

METHOD AND APPARATUS FOR DETECTING, EVALUATING AND DISPLAYING
MEASUREMENT VALUES OF MOTORS OF ELECTRIC DRIVES

5 The invention relates to a method for detecting, evaluating and displaying measurement values of motors of electric drives, and to an apparatus for implementing said method.

10 In numerous technical apparatus, switching operations between mechanical states are realised by means of electric motors. Frequently, the switching operations are cyclic in the sense that switching is always back and forth between at least two defined states. Examples of such electrically driven systems are barriers for railway level crossings, drives for positioning the switches in rail-bound traffic, or drives for opening and closing windows, gates, etc. The servomotors run in a reproducible manner from defined initial points to defined endpoints and back again.

15 If the functional capability and the technical condition of such installations are to be monitored, it is necessary inter alia to make a statement about the sluggishness of the installation. For this purpose, for example, the electrical characteristic curves of the drive motors are determined and evaluated. Sluggishness, which can be caused by wear, for example, would be noticed by the fact that greater power consumption of the motor is measured than given by the reference values.

20 In order to be able to assess the technical state of an electrically driven system, it is necessary to evaluate the data of measurement value.

 With respect to switching drives, for example, the current profile during a switchover operation is recorded and compared with a reference curve.

25 The data are displayed on an output device by means of an ordinary coordinate system in which the measuring time is selected as the abscissa and the electrical current's magnitude or the difference between the measured current values and the reference curve is selected as the ordinate.

 In such a representation, however, a comparison with earlier or later measurements is difficult to visualise.

30 DE 197 33 001 A1 describes a method for detecting, evaluating and displaying measurement values, in which the measurement or comparison values are displayed in alphanumeric form, wherein the alphanumeric representation of a measurement or

comparison value is assigned a colour value in the representation, selected in each case as a function of the determined comparison value.

The problem addressed by the present invention is that of providing a method by which the technical state of motors of electric drives can not only be assessed at a given time, but also the development over time of the state is recorded and visualised, so that also statements about an expected maintenance scope can be made and conclusions drawn regarding the causes of the changes in state. Moreover, an apparatus is to be provided, which implements the method.

These problems are solved by the method according to the invention as disclosed in claim 1 and the corresponding apparatus according to claim 4.

Advantageous further developments are the subjects of the dependent claims.

The method according to the invention as disclosed in claim 1 represents a measuring method in which the measurement values of motors of electric drives are detected, evaluated and displayed. In particular, the electrical characteristic values of the motor measured by at least one sensor can be used as measurement values. Moreover, basic parameters such as temperature, humidity, etc. can also be measured and included in the evaluation. The measurement values are transmitted to a data processing system where they are stored and evaluated. Within the evaluation, it can be advantageous to process appropriately the measurement values. For example, an evaluation function can compare the measurement values with reference values under the specified basic conditions, and, as further data to be considered, only use the differences between the measurement values and the reference values. Since electric motors such as those used in the case of drives for barriers, switches, windows or gates have a cyclic operating pattern, the measurement values can be compared with one another as a function of the mechanical position of the driven components over a period of several control cycles. For example, if the start-up characteristic of the motor changes due to wear-induced sluggishness of the mechanism, the power consumption requirement of the drive gradually increases over time. In order to recognise such a trend at an early stage, the data have to be compared with one another over a long period. In a display of the data on a two-dimensional screen or on a two-dimensional paper printout, a multidimensional representation is only clear when the information is processed. This takes place according to the invention, in that two time coordinates are considered. The measurement values within a revolution cycle of the drive are described

