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San Francisco 220 Montgomery Street Ste. 438, San Francisco CA 94104 U.S.A tel +1.415.576.9500 fax +1.415.520.0525
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London 8-11 St. John's Lane, London EC1M 4BF, United Kingdom Tel +44.20.7553.4100 Fax+44.20.7990.9909
Paris 75 Boulevard Haussmann, F- 75008 Paris, France tel +33.1.42.68.51.47 fax +33.1.77.72.90.25
Hong Kong 20th Floor, Central Tower, 28 Queen's Road, Central, Hong Kong tel +852.2159.9143 fax +852.3010.0082
translations@geotext.com | www.geotext.com

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(71) Applicant:

Robert Bosch GmbH, 7000 Stuttgart, DE; Reitter & Schefenacker KG, 7300 Esslingen, DE; Domatic GmbH, 7034 Gaertringen, DE

(72) Inventors:

Lamm, Hubert, 7594 Kappelrodeck, DE; Kiefer, Stefan 7601 Ortenberg, DE; Knecht, Gerhard, 7557 Iffezheim, DE; Mau, Gert, 7042 Aidlingen, DE; Zottmaier, Rainer, Dr., 7300 Esslingen, DE

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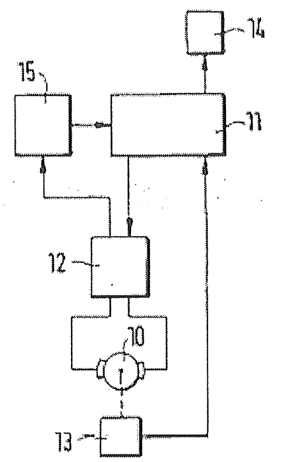
(54) Method and device for operating power-actuated components which pose a clamping hazard

(57) The invention relates to a method and a device for operating power-actuated components which pose a clamping hazard to objects or body parts of people, wherein at least one derivative of a parameter is determined with respect to the path traveled by the component, said parameter having a relation to the force of actuation of the component. If at least one threshold value is exceeded, the device is switched off or the direction of movement is reversed.






**DE 40 00 730 A 1**

Description

Prior art

The invention relates to a method and device for operating power-actuated components which pose a clamping hazard to objects or body parts of people.

A method for the electronic monitoring of opening and closing processes of electrically-operated window lift motors and sunroofs in vehicles is known from DE-PS 30 34 118. The path traveled by the moving component during the opening and closing process is divided into multiple regions. In a first and third region, the electric motor is switched off as soon as a time limit is reached when a blocking state arises, wherein the same is determined by a detection of the rotary speed of the drive. In a second region, measured values which are dependent on the rotary speed or on the speed of the moving component, or of the drive motor, are continuously determined during the closing process, and compared to a threshold value related to an initial measured value at start. If the threshold is exceeded, the drive direction of the electric motor is briefly reversed, and then the drive is switched off. The path traveled by the moving component is determined by integration of a rotary speed signal in a device which processes signals.

The invention addresses the problem of providing a method and device for the operation of power-actuated components, to reliably detect the clamping of objects or persons by the component in all operating conditions, and to immediately initiate counter measures.

Advantages of the invention

In the method and the device according to the invention, first a parameter is detected which has a relation to the actuating force of the component, and of the path traveled by the component. Next, at least one derivative of the profile of the parameter with respect to the path of travel is determined. The term ‘derivative’ means the determination of the differential quotient using analog calculations, and the determination of a difference quotient using digital calculation. If a threshold value is exceeded which is pre-specified for the result of the at least one derivative, this leads to the component being switched off and/or to the reversal of the direction of movement.

The determination of the first derivative is enough to allow the recognition of a clamping occurrence with high reliability. The additional or alternative determination of higher derivatives, preferably at least of the second derivative, further increases the detection reliability, because changes influence the result more strongly than in the first derivative. If more than one derivative is determined, then each result is compared to its own threshold value, wherein the threshold values can be different. The component is switched off, or the direction of movement thereof is reversed, if at least one threshold value is exceeded. The method and the device according to the invention have the advantage that the speed of the actuated component need not be taken into account. The speed of the component can therefore change within wide boundaries over the complete



path of travel, as long as the result of at least one derivative does not exceed the pre-specified threshold.

