28, 29, 30, 31, 32) comprised in the control unit (9) are arranged to perform the procedures defined for the means (28, 29, 30, 31, 32) again at certain pre-defined intervals, to update the signal and to present the change of the signal in the user interface.

19. The system according to claim 17, **characterized** in that the first data points are coefficients of variation, which describe the coefficient of variation curve formed with a sliding calculation method.

20. The system according to claim 17, **characterized** in that the measurement devices (8) are arranged to continuously measure at least one controllable variable of the process directly or indirectly.

21. The system according to claim 17, **characterized** in that the collection means (27) are arranged to collect measured process data continuously.

22. The system according to claim 17, **characterized** in that a pre-determined time horizon is arranged to be used in collecting and processing process data measured from the process, which time horizon has at least a defined length, which is backwards from the present moment.

23. The system according to claim 17, **characterized** in that the fourth means (31) are arranged to define a first and second limit value of the cumulative curve of the coefficients of variation (COV) between 0 and 100% so that the limit values are unequal.

24. The system according to claim 17, **characterized** in that a parameter describing the slope of the line is the angular coefficient of the line.

25. The system according to claim 17, **characterized** in that the first and second limit value of the cumulative curve of the coefficients of variation (COV) are defined as fixed and the difference Δy of the y-coordinates of the end points of the line are used as a parameter describing the slope of the line.

26. The system according to claim 17, **characterized** in that the second means (29) are arranged to calculate first data points with a sliding calculation method so that:

- a calculation window of a desired length is selected,
- the standard deviation of the data within the window over the mean value of the data within the window is calculated,
- the calculation window is moved over the data processed in the calculation horizon,
- the calculation is performed again.

27. The system according to claim 17, **characterized** in that the third means (30) are arranged to form a set of second data points by arranging the coefficients of variation (COV) in the order of magnitude and calculating the relative amounts below different numeric values.

28. The system according to any of the preceding claims 17 to 27, **characterized** in that the system is arranged to define simultaneously at least two cumulative curves of coefficients of variation (COV), which have different time horizons.

29. The system according to any of the preceding claims 17 to 28, **characterized** in that same user interface (10) is arranged to present the signals defined for different time horizons.

30. The system according to claim 17, **characterized** in that the controllable variable is a variable that can be measured or calculated in the process for producing paper or pulp, on the basis of which variable it is possible to control the process.

31. The system according to claim 17, **characterized** in that the signal presented in phase f) is one of the following: a curve generated on the basis of the parameters of the line, a column graph, a color scale, a text that is spoken or shown in the user interface, or an acoustic signal.

32. The system according to claim 17, **characterized** in that the user interface (10) is arranged to present the parameter describing the slope of the line and the y-coordinate of the point defined between the limit values as a point in the plane.

