The concepts for cooling electric motors of separators according to the prior art have proven themselves in practice. The disadvantage of these concepts is that the coolant consumption is still quite high.

The object of the invention is to solve this problem.

The disclosure achieves this object by the method as defined herein.

A method is provided for controlling the coolant temperature of an electric motor of a drive device of a rotor of a centrifuge, in particular a separator with a vertical axis of rotation, in particular during execution of a centrifugal separation of a suspension into at least two different product phases; wherein the rotor of the centrifuge has at least one rotatable drum, and wherein the drive device has an electric motor which directly or indirectly rotates the rotor, and wherein the drive device further has an apparatus for supplying the electric motor with a coolant, which comprises a control apparatus, wherein the method comprises at least the following steps of:

a) providing the centrifuge with the drive device;
b) driving the rotor with the electric motor, in particular during execution of the centrifugal separation of a suspension into at least two different product phases, and
c) controlled cooling of the electric motor at least during step b) for a limited cooling phase in cycles interrupted by breaks.

In one aspect, the disclosure provides a method for controlling the coolant temperature of an electric motor of a drive device of a rotor of a centrifuge, preferably of a separator with a vertical axis of rotation, in particular during execution of a centrifugal separation of a suspension into at least two different product phases; wherein the rotor has at least one rotatable drum, and wherein the drive device has an electric motor which directly or indirectly rotates the rotor, and wherein the drive device further has an apparatus for supplying the electric motor with a coolant, which comprises a control apparatus, **characterized by** at least the following steps of:

a) providing the centrifuge with the drive device;
b) driving the rotor with the electric motor, in particular during the centrifugal separation of a suspension into at least two different product phases, and
c) controlled cooling of the electric motor at least during step b) for a limited cooling phase in cooling cycles interrupted by breaks.

It can also preferably be provided that the length of the cooling phase of a respective cycle is calculated by the control apparatus taking into account one or more measured values, wherein the at least one measured value or the several measured values can be measured temperature values.

Cooling in cycles generally significantly reduces coolant consumption compared to continuous cooling. In a cooling system that is set up as a circuit, it is possible to work with a reduced coolant volume per time or less coolant is moved in the circuit.

According to a particularly advantageous variant, the cycles of step c) comprise the following sub-steps of:

c1) opening an opening valve of the coolant supply system to generate a flow of coolant through a cooling fluid system of the electric motor, which has at least one coolant supply line and one coolant discharge line as well as a motor coolant passage;

c2) measuring an instantaneous temperature of the coolant T_{inst} after a predetermined time t_{meas} has elapsed at the coolant discharge line by a temperature measuring device and transmission of the measured value for T_{inst} to a control apparatus, wherein the predetermined time t_{meas} is determined as a function of a length of the coolant discharge line between the electric motor and the temperature measuring device;

c3) comparing the measured value of T_{inst} with an upper limit value of the coolant temperature T_{limit};

c4) calculating a time t_{cool} by the control apparatus as a function of T_{inst}, during which the opening valve also remains open;

c5) closing the opening valve after t_{meas} and t_{cool} have elapsed for a cycle pause time t_{pause};

whereupon the method steps c1) to c5) are run through again virtually endlessly in the manner of a program loop after t_{pause} has elapsed until the drive motor of the centrifuge stops operating.

This results in the following total cycle time: $t_{cycle} = t_{meas} + t_{cool} + t_{pause}$

This creates a method for monitoring and controlling the coolant temperature of a centrifuge, in which the instantaneous coolant temperature can be kept as constant as possible at a defined upper coolant temperature limit. In this way, the electric motor of the separator is operated at the maximum permissible temperature and the lowest possible coolant consumption, regardless of its load, the ambient temperature and the temperature of the incoming coolant.

A further advantage of the method according to the disclosure or a separator with a correspondingly equipped control apparatus is that it can be easily retrofitted to existing coolant-cooled electric motors, as basically only the temperature measuring device on the coolant discharge line needs to be added on the hardware side. A temperature sensor inside the electric motor is not required, although it may be provided. In addition, only a simple valve with two switching positions ("open" and "closed") is required as an opening valve. Therefore, no control valve or controllable iris diaphragm is required, nor

are several valves and lines, as in prior art solutions.

A computer program product is also stored and executed on the control apparatus or other memory connected or connectable thereto, comprising instructions which cause the method steps of the method for cooling the electric motor in cycles, in particular the method steps as described herein, to be executed on the separator for cooling the drive device.