The method and the device according to the invention are suitable for the operation of sliding doors and other stationary, power-actuated components which pose a clamping hazard to objects or body parts of people. [They are] particularly suitable for the operation of sliding sunroofs, window lift motors, door closing mechanisms, and seatbelt positioning devices in vehicles. [They are] particularly advantageous when used for power-actuated hand tool machines in assembly processes. [They are] further suitable for the operation of rolling shutters and access gates, and particularly parking spot placeholder devices.

Implementations and improvements of the method and of the device according to the invention are found in the dependent claims. In cases where more than one derivative—for example the first and the second—is calculated, there is a simplification resulting from combining the results of the derivatives, and subsequently comparing [the combined results] to a threshold value. A combination of the results can be performed, by way of example, by addition, wherein the sum is compared to the threshold value.

In one particularly advantageous implementation of the method and of the device according to the invention, multiple determinations are made of at least one derivative, with respect to different paths of travel. It is possible to make an adjustment by means of this measure for different objects or body parts of people, wherein the invention aims to prevent the clamping of the same. The differing density of objects or body parts leads to hard or correspondingly soft clamping processes which are revealed by different changes in the parameters with respect to the path of travel. A determination set for a hard clamping of at least one derivative would, for example, not recognize a soft clamping. Thus, in further development, the start of the clamping of various objects will be able to be identified as quickly as possible. In each case, calculating the first derivatives is already sufficient. It is possible here as well to increase the reliability of detection by determining higher derivatives—preferably the first and second derivative. The results of the multiple calculations of the derivatives running in parallel are each compared to a threshold value. If the first and/or higher derivatives are likewise determined, separate threshold values are provided for these results as well.

In implementations of the method where different derivatives are determined, a combination of the first and/or higher derivatives is possible as well, along with a subsequent comparison to a single threshold value. As such, for the calculations running in parallel, only as many threshold values need be provided as calculations are carried out.

In one practical embodiment, the threshold values are determined adaptively by means of clamping tests. With this measure, it is possible to pre-specify optimum threshold values of each individual component.

A further improvement of the method and of the device according to the invention relates to a division of the entire path of travel of the component into multiple subregions, wherein a threshold value is assigned to each of the same.

The division into multiple subregions enables the incorporation of different dimensions of objects or body parts of people.

A signal filter during the detection of the profile of the parameter increases the reliability of the method and of the device in the presence of mechanical influences on the component, such as shaking and the resulting high-frequency interference signal components, by way of example. High-frequency interference signals would have an effect in the determination of higher derivatives, and potentially falsify the appearance of a clamping occurrence.

The method according to the invention can be realized in a particularly simple manner if the rotary speed of the drive of the component is used as the parameter, and is detected by a sensor. The path traveled by the component can then be calculated in a simple manner by means of integration of the rotary speed signals.

A further improvement of the method and the device according to the invention is possible by pre-specifying a minimum rotary speed, wherein the component is switched off or the direction of movement thereof is reversed if the rotary speed drops below this minimum speed. The additional monitoring of a minimum rotary speed also rules out [sic] the prevention of the clamping of objects or body parts of people when the determination of at least one derivative is no longer possible because the rotary speed is too low to make it possible to detect a significant change.

A simple realization of the component is possible with an electric motor drive.

In one particularly advantageous implementation of the method and of the device according to the invention, where an electric motor drive is used, the detected rotary speed is corrected according to the operating voltage. A change in the rotary speed can be caused both by a clamping and by a change in the operating voltage, wherein it would not be possible to differentiate between both causes in a signal-processing device without the corresponding correction of the detected rotary speed according to the operating voltage, with no other input. This correction is particularly simple when a direct current motor drive is used, because a change in the operating voltage results in a parallel shift of the linear rotary speed – rotary torque characteristic curve in the region of interest, where the increase in the rotary speed in the working range being observed has a linear relationship to the change in the operating voltage. The correction value is then dependent on the measured voltage which is multiplied by a constant value.

Additional details and advantageous embodiments of the method and of the device according to the invention are found in additional dependent claims in combination with the following description.

## Figures

**Fig. 1** shows a block diagram of a drive of a power-actuated component, and **Fig. 2** shows a functional relationship between rotary speed and rotary torque of a direct current electric motor at different operating voltages.

