

The invention relates to a process for controlling an electronically commutated motor in accordance with the preamble of Claim 1.

In electronic devices with motors which are used therein for example as tape-, disc- or head drives, the problem exists of being able to set up different operating states as rapidly as possible. Such operating states consist of speeds, torques or a combination of the two. In order to change the speed and/or the torque it is basically possible to change the current through the windings from a first value to a second value. The speed or torque of the motor then asymptotically approximates the target speed or target torque predetermined by the winding current.

An improvement can be achieved if, during the acceleration or deceleration phase in the case of changes in speed or in the load-change phase in the case of changes in torque, firstly a current which substantially overshoots or undershoots the stationary value is fed in. When the final value of the speed or torque has been reached, the current through the windings is then changed to the stationary value corresponding to the altered operating state.

Although this procedure brings about a substantial improvement, with increasing demands on the speed and accuracy of the devices it is no longer adequate.

Therefore the aim of the invention is to improve upon the process referred to in the introduction inasmuch as for the control of motors improved acceleration or deceleration values and faster reactions to changes in load can be achieved than would be possible by changing the winding current exclusively in terms of amount.

This aim is fulfilled in a process according to the preamble of Claim 1 by the features described in the characterising clause.

The document DE-OS 20 52 694 has disclosed circuit devices for an electronically commutated d.c. motor by means of which the torque-speed characteristics of the motor - the dimensions of which have already been specified - can be electronically altered in that the duration of the energizing- or load pulses and their delay in relation to sampling pulses, obtained by means of sensors coupled to the motor, are regulated by electrical variables, for example in dependence upon the speed and/or torque of the motor and in dependence upon a signal proportional to the speed and/or torque.

The invention is based on the following considerations:

In order to achieve a high level of efficiency of the electronically commutated motor, the commutation time is contrived such that the magnetic field, which builds up and decays as a result of the commutation current, can exert a maximum attraction and repulsion force upon the poles of the motor. When the motor is in the stationary state the winding impedance comprises a strongly inductive component. Therefore the magnetic field builds up and decays slowly. To enable the magnetic field to reach a maximum precisely when the position of the poles permits a maximum attraction and repulsion force, the commutation time is set substantially prior to the time at which the position of the poles permits this maximum attraction and repulsion force.

When the motor is loaded, thus for example during the acceleration phase or in the case of a change in load, the ohmic portion of the winding impedance increases with the result that the magnetic field builds up and decays more

rapidly. Retaining the commutation times which apply to the no-load state or stationary operation, this would lead to a shift in the time maximum of the magnetic field compared to the time at which a maximum attraction and repulsion force is obtained. Consequently the attraction and repulsion force exerted upon the poles can no longer exert an optimal effect.

If the commutation times are now adjusted such that the time maximum of the magnetic field coincides with the position of the poles for the attainment of a maximum attraction and repulsion force, improved efficiency is also achieved during the acceleration phase or a change in load, i.e. the energy which is used leads to an improvement in the acceleration and a faster reaction in the event of load changes.

The invention further relates to a device for controlling an electronically commutated motor in accordance with the preamble of Claim 3.

In this respect the aim of the invention is to improve upon the device inasmuch as for the control of motors improved acceleration- or deceleration values together with faster reactions to changes in load can be achieved than would be possible by changing the winding current exclusively in terms of amount.

This aim is fulfilled in the case of a device according to the preamble of Claim 3 by the features described in the characterising clause.

Further developments and advantageous embodiments of the invention are described in the claims, the continued description and the drawing which illustrates an exemplary embodiment.

In the drawing:

Fig. 1 is a diagram of the winding current plotted over the time for different drive situations;

Fig. 2 is a diagram of the motor speed plotted over the time for the drive situations illustrated in Figure 1 and the drive situation according to the invention;

Fig. 3 is a diagram of the commutation time plotted over the time and

Fig. 4 shows a circuit arrangement for the implementation of the process according to the invention.

