Claims:

1. Monitoring means, for monitoring at least one step of a predefined process performed on an industrial site comprising means for running said process on said site, including a control unit (13) controlling initiation and performance of steps of said process, and measurement devices (MD) involved in the performance of the steps for measuring process related quantities, comprising:

- a monitoring unit (25) designed to be set up and connected such, that it has real-time access to measurement results ($MR_{MD}(t_j)$) obtained by the measurement devices (MD) involved in the performance of the steps to be monitored and the times (t_j) at which they were obtained in relation to a starting time (t_0) at which performance of the respective process step was started during the respective run, comprising:

-- a memory (27) storing a model for each step to be monitored, each model comprising:

a) a primary model for at least some, in particular all measurement devices (MD) involved in the performance of the respective step, each comprising:

- a basic function ($f_{MD}(t; C_{MD})$) of time (t) and a set of coefficients (C_{MD}) representing a time dependency of the measurement results (MR_{MD}) of the respective measurement device (MD) to be expected during faultless performance of the step,
- a first property (K1) given by a set of fitted coefficients (D_{MD}) determined by best fitting the basic function ($f_{MD}(t; C_{MD})$) to the measurement results (MR_{MD}) obtained by the respective measurement device (MD) during a performance of the step, and a reference range (R_{K1}) for the first property (K1),

b) a secondary model for each of the primary models, each comprising a second property (K2) given by a dispersion of residues (Δ_{MD}) between the measurement results (MR_{MD}) obtained by the respective measurement device (MD) during a performance of the step and the corresponding fitted function ($f_{MD}(t, D_{MD})$), and a reference range (R_{K2}) for the second property (K2), and

c) tertiary models for pairs of measurement devices (MDa, MDb) involved in the performance of the step, which render correlated measurement results (MR_{MDa}, MR_{MDb}) during faultless performance of the step, each tertiary model comprising a third property (K3), given by a degree of correlation ($Corr(MR_{MDa}, MR_{MDb})$) between simultaneously obtained measurement results (MR_{MDa}, MR_{MDb}) of the respective pair during performance of the respective step, and a reference range (R_{K3}) for the third property (K3)

wherein each of the reference ranges (R_{K1}, R_{K2}, R_{K3}) comprises a range for the respective property (K1, K2, K3) within which the respective property (K1,K2, K3) is expected to occur during faultless performance of the step, and

-- computing means (29) for determining the properties (K) pertinent to the primary, secondary and tertiary models based on the measurement results ($MR(t_j)$) obtained by the measurement devices (MD) involved in the performance of the monitored

steps during monitored runs of the process, and for detecting a fault, in case at least one of these properties (K) exceeds the corresponding reference range (R_K),

- wherein each model in said memory (27) is a model determined by a method performed on said site comprising the steps of:

-- performing a number of test runs of the process and determining whether a result produced by the respective test run is compliant to predefined quality requirements,

-- recording the measurement results (MR^i_{MD} (t_j)) obtained by measurement devices (MD) involved in the performance of the respective step together with the times (t_j) at which they were obtained in relation to a starting time (t_0) at which the respective process step was started during the respective test run for all test runs, for which compliancy to the quality requirements was determined, as performed reference runs,

-- determining the primary, secondary and tertiary models based on the measurement results (MR^i_{MD}) of a population of reference runs RRi, comprising the performed reference runs or the performed reference runs and simulated reference runs, obtained by simulations performed based on the measurement results (MR^i_{MD}) of the performed reference runs, which generate measurement results (MR^i_{MD}) of the measurement devices (MD) to be expected during faultless performance of the step.

2. Method of monitoring performance of a step of a predefined process performed on the industrial site comprising means for running said process on said site, including a control unit (13) controlling initiation and performance of steps of said process, and measurement devices (MD) involved in the performance of the steps for measuring process related quantities, and monitoring means according to claim 1, having real-time access to measurement results ($MR_{MD}(t_j)$) obtained by the measurement devices (MD) involved in the performance of the steps to be monitored and the times (t_j) at which they were obtained in relation to a starting time (t_0) at which performance of the respective process step was started during the respective run, comprising the steps of:

A) determining said models stored in said memory (27) by a method performed on said site comprising the steps of:

- performing a number of test runs of the process and determining whether a result produced by the respective test run is compliant to predefined quality requirements,