**Fig. 1** shows an electric motor **10** which is controlled by a signal-processing device **11** via a motor driver circuit **12**. A sensor **13** detects the rotary speed of the motor **10** and relays the same to the signal-processing device **11**. The device **11** is given commands for the control of the motor **10** via an operating device **14**. In addition, the device **11** can give signals to the operating device **14**, and these are then displayed by the same, for example. As a further input variable, the operating voltage of the electric motor **10**, detected by a voltage meter **15**, is fed to the device **11**, wherein, for example, the operating voltage can be detected from the motor driver circuit **12**. The electric motor **10** drives a component which is not illustrated but which poses the danger of clamping objects or body parts of people.

**Fig. 2** shows a functional correlation between the rotary speed n and the rotary torque M of a direct current motor. Three characteristic curves **16** are included which apply to different operating voltages U of the electric motor **10**.

The methods and the device according to the invention for operating power-actuated components which pose a clamping hazard to objects or body parts of people is described in greater detail using the block diagram shown in **Fig. 1**, and the functional relationship shown in **Fig. 2**:

The electric motor **10** drives an actuated component which is not shown in the figure and which poses a clamping hazard. In place of the electric motor **10** shown in **Fig 1**, a pneumatic or hydraulic drive can be included for the component. The detection of a parameter which has a relationship to the force of actuation of the component is essential. The sensor **13** in **Fig. 1** is included for this purpose, detecting for example the rotary speed n of the motor **10**. In place of the motor rotary speed, another rotary speed can be detected—for example at a gearbox. At a given rotary speed n, a specific rotary torque M and therefore a force of actuation can be obtained using the characteristic curve in **Fig. 2**. The functional relationship shown in **Fig. 2** also applies for a direct current electric motor, wherein the operating voltage U is incorporated as the parameter for the three different characteristic curves **16** included.

At least one derivative with respect to the path traveled by the component is determined from the profile of the parameter in the signal-processing device **11**. If the rotary speed of the drive **10** is used as the parameter, the path traveled can be obtained by an integration of the rotary speed signal. At least one derivative is continuously determined during the operation of the component, and the result is compared to a pre-specifiable threshold. If the threshold is exceeded, the device is switched off or the direction of movement of the drive **10** is reversed. The first derivative is preferably determined. In addition or as an alternative, higher derivatives, and preferably at least the second derivative, are determined. The incorporation of higher derivatives, optionally in addition to the first derivative, increases the reliability of the detection of a clamping occurrence, because changes in the profile of the parameter with respect to the path traveled are more evident at higher derivatives than in the first derivative.

If the determination of multiple derivatives is included, multiple threshold values can be pre-specified, wherein once a single threshold value is exceeded, the device is switched off or the direction of movement is reversed. If multiple derivatives are calculated, a simplification of the evaluation method is achieved by combining the results of the derivatives and making a comparison. A combination is realized, by way of example, by an addition of the results of the individual derivatives, and a subsequent comparison of the sums with a single threshold value.

The embodiment advantageously includes multiple determinations of at least one derivative with respect to different paths traveled by the component, wherein the results of the derivatives are each compared to a pre-specified threshold value. Using this measure, it is possible to take varying density of a clamped object or body part of a person into account. For example, if a comparatively strong drop in the parameter is detected, then it can be assumed that the start of a clamping of a hard object has occurred. Then, a very fast reaction to the start of the clamping occurrence is possible. When a clamping occurs of a softer object or body part of a person, the change of the parameter has the same amount as that for a hard object only over a longer section of the path traveled, with the consequence that the threshold determined for the hard clamping occurrence would not be reached. The calculation of at least one further derivative with respect to a further path, and the pre-specification of a separated threshold value in this case provides the solution. As a result, it is also possible to switch off the device as quickly as possible when a softer object is clamped.

In the case of this evaluation as well, it is possible to determine both the first and also higher derivatives. Separate threshold values are provided for the result of the first and/or each of the higher derivatives, wherein the device is switched off or the direction of the movement is reversed after a single threshold value is exceeded.

The pre-specification of different threshold values for different derivatives, as well as the pre-specification of a different set of threshold values for each of multiple determinations of the derivatives, running in parallel, with respect to the