as a function of a first time coordinate, which is referred to as the rotation time T_u . The second time coordinate is designated as the comparison time T_v and indicates the time of each individual revolution. Two or more successive revolutions of the drive thus occur at two or more different time points T_{v1} and T_{v2} etc. At each of these time points, there is a measurement value characteristic during one revolution $z = f_{T_{vi}}(T_u)$. In order to describe the dependency of the data on both time coordinates, both coordinate axes according to the invention are selected perpendicular to one another. For example, T_v can be represented in the x-direction, while the y-direction is characterised by T_u . In order to now be able to display, on a two-dimensional display plane, the values of the data in the coordinate system belonging to each $(y_i; z_i)$ pair, a perspective representation could be selected. However, since this can quickly become confusing, according to the invention a projection of the z-axis on the x-y plane. In order to be able to display information about the numerical values of the data, the z_i -values are colour-coded. The sequence of coloured data points in the y-direction indicates the difference between the data value and the reference value within a revolution time T_u , which was measured at time T_{vi} during a revolution. During the next revolution of the actuator in the same direction, the data values at $T_{v(i+1)}$ are displayed in the same manner. Since the (y_{i+1}, z_{i+1}) pairs of values are shifted parallel to the $(y_i; z_i)$ pairs of values in the direction of the T_v -axis, both measurements are displayed side by side and can easily be compared with one another for evaluation. Data values for the same phases of the switching operation for different control cycles always lie on a parallel to T_v -axis. Thus, the development of the measurement values at each phase of the switching process can be efficiently evaluated by analysing the development of the colour along parallels to the x- and/or T_v -axis.

Particularly advantageously, the information quantity is therefore reduced in that not every single z -value, but only certain value classes, which are oriented towards defined tolerance values for the data, are coded. By comparing the data with reference values and a specification of one to a few tolerance ranges, a meaningful representation is achieved with the aid of a few colour values. It is therefore apparent, based on the colour of the data point, which tolerance limit is exceeded by the data point $(y; z)$.

Moreover, it is advantageous if, during the evaluation of the data, attention is drawn to the requirement to investigate the drive. This can then occur, for example, if a

data point has at least once reached a tolerance limit to be defined, which is known as evidence of damage or hazard to the drive.

Moreover, the data points along a parallel to the comparison time axis are analysed as to whether a change in the data points takes place in the direction of a tolerance limit to be defined. Thus, if a data value, at a particular revolution phase of the drive, gradually exceeds increasingly higher tolerance thresholds, it should be expected that a critical state of the drive is imminent, so that here a message is issued at the output unit, too, which indicates that the system must be investigated by the service personnel.

Claims 4 to 6 relate to an apparatus for implementing the method from the preceding claims.

According to the invention, an apparatus is provided, which detects, stores, evaluates and displays measurement values of motors of electrical drives.

The apparatus consists of at least one measuring sensor that is connected to a data processing system, which has an output unit for displaying the evaluation results, as well as means for data input. The measurement data are evaluated by means of the data processing system.

In particular, the electrical characteristic values of the motor measured by at least one sensor can be used as measurement values. Moreover, the apparatus can also measure basic parameters such as temperature, humidity, etc., and incorporate them in the evaluation.

For the evaluation of the data, it can be advantageous if the apparatus appropriately processes the measurement values. For example, with the aid of an evaluation function, the apparatus can compare the measurement values with reference values under the given basic conditions, and only use the differences between the measurement values and the reference values as further data to be considered. The apparatus according to the invention considers two time co-ordinates. It describes the measurement values within a revolution cycle of the drive as a function of the revolution time T_u . The second time coordinate is used as a comparison time T_v and it specifies the time point of each individual revolution. Two or more consecutive revolutions of the drive therefore occur at two or more different time points T_{v1} and T_{v2} . Each of these time points has a measurement value characteristic during a revolution $z = f_{T_{vi}}(T_u)$.

The data are represented in a two-dimensional coordinate system with two coordinate axes perpendicular to one another, with T_v as abscissa (x-axis) and T_u as ordinate (y-axis).

On its output unit, the apparatus displays the values of the data belonging to each $(y_i; z_i)$ pair in the coordinate system by projecting the measurement values onto the T_u axis, thereby colour coding the measurement values specified by the z_i -values. The sequence of coloured data points in the y -direction indicates the difference between the data value and the reference value within one revolution time T_u , which was measured at time T_{vi} during a revolution. During the next revolution of the actuator in the same direction, on its output unit the apparatus displays the data values at $T_{v(i+1)}$ in the same manner. Since the $(y(i+1); z(i+1))$ pairs of values are offset parallel to the $(y_i; z_i)$ pairs of values in the direction of the T_v -axis, the two adjacently displayed measurements can be compared easily with one another for evaluation.