In Fig. 1 curve A shows a drive situation in which the winding current through the motor winding is increased from a first stationary value to a second stationary value. The course of the motor speed, which likewise changes as a result of the change in the winding current, has been shown in Fig. 2, likewise in curve A. As can be seen from the curve, in this drive situation the speed changes only very slowly. The target speed is reached only after a very long period of time.

A different drive situation is shown in Fig. 1 as curve B. In this case during the acceleration phase firstly the current is increased substantially above the stationary final value and when the target speed is reached is then reduced to the second, i.e. the stationary value.

The reaction of the motor speed to this drive situation is represented by the curve B in Fig. 2. This shows that now the stationary elevated speed is reached substantially faster. However, an increase in the acceleration behaviour by an extreme increase in the winding current is subject to practical limits, i.e. the magnetic saturation in the iron, the limited heat dissipation of the winding, the capacity of

the current supply and the disturbing effects of the current peaks upon adjacent assemblies.

A further improvement in the acceleration without the previously described disadvantages is achieved, however, in that, in accordance with Fig. 3, the commutation time is additionally changed during the acceleration phase. In this case the diagram shown in Fig. 2 illustrates, in the form of curve C, that the motor speed now reaches its stationary target value more rapidly than in the drive situation corresponding to curve B.

Fig. 4 illustrates the principle of a circuit according to the invention. A sensor device, consisting in particular of a sensor disc 1, connected to the rotor of the motor and provided with marks 2, and of a sensor 3, taps signals which are used for the commutation and fed to a commutation circuit 4. The commutation circuit 4 in turn switches on and off controllable end stages 12, 13, 14 which supply motor windings 5 with a variable current. The commutation circuit 4 is set at fixed commutation times which produce an optimal efficiency of the motor only in one single operating state.

Also provided is a computer 6 which controls the end stages 12, 13, 14 in dependence upon the signals tapped by the sensor. This computer 6 could also simulate the commutation circuit 4 which here has been shown separately.

In accordance with the invention, a variable delay element, for example in the form of a shift register 7, is arranged between the sensor 3 and the commutation circuit 4. The shift register 7 possesses a control input 8 via which the delay time can be influenced by means of a correcting variable. The correcting variable is obtained by means of a control circuit 9 from a control variable via a control

characteristic quantity or, in the case of a sequence of characteristic quantities, via a control characteristic curve. The function of these assemblies could also be assumed by the computer 6.

The variable current with which the motor windings 5 are fed can be utilized for example as control variable. It is also conceivable to measure the torque obtained from the rotor and to determine a control variable therefrom.

The relationship between the control variable and the correcting variable, namely the control characteristic quantity or the control characteristic curve, can be determined in a series of tests for different operating situations. The advantage of empirical determination consists in that all the motor characteristics are automatically taken into consideration and therefore it is unnecessary to estimate and calculate the influences of these motor characteristics.

In such a series of tests the motor to be used or a motor of the same construction type is accelerated or decelerated at different commutation times or subjected to different loads at the same speed. From the determined acceleration values and load values the optimal commutation times are selected, these being associated with corresponding correcting variables of the control circuit 9.

In accordance with a further development, this series of tests can also be carried out at the final location of use of the motor. For this purpose a measuring circuit 10 is then used which at predetermined intervals of time or in the event of a change in the values due to ageing or maladjustment undertakes the appropriate measurements and then transmits the determined control characteristic quantity or control characteristic curve to the control

circuit 9. The value of the control characteristic quantity or the values of the control characteristic curve previously stored therein are overwritten with the updated values. In practice these circuits can also be formed by means of a programme-controlled computer 6.

Even better results can be achieved if a correcting circuit 11 is provided, which analyses measured values of the measuring circuit 10 and transmits correcting signals to the control circuit 9. The correcting circuit 11 stores the acceleration- and/or deceleration values obtained from the measuring circuit 10. In the event of deviations from the original maximum values, provisional correcting signals are transmitted to the control circuit 9 which in response also stores altered acceleration- and/or deceleration values later determined by the measuring circuit 10. By comparing the stored values of numerous previous series of measurements, for example the tendency of the effects in the case of the ageing of the components can be detected. From this, a corrected control characteristic quantity or control characteristic curve, which latter is valid for a longer period of time, is extra- or interpolated and transmitted as correcting signal to the control circuit 9.