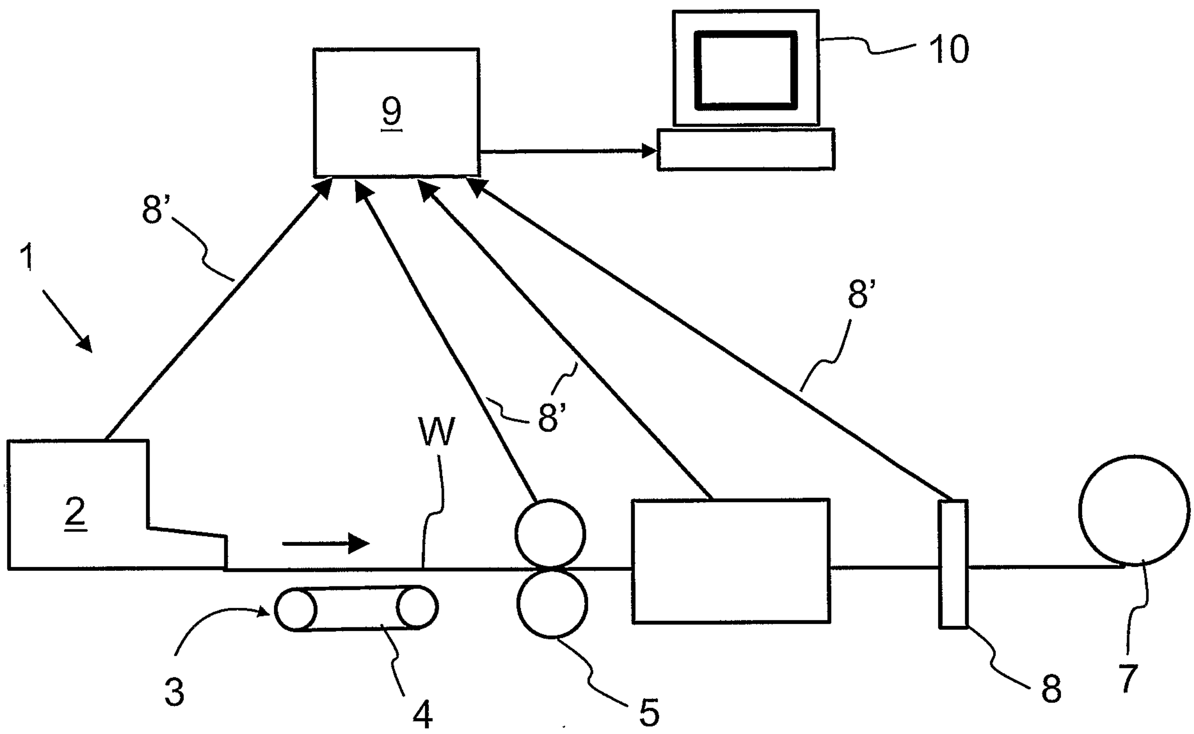


Fig. 1

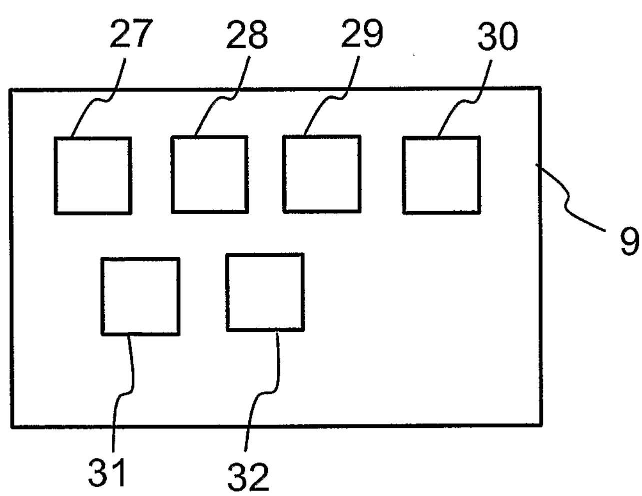


Fig. 7

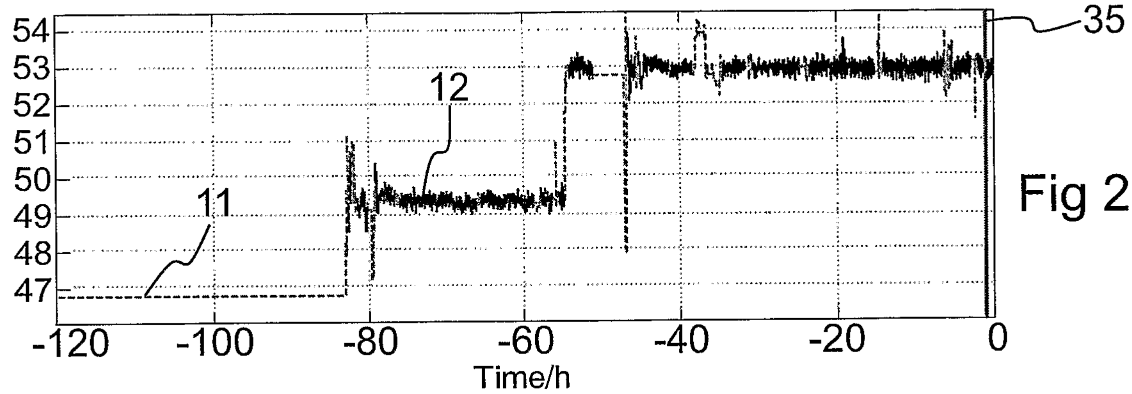


Fig 2a

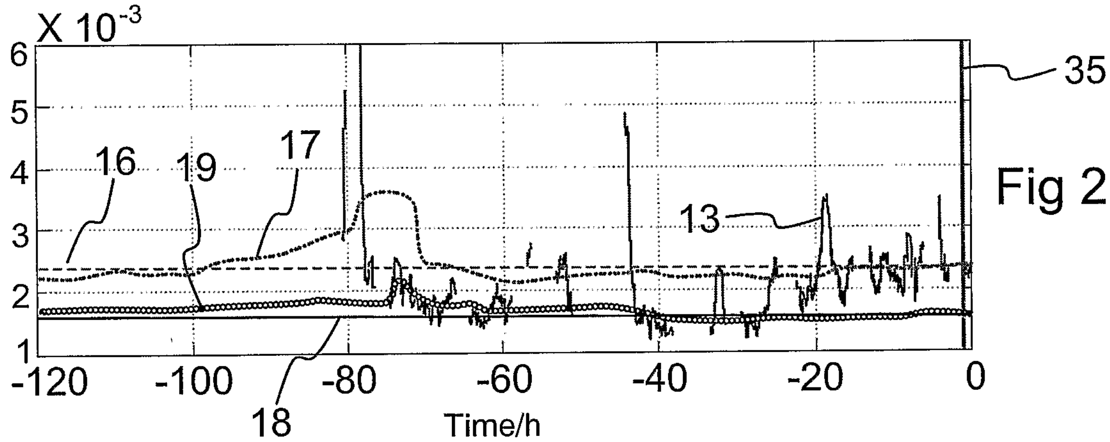