The apparatus particularly advantageously reduces the information quantity by not coding each individual measurement value in the measuring range with its own colour, but only certain classes of values that conform to defined tolerance values for the data. By comparing the data with reference values and a specification from one to a few tolerance ranges, the apparatus allocates only a few colours to the z -values. Based on the colour of the data point, it is apparent which tolerance limit is exceeded by the data point $(y; z)$.

During the evaluation of the data, the apparatus advantageously indicates an investigation requirement of the drive. This can then occur, for example, if at least once a data point has reached a tolerance limit to be defined, which is known as evidence of damage or hazard to the drive.

Moreover, the apparatus analyses the data points along a parallel to the comparison time axis, as to whether a change in the data points takes place in the direction of a tolerance limit to be defined. If a data value at a particular revolution phase of the drive gradually exceeds increasingly higher tolerance thresholds, the apparatus issues a message at the output unit, which indicates that the system must be investigated by the service personnel.

The invention is explained below in more detail with reference to an exemplary embodiment that is represented by two figures.

Fig. 1 shows, by way of example, the analysis of switches on a railway network of a track-bound traffic system. By means of magnetic field sensors that are designed, for example, as 3D or multi-dimensional magnetic field sensors, the current magnitude and the direction of rotation of the switch drive are determined by means of the measured magnetic fields by a data processing system.

The current curve is used in the analysis of the data as a measure of the sluggishness of the switch.

In the figure, a single dash is assigned to each 4-wire switch drive cable; 3 switches are thus monitored with the diagnostic apparatus.

The diagnostic apparatus directly measures existing cabling of the respective switch drive, near a terminal bar. The terminal bar between the outer cable and the inner cable is ideal for this purpose.

The measurement data is transmitted by means of a suitable interface. In this example, a 4-20 mA interface is used. Depending on environmental conditions and distances, also, other wire-bound interfaces are possible, as well as wireless, e.g. radio interfaces.

The control of the measuring process, the preparation of the measurement data and the forwarding to a diagnostic system are functions of the connected data processing system.

Fig. 2 shows an exemplary representation of the measurement data for an evaluation of the switch-drive data. The measured current values are subtracted from the reference values of an intact drive stored in a database.

The differences from the reference values ΔI are divided into tolerance ranges. In this example, none or only slight deviations from the reference value are assigned to the tolerance range T0. Greater deviations correspond to tolerance ranges T1 to T4. When the tolerance range T4 is reached, an acute danger to the operability of the drive exists.

Negative deviations point to a better sluggishness of the drive in comparison with the reference values. These measurement values are assigned to tolerance range T-1. Each tolerance range is now assigned its own colour when displaying the measurement values.

In this example, the colour green is assigned to the tolerance range T0 and thus represents an agreement between the measurement data and the reference values or

only a minor deviation. To T1 to T4, for example, are assigned the colours yellow, orange, light red and dark red, T-1 the is assigned the colour blue.

The comparison time T_v is assigned to the x-direction and the y-direction shows the measurement values during a revolution (T_u) of the drive. Starting from the x- axis in the middle of the figure, underneath the movement of the switch drive into a right-hand position is shown, while the data shown from the centre upwards describe a deflection of the drive into the left-hand position. Along the T_v -axis, several revolutions are represented next to one another. The switch drive comes to the end position after about the same period of revolution T_{UE} . The same phases of the revolution can therefore be compared with one another along the parallels to the T_v -axis.