According to a particularly preferred example variant of the disclosure, it is provided that the opening valve is closed immediately after the time period t_{meas} when the instantaneous coolant temperature T_{inst} is below an upper limit value of the coolant temperature T_{limit}. This allows the coolant to absorb thermal energy up to a defined upper limit temperature for the coolant, whereby the required coolant volume flow can be advantageously reduced.

According to a further particularly preferred example variant of the disclosure, it is provided that the opening valve remains open for a further time t_{cool} if the instantaneous coolant temperature T_{inst} is greater than or equal to the upper limit value of the coolant temperature T_{limit}. As a result, an increased coolant temperature is lowered to a defined upper limit temperature for the coolant, while at the same time advantageously minimizing the coolant volume flow required for this.

Furthermore, according to a further particularly preferred example variant of the disclosure, it may be provided that a correlation table of the measured values of T_{inst} and t_{cool} is determined experimentally, resulting in a centrifuge-specific or coolant supply system-specific characteristic curve which represents the relationship between T_{inst} and t_{cool}, so that a coolant temperature control is designed as a type of characteristic curve control. This results in an advantageously simple operating principle for coolant control, which can be individually adapted to the respective separator.

Alternatively, according to a further particularly preferred example variant of the disclosure, it may be provided that in step c) one or more measured values of the instantaneous coolant temperature T_{inst}, and preferably additionally one or more measured values of the ambient temperature and one or more instantaneous motor load characteristic values, are supplied to the control apparatus - in particular to a

higher-level control device of the separator - whereupon the control apparatus determines a cooling time t_{cool} with the aid of these measured values according to an algorithm. If the coolant temperature does not change in the desired direction after several subsequent cooling cycles, the algorithm is adapted by the control apparatus, preferably by the higher-level control device, until the coolant temperature is set to the value T_{limit}. This adaptability of the algorithm means that the control system can adapt particularly well to changing operating conditions.

Alternatively, according to a further particularly preferred example variant of the disclosure, it may be provided that a PID controller can be used as the control apparatus. This allows the coolant temperature to be monitored and controlled in a particularly flexible manner.

The disclosure can be used constructively in various cooling system variants.

Likewise, according to a further particularly preferred example variant of the disclosure, it may be provided that the coolant supply system is designed according to the principle of a closed coolant circuit.

According to a further particularly preferred example variant of the disclosure, it is provided that the coolant is pumped in the circuit with the aid of a pump and cooled with a heat exchanger and the required cooling capacity is supplied to the heat exchanger via a refrigeration circuit.

Furthermore, according to another particularly preferred example variant, it may be provided that the coolant can be taken from a storage tank and pumped back into the storage tank after flowing through the electric motor and absorbing heat. This creates an open circuit to which coolant can be added or removed as required. This is advantageous for short peak loads, for example. Coolant consumption is also effectively minimized with this variant.

In this context, according to a further preferred example variant, it may be provided that the heat absorbed by the coolant is released back to the surroundings of the storage tank by convection via a wall of the storage tank. This effectively minimizes a possible coolant refill volume, thereby advantageously saving coolant.

It is particularly advantageous if the wall of the storage tank is equipped with suitable means to improve convective heat dissipation. This further effectively minimizes any possible coolant refill volume, thereby saving coolant.

The disclosure also provides a separator comprising a control apparatus and other means adapted to perform the steps of the method as described herein. It also provides a computer program product comprising commands or instructions which cause the separator as defined herein to perform the method steps as defined herein. A computer readable medium is also created on which the computer program is stored.

Further advantageous designs of the disclosure can be found as described herein.

In the following, the invention is described in more detail with reference to the drawing by means of exemplary embodiments. The invention is not limited to these exemplary embodiments, but can also be realized in other ways according to the wording or in other equivalent ways, wherein:

Fig. 1 shows a schematic sectional view of a separator with a coolant supply system for the drive motor;
Fig. 2 shows a simplified circuit diagram of a coolant supply system for a separator;
Fig. 3 shows an embodiment variant of the coolant supply system from Fig. 2;
Fig. 4 shows a further embodiment variant of the coolant supply system shown in Fig. 2; and
Fig. 5 shows a flow chart illustrating an exemplary method according to the invention; and
Fig. 6 shows a further flow diagram illustrating sub-steps from Fig. 5.

Several exemplary embodiments are described in the following description of the figures. The individual features of these exemplary embodiments can also be combined with exemplary embodiments not shown and are also suitable in each case as advantageous designs of the objects described in one or more of the main and sub-claims.