Fig 2b

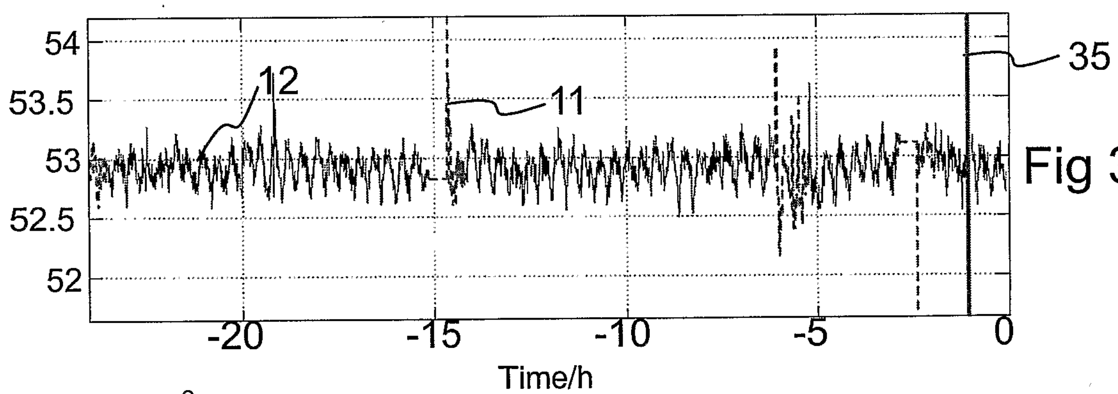


Fig 3a

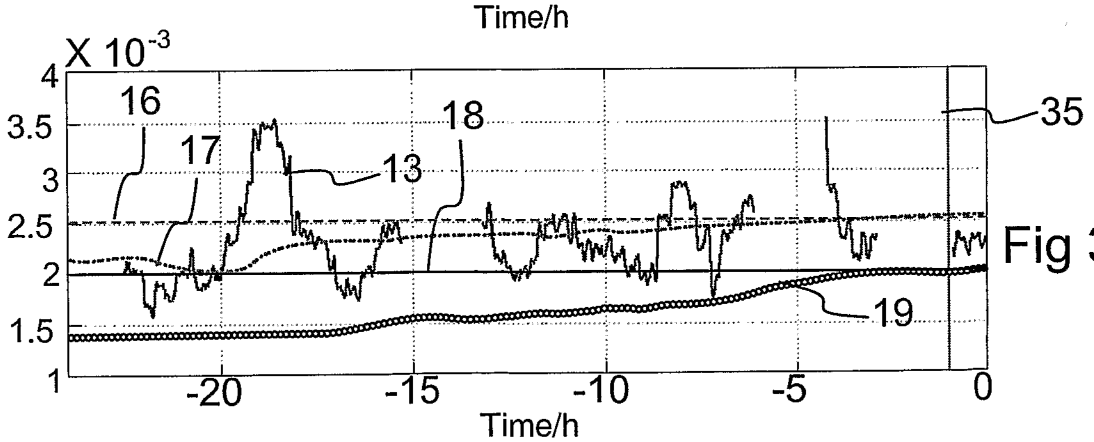
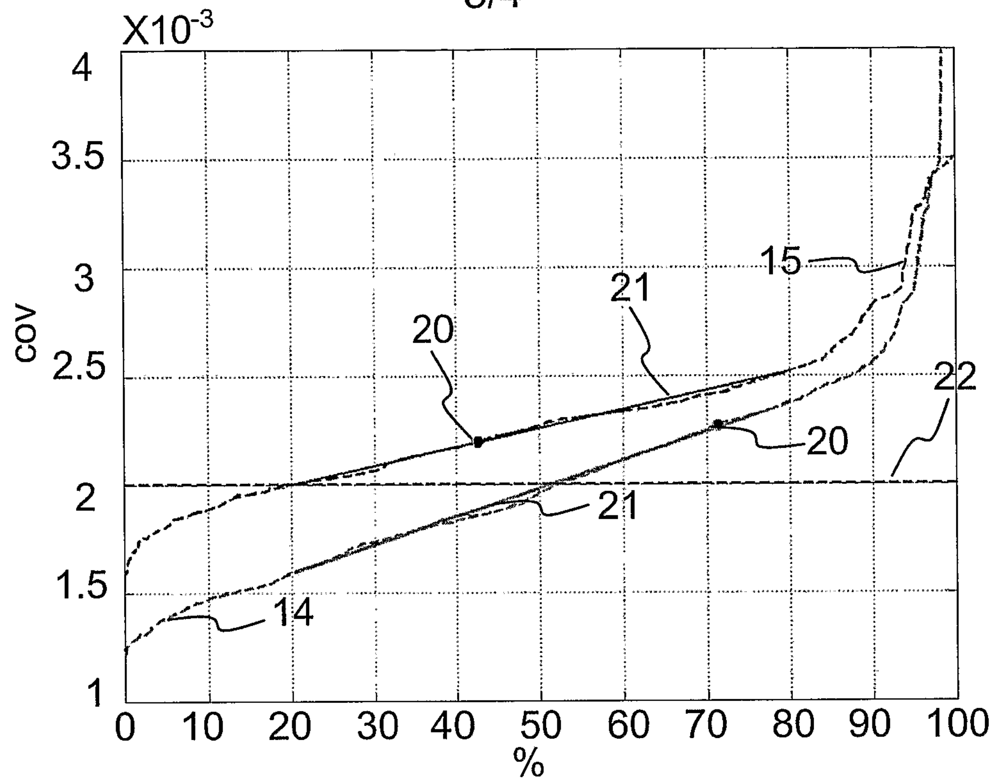


Fig 3b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3.5