With a self-learning circuit of this kind it is unnecessary to provide separate recording of corresponding measured values which inevitably leads to an - albeit drastically reducible - down time for the user. The optimal values are obtained individually for each motor of a series after a specific build-up time. The advantage is also obtained that ageing influences, which would impair a setting made at the factory, can be automatically taken into consideration and compensated for. Should a sudden impairment ever occur, for example due to rough transport of the device, this is also recognised immediately after the start-up of the device and corrective measures are immediately commenced.



1. A process for controlling an electronically commutated motor by controlling the winding current, wherein in an acceleration-, deceleration- or load phase the winding current is firstly changed beyond a stationary value assigned to a target speed or a load situation and when the target speed or the stationary load state is reached is set at the stationary value and wherein in the acceleration-, deceleration- and/or load phase additionally the commutation time of the winding current is changed in dependence upon a control characteristic quantity or control characteristic curve which predetermines the acceleration, deceleration and/or load, characterised in that the control characteristic quantity is defined on the basis of motor characteristics in that acceleration-, deceleration- and/or load values of the motor are determined in the case of different control characteristic quantities and the value(s) of the control characteristic quantity for maximum acceleration-, deceleration- and/or load values is/are transferred as operating values of the control characteristic quantity or control characteristic curve, where the determination of the value or values of the control characteristic quantity takes place automatically following each switching on of the device which contains the motor and/or at predetermined intervals of time and/or in the event of a change in the values due to ageing or maladjustment.

2. A process as claimed in Claim 1, characterised in that the acceleration-, deceleration- and/or load values of the motor are monitored, that in the event of deviations from the original, maximum values the operating values of the control characteristic quantity or control characteristic curve in normal operation are changed and the resultant changes in the acceleration-, deceleration- and/or load



values of the motor are detected and stored, and that by comparing the stored values a corrected control characteristic quantity or control characteristic curve is extra- or interpolated.

3. A device for controlling an electronically commutated motor, comprising a sensor (1, 2, 3) which taps signals to be used for the commutation, a commutation circuit (4), controllable end stages (12, 13, 14) which are switched by the commutation circuit (4) and supply a variable current to motor windings (5), a variable delay element (7), which is electrically connected to the sensor (1, 2, 3) and the commutation circuit (4), with a control input (8) via which the delay time of the commutation can be controlled by means of a correcting variable, and with electronic circuit means for acquiring the correcting variable for the control of the delay time, characterised in that the variable delay element (7) is arranged between the sensor (1, 2, 3) and the commutation circuit (4), that a control circuit (9) is provided which, from a control variable which predetermines the acceleration, deceleration and/or load of the motor, supplies the correcting variable to a control input (8) of the delay element (7), where the control variable consists of a quantity derived from the theoretical current and the actual current through the winding, that the control circuit (9) acquires the correcting variable from the control variable in dependence upon a stored control characteristic quantity or control characteristic curve, and that a measuring circuit (10) is provided which at predetermined intervals of time or in the event of a change in the values due to ageing or maladjustment automatically determines acceleration-, deceleration- and/or load values of the motor in the case of different control characteristic quantities and transfers the value or values of the control characteristic quantity for maximum acceleration-, deceleration and/or load values as operating values of the



control characteristic quantity or control characteristic curve to the control circuit (9).

4. A device as claimed in Claim 3, characterised in that a correcting circuit (11) is provided which stores the acceleration-, deceleration- and/or load values determined by the measuring circuit (10), in the event of deviations from the original, maximum values transfers temporary correction signals to the control circuit (9), likewise stores the changed acceleration-, deceleration- and/or load values determined by the measuring circuit (10), and by comparing the stored values extra- or interpolates a corrected control characteristic quantity or control characteristic curve and transfers operation correcting signals to the control circuit (9).