- recording the measurement results (MR^i_{MD} (t_j)) obtained by measurement devices (MD) involved in the performance of the respective step together with the times (t_j) at which they were obtained in relation to a starting time (t_0) at which the respective process step was started during the respective test run for all test runs, for which compliancy to the quality requirements was determined, as performed reference runs,

- determining the primary, secondary and tertiary models based on the measurement results (MR^i_{MD}) of a population of reference runs RRi, comprising the performed reference runs or the performed reference runs and simulated reference runs, obtained by simulations performed based on the measurement results (MR^i_{MD}) of the performed reference runs, which generate measurement results (MR^i_{MD}) of the measurement devices (MD) to be expected during faultless performance of the step, and

B) monitoring at least one step of said process for which a model has been determined by a method performed on said site comprising the steps of:

- recording the measurement results (MR^{PR}_{MD}) obtained by the measurement devices (MD) involved in the performance of the step during performance of the step,
- based on the recorded measurement results (MR_{MD}) determining the properties (K) pertinent to the primary, secondary and tertiary models of the respective step, and
- detecting a fault, in case at least one of the properties (K) exceeds the corresponding reference range (R_K).

3. Method according to claim 2, comprising the steps of determining each primary model by:

- determining the basic function $f_{MD}(t; C_{MD})$, based on the time dependency of the measurement results ($MR_{MD}^i(t_j)$) obtained by the respective measurement devices (MD) during performance of the respective step during the reference runs (RRi) ,
- determining the reference range (R_{K1}) for each first property (K1) by
-- determining a set of fitted coefficients (D^i_{MD}) for each reference run (RRi) by best fitting the respective basic function ($f_{MD}(t; C_{MD})$) to the measurement results (MR^i_{MD}) obtained by the respective measurement device (MD) during performance of the step during the respective reference run (RRi),
-- based on a distribution of the determined sets of fitted coefficients (D^i_{MD}), determining a probability of a first property (K1) determined during a monitored run to belong to this distribution, and
-- determining the reference range (R_{K1}) such, that it includes all first properties (K1), for which the probability to belong to the distribution is larger than or equal to a predetermined probability threshold.

4. Method according to claim 2, comprising the step of determining the reference range (R_{K2}) for each of the second properties (K2) by, for each reference range (R_{K2})

- determining a dispersion of residues (Δ^i_{MD}) between the measurement results (MR^i_{MD}) obtained by the respective measurement device (MD) during performance of the step during one of the reference runs (RR_i) and the corresponding fitted function ($f^i_{MD}(t; D^i_{MD})$) determined for this measurement device (MD) for this reference run (RRi) for each of the reference runs (RRi),

- based on all determined dispersion of residues (Δ^i_{MD}) determining a probability distribution ($PDF_{MD}(\Delta_{MD})$) representing the probabilities of residues (Δ_{MD}) to occur during faultless performance of the step as a function of their size, and
- determining the reference range (R_{K2}) such, that it includes all second properties (K2), for which the probability to belong to the corresponding probability distribution ($PDF_{MD}(\Delta_{MD})$) is larger than or equal to a predetermined probability threshold, in particular by determining the reference (R_{K2}) as a range for a variance (σ^2_{MD}) of the residues (Δ_{MD}) of the dispersion of residues (Δ_{MD}).

5. Method according to claim 2, comprising the steps of:
- identifying pairs of measurement devices (MD_a, MD_b) involved in the performance of the step which render correlated measurement results (MR_{MDa}, MR_{MDb}) during faultless performance of the step, in particular identifying them by
-- for each possible pair of measurement devices (MDa, MDb) involved in the performance of the step determining a degree of correlation $Corr(MR^i_{MDa}, MRi_{MDb})$ between their simultaneously obtained measurement results (MR^i_{MDa}, MRi_{MDb}) during performance of this step for each reference run (RRi), and
- identifying the pairs rendering correlated measurement results (MR_{MDa}, MR_{MDb}) based on the degrees of correlations ($Corr(MR^i_{MDa}, MRi_{MDb})$) determined for all possible pairs for all reference runs (RRi), and
- for each identified pair, determining the reference range (R_{K3}) for the respective third property (K3) such, that it includes all respective third properties (K3), for which the probability to belong to a reference distribution given by a distribution of the corresponding degrees of correlations ($Corr(MR^i_{MDa}, MRi_{MDb})$) determined for the respective pair for the reference runs (RRi) is larger than or equal to a predetermined probability threshold.