3
2.5
2
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cov
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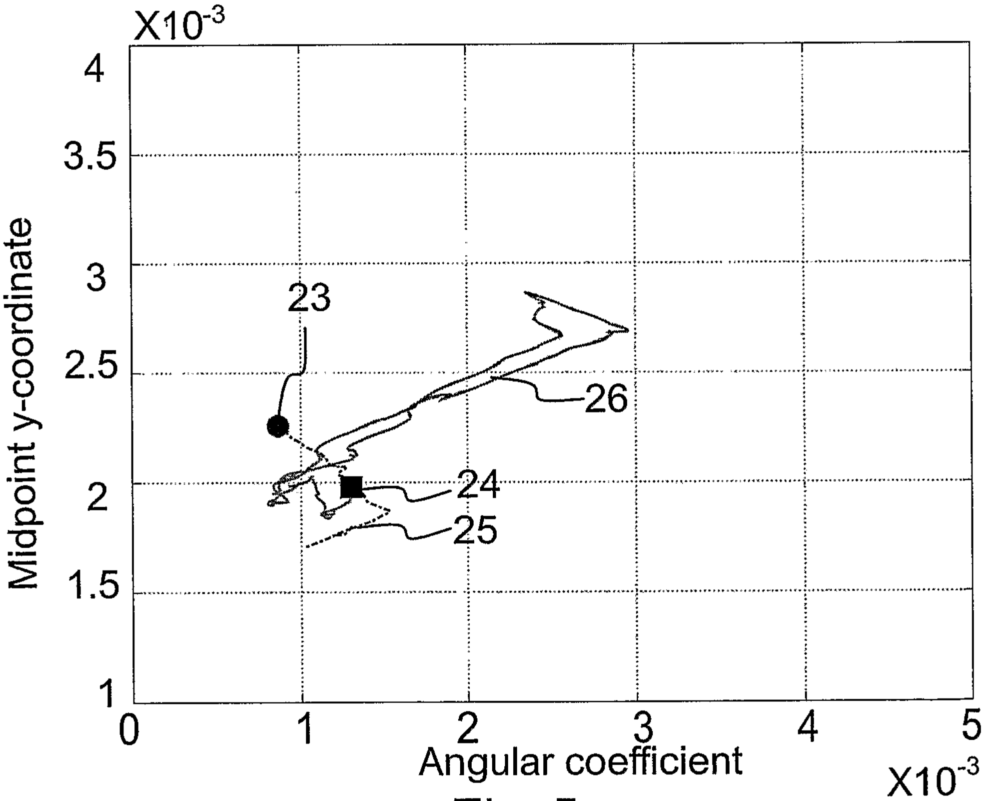
%
15
21
20
22
20
21
14