In the lower section of Figure 2 (clockwise), it can be seen how the values gradually deviate from the reference value over several revolutions during approximately half the period of revolution. This can be seen in the fact that in the case of T_u , the colour has migrated from green via yellow to orange within the range of half a revolution cycle time along a parallel to the T_v -axis. For the first revolutions at the beginning of measurements, the measurement value still corresponded with the reference value, whereas it has shifted more and more distant from its reference value during an increasing number of revolutions.

This is an indication that the condition of the drive has deteriorated as compared to the start of the measurements, and thus, there is a need for maintenance before the drive reaches a critical state. When analysing the data, an order to inspect the switch drive is therefore triggered. In this case, a prediction of expected damage history is displayed by comparison with data stored in the database. Based on this forecast, the optimum maintenance time can be defined.

In the upper area of Figure 2 (anti-clockwise), it can be seen, for example, how a sudden transition from green colour values to red ones takes place. An event has occurred here and damaged the switch, which must be corrected immediately. Correspondingly, an alarm message is issued and an immediate check of the system is triggered. The spare parts required for repair are determined and displayed from comparison with the data stored in a database.

CLAIMS

1. Method for detecting, evaluating and displaying of measurement values of motors of electric drives, wherein measurement values are determined by at least one sensor, which are transmitted to a data processing system **characterised in that** two time coordinates are considered, wherein the measurement values within one revolution cycle of the drive are described as a function of a first time coordinate (revolution time) and the successive revolutions of the drive are described as a function of a second time coordinate (comparative time), wherein the measurement values of a revolution cycle of the electric drive are stored and if necessary, processed by means of an evaluation function, these data then being compared with a reference curve, wherein the deviations between the data and the reference curve are colour-coded and displayed on an output unit in such a way that the two time coordinates are displayed perpendicular to each other and, for each data point, the colour corresponding to the deviation from the reference value is displayed on the revolution - time axis so that in the case of several measurement cycles a successive series of the colour-coded data points results.
2. Method for detecting, evaluating and displaying of measurement values of motors of electric drives according to claim 1, wherein the coding of the colour values for the deviations of the data from the reference values is selected as function of tolerance ranges such that owing to the colour of the data point when the data are output, it is apparent, which tolerance limit is exceeded by the measurement values at the respective data point.
3. Method for detecting, evaluating and displaying of measurement values of motors of electric drives according to one of the preceding claims 1 to 2, wherein attention is drawn to the requirement to investigate the drive, if a data point has at least once reached a tolerance limit to be defined or when the comparison of the data points along a parallel to the comparison time axis results in a change of the data points in the direction of a tolerance limit to be defined.

4. Apparatus for the detecting, evaluating and displaying of measurement values of motors of electric drives, wherein at least one sensor measures measurement values and transmits them to a data processing system, **characterized in that** the data processing system is set up to use time coordinates for the evaluation, wherein it describes the measurement values within a revolution cycle of the drive as a function of the first time coordinate (revolution time), and it describes the successive revolutions of the drive as a function of the second time coordinate (comparison time), wherein it stores the measurement values of a revolution cycle of the electric drive and, if necessary, processes them by means of an evaluation function, then compares these data with a reference curve, wherein it colour codes the deviations between the data and the reference curve and displays them on an output unit such that it represents the two time coordinates perpendicular to each other, thereby displaying for each data point the colour corresponding with the deviation from the reference value on the revolution - time axis, so that a successive series of the colour-coded data points results in the case of several measurement cycles.

5. Apparatus for the detecting, evaluating and displaying of measurement values of motors of electric drives according to claim 4, wherein the data processing system is configured in such a way that it selects the coding of the colour values for the deviations of data from the reference values as a function of tolerance ranges, so that based on the colour of the data point at the output unit, it is apparent which tolerance limit the measurement values exceed at the respective data point.

6. Apparatus for the detection, evaluation and display of measurement values of motors of electrical drives according to one of the preceding claims 4 to 5, wherein the data processing system is configured in such a way that it indicates an investigation requirement of the drive by means of a message, if at least once a data point reaches a tolerance limit to be defined or when the comparison of data points along a parallel to the comparison - time axis results in a change of the data points in the direction of a tolerance limit to be defined.