Fig. 1 shows a centrifuge, which can be designed as a separator 1. The centrifuge - in

CLAIMS

1. Method for controlling the coolant temperature of an electric motor of a drive device of a rotor of a centrifuge, preferably of a separator with a vertical axis of rotation, in particular during execution of a centrifugal separation of a suspension into at least two different product phases; wherein the rotor has at least one rotatable drum, and wherein the drive device has an electric motor which directly or indirectly rotates the rotor, and wherein the drive device further has an apparatus for supplying the electric motor with a coolant, which comprises a control apparatus, **characterized by** at least the following steps of:
   a) providing the centrifuge with the drive device;
   b) driving the rotor with the electric motor, in particular during the centrifugal separation of a suspension into at least two different product phases, and
   c) controlled cooling of the electric motor at least during step b) for a limited cooling phase in cooling cycles interrupted by breaks.

2. Method according to claim 1, characterized in that the length of a respective cooling phase is determined by the control apparatus taking into account one or more measured values.

3. Method according to claim 2, characterized in that the length of a respective cooling phase is determined by the control apparatus taking into account one or more measured temperature values.

4. Method according to claim 1, characterized in that the cooling cycles of step c) comprise the following sub-steps of:
   c1) opening an opening valve of the coolant supply system to generate a flow of coolant through a cooling fluid system of the electric motor , which has at least a coolant supply line and a coolant discharge line as well as a motor coolant passage;
   c2) measuring an instantaneous temperature of the coolant T_{inst} after a predetermined time t_{meas} has elapsed at the coolant discharge line by a temperature measuring device and transmission of the measured value of the instantaneous temperature of the coolant T_{inst} to a control apparatus , wherein the predetermined time t_{meas} is determined as a function of a length of the coolant discharge line between the electric motor and the temperature measuring device;

c3) comparing the measured value of the instantaneous temperature of the coolant T_{inst} with an upper limit value of the coolant temperature T_{limit};

c4) calculating a time t_{cool} by the control apparatus as a function of the instantaneous temperature of the coolant T_{inst}, during which the opening valve also remains open;

c5) closing the opening valve after the specified time t_{meas} and the time t_{cool} have elapsed for a cycle pause time t_{pause};

whereupon the method steps c1) to c5) are run through again in the manner of a program loop after the cycle pause time t_{pause} has elapsed until the electric motor stops operating.

5. Method according to claim 4, **characterized in that** in step c5) the opening valve is closed immediately after the time period t_{meas} if the instantaneous coolant temperature T_{inst} is below an upper predetermined limit value of the coolant temperature T_{limit}.

6. Method according to claim 4, **characterized in that** the opening valve remains open for a further time t_{cool} when the instantaneous coolant temperature T_{inst} is above the upper predetermined limit value of the coolant temperature T_{limit}.

7. Method according to one of the preceding claims, **characterized in that** a correlation table of the measured values of T_{inst} and t_{cool} is determined experimentally, resulting in a centrifuge or coolant supply system-specific characteristic curve which represents the relationship between T_{inst} and t_{cool}, so that the coolant temperature control is designed as a characteristic curve control.

8. Method according to one of claims 1 to 7, **characterized in that** a PID controller is used as the control apparatus.

9. Method according to one of the preceding claims, **characterized in that** the control apparatus is supplied in step c) with one or more measured values of the instantaneous coolant temperature T_{inst}, and preferably additionally with one or more measured values of the ambient temperature and one or more instantaneous motor load characteristic values, whereupon the control apparatus uses these measured values to determine a cooling time t_{cool} according to an algorithm, wherein if the coolant temperature does not change in a desired direction after several subsequent cooling cycles, the algorithm is adapted by the control

apparatus until the coolant temperature adjusts to the value T_{limit}.

10. Method according to one of the preceding claims, **characterized in that** the coolant supply system is designed according to the principle of a closed coolant circuit.

11. Method according to claim 10, **characterized in that** the coolant is pumped in the circuit with the aid of a pump and cooled with a heat exchanger and the required cooling capacity is supplied to the heat exchanger via a refrigeration circuit.

12. Method according to one of claims 1 to 9, **characterized in that** the coolant is taken from a storage tank and, after flowing through the electric motor and absorbing heat, is pumped back into the storage tank.

13. Method according to claim 12, **characterized in that** the heat absorbed by the coolant is released again to the surroundings of the storage tank by convection via a wall of the storage tank.

14. Method according to one of claims 12 to 13, **characterized in that** coolant which is too hot can be discharged from the storage tank via a first line and cold coolant can be fed into the storage tank via a second line.