Fig. 4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Angular coefficient
X10-3
23
26
24
25

Fig. 5

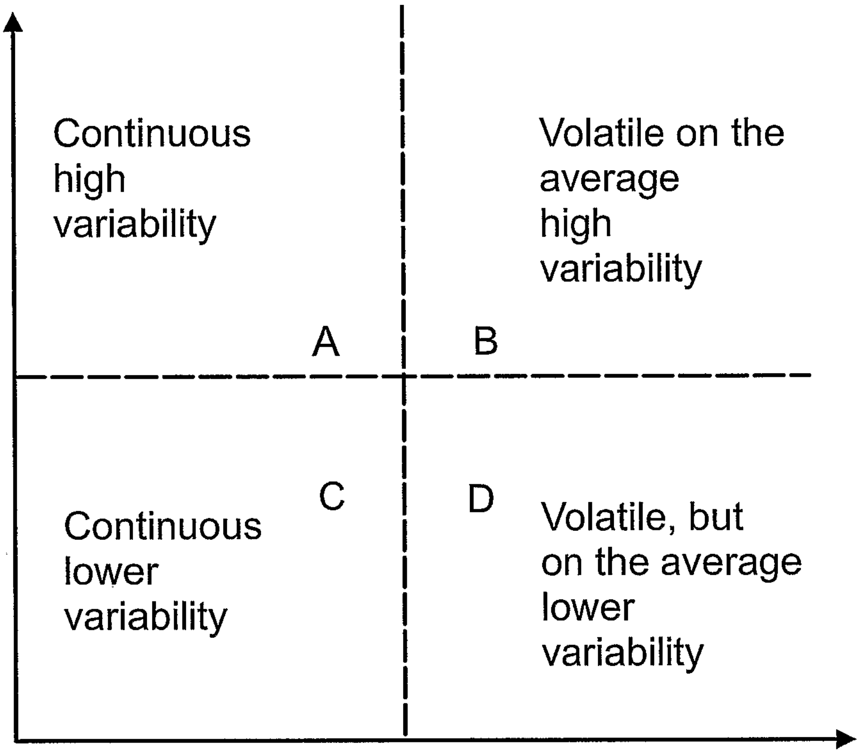
Continuous
high
variability
Volatile on the
average
high
variability
A
B
C
D
Continuous
lower
variability
Volatile, but
on the average
lower
variability

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050309

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC8: G06F, G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 95/18420 A2 (ASEA BROWN BOVERI et al.) 06 July 1995 (06.07.1995), abstract, page 11 lines 1-16, Figs 6, 8	1-32
A	US 6785632 B1 (GOKER TURGUY) 31 August 2004 (31.08.2004), abstract	1-32
A	US 5838561 A (OWEN JAMES GARETH) 17 November 1998 (17.11.1998), abstract, column 4 lines 28-66	1-32
A	US 5392226 A (HAMILTON JEFFREY L) 21 February 1995 (21.02.1995), abstract, column 1 lines 15-58, column 2 line 35 - column 3 line 45, column 7 line 60 - column 8 line 38, Figs. 1, 9A-9G	1-32
A	GB 2304477 A (HYDRONIX LTD) 19 March 1997 (19.03.1997), abstract	1-32

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"E" earlier application or patent but published on or after the international filing date

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"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
09 August 2007 (09.08.2007)	02 October 2007 (02.10.2007)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2007/050309

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
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		AU 2562997 A	19/11/1997
US 5392226 A	21/02/1995	None	
GB 2304477 A	19/03/1997	None	

International application No.
PCT/FI2007/050309

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
G06F 17/18 (2006.01)
G06F 17/17 (2006.01)
G05B 23/02 (2006.01)