6. Method according to claim 2, comprising the step of indicating a warning in case at least one of the determined properties (K1, K2, K3) occurred in a range, which according to a distribution of the respective property (K1,K2, K3), to be expected during faultless performance of the step, in particular a corresponding distribution of sets of fitted coefficients (D_{MD}), a corresponding probability distribution of residues ($PDF(\Delta_{MD})$) and a corresponding reference distribution of the degrees of correlation ($Corr(MR_{MDa}, MR_{MDb})$), has a low probability of occurring.

7. Method according to claim 2, performed on an industrial site comprising monitoring means according to claim 1, further comprising the steps of determining an impact of a disturbance of a certain type on the properties (K) of the model for a step of the process monitored by the monitoring unit (25) according to claim 1, comprising the step of:

- recording measurement results (MR^{DR}_{MD}) of the measurement devices (MD) involved in the performance of the step during disturbed runs of the process step, during which a disturbance of this type has been voluntarily induced, and/or generating corresponding measurement results (MR^{DR}_{MD}) to be expected during performances of this step suffering from the respective disturbance by numerical simulations,
- determining disturbed primary, secondary and tertiary models in the same way as the primary, secondary and tertiary models representing the faultless performance of the respective step were determined based on recorded and/or generated measurement results (MR^{DRi}_{MD}) of a population of disturbed runs (DRi) suffering from disturbances of the same size and type,
- repeating the determination of the disturbed primary, secondary and tertiary models for increasing sizes of the same type of disturbance,
- determining the impact of the type of disturbance on the properties (K) of the model by comparing the distributions of the properties (K), in particular the distributions of the sets of fitted coefficients (D_{MD}), the probability distribution of the residues ($PDF(\Delta_{MD})$) and the reference distributions of the degrees of correlation ($Corr(MR_{MDa}, MR_{MDb})$), determined based on the measurement results (MR^{i}_{MD}) of the reference runs (RRi) to the corresponding distributions of the same properties (K) determined based on the measurement results (MR^{DRi}_{MD}) of the disturbed runs (DRi).

8. Method according to claim 2, comprising the steps of:
- validating performances of monitored steps during which no fault was detected,
- in particular validating them with a reliability determined based on a confidence level (α) for detecting a fault, in case a disturbance of a certain type and this size or larger is present, and/or a probability (β) of not detecting a fault, even though a disturbance of a certain type and this size is present, determined for one or more disturbances,
-- for which disturbances their impact on the properties (K) has been determined based on the method according to claim 7, and
-- for which disturbances the confidence level (α) and/or the probability (β) has been determined based on the distributions of the properties (K) determined based on the measurement results (MR^{DRi}_{MD}) of the disturbed runs (DRi) suffering from increasing sizes of disturbances of this type and the reference ranges (R_K) for the monitored properties (K).

9. Method according to claim 2, comprising the steps of:
- storing the measurement results (MR_{MD}) obtained during validated performances, and
- updating the model stored in the monitoring unit (25) based on measurement results (MR_{MD}) of validated performances of the respective step.

10. Monitoring means according to claim 1, further comprising a diagnosing unit (31) for performing diagnoses regarding faults detected by the monitoring means according to claim 1,said diagnosing unit (31) comprising a data base (33) for storing data sets related to known types of disturbances, which can occur during performance of one of the steps for which a model is stored in the memory (27) of the monitoring unit (25), wherein each data set comprises:
- the type of disturbance, and
- its impact on each of the monitored properties (K) determined by the method according to claim 7.

11. Monitoring means according to claim 10, wherein at least one data set comprises
- a list of at least one root cause, causing the respective disturbance,
- in particular a list of at least one root cause and a list of at least one action for at least one of the listed root causes, in particular an action directed towards the determination, whether the respective root cause is present, and/or an action given by a remedy suitable of resolving the respective root cause.

12. Method according to claim 7, performed on an industrial site comprising monitoring means according to claim 10 or 11, further comprising the step of performing a diagnosis regarding a fault detected by said monitoring means by:
- searching the data base (31) for data sets stored for disturbances, which have an impact on the individual properties (K), which matches the properties (K) determined for the present faulty performance of the respective step of the process, and
- in case at least one matching disturbance is found,
-- determining the root causes stored in the respective data sets, as possible root causes, which may have caused the detected fault, and
-- performing the diagnosis based on the determined possible root causes.

13. Method according to claim 7, performed on an industrial site comprising monitoring means according to claim 10 or 11, further comprising the step of performing a diagnosis regarding a fault detected by said monitoring means comprising the steps of:
- searching the data base (31) for data sets stored for disturbances, which have an impact on the individual properties (K), which matches the properties (K) determined for the present faulty performance of the respective step of the process, and
- in case no matching disturbance is found,
-- determining in which direction the properties (K), which exceeded the corresponding reference range (R_K), exceeded the corresponding reference range (R_K),
-- for each property (K), for which the direction, in which it exceeded the corresponding reference range (R_K), was determined, searching the data base for disturbances

which cause the same property (K) to exceed this reference range (R_K) in the same or a similar direction,

-- determining the root causes stored in the data sets of the disturbances, which cause the respective properties (K) to exceed the corresponding reference range (R_K) in the same direction, as possible root causes, and

- performing the diagnosis based on the determined possible root causes.

14. Method according to claim 7, performed on an industrial site comprising monitoring means according to claim 10 or 11, further comprising a method of performing a diagnosis regarding a fault detected by said monitoring means comprising the steps of:

- in case the first or the second property (K1, K2) determined for one of the measurement devices (MD) involved in the performance of the step exceeded the corresponding reference range (R_{K1}, R_{K2}) and one of the third properties (K3) related to a tertiary model pertinent to the same measurement device (MD) shows a reduced degree of correlation diagnosing a disturbance pertinent to this measurement device (MD), and/or
- in case the first or the second property (K1, K2) determined for one of the measurement devices (MD) involved in the performance of the step (MD) exceeded the corresponding reference range (R_{K1}, R_{K2}) and none of the third properties (K3) related to a tertiary model pertinent to the same measurement device (MD) shows a reduced degree of correlation diagnosing a disturbance affecting the quantity measured by this measurement device (MD).

15. Method according to claim 12, 13 or 14 performed on an industrial site comprising a monitoring means according to claim 10 or 11, wherein

- additional information is stored in the data base (33),
- in particular information on additional disturbances, root causes, actions related to root causes and/or additional diagnostic information, in particular rules for determining root causes, diagnosing tools and/or diagnosing methods, and
- the additional information is applied during performance of the diagnosis, in particular in order to determine the disturbance and/or the root cause that caused the detected fault.

16. Method according to claim 12 or 15, performed on an industrial site comprising monitoring means according to claim 11, comprising the step of performing a diagnosis regarding a fault detected by said monitoring means comprising the step of: determining the root cause of the detected fault based on the determined possible root causes and the actions directed towards the determination of their presence stored in the data base, by performing the actions in an order, in particular an order recommended by the diagnosing unit (31), corresponding to their availability and the

time and cost involved in their performance, in particular by having at least one of those actions, which can be performed in an automated fashion on the site, performed in an automated fashion based on a corresponding request issued by the diagnosing unit (31) and/or by having at least one of those actions initiated and/or performed by an operator of the site.

17. Method according to claim 12 or 15, comprising the steps of:
- determining the root cause, that caused the presently detected fault,
- applying a remedy to resolve the root cause, and
- during a verification time interval monitoring consecutive performances of the step of the process, and
- validating the applied remedy, in case no further fault was detecting during performances of the respective step during the verification time interval.

18. Method according to claim 7 performed on an industrial site comprising monitoring means according to claim 10 or 11, further comprising the step of amending the data base of the diagnosing unit (31) by
- adding at least one data set related to a disturbance, which had occurred on the site and was subsequently identified, in particular a data set comprising an impact of this disturbance on the properties (K), in particular an impact determined by the method according to claim 7,
- adding at least one root cause, causing one the disturbances contained in the data base, in particular root causes identified by the operator during operation of the site,
- adding at least one action, related to one of the root causes listed in the data base, in particular an action identified by the operator during operation of the site,
- for at least one property measured by one of the measurement devices (MD) adding a list of at least one root cause, in particular a list of at least one root cause and list of at least one action related to one of the root causes, affecting this measured property, and/or
- for at least one of the measurement devices (MD), adding a list of at least one root cause, in particular a list of at least one root cause and list of at least one action related to one of the root causes, causing an impairment of this measurement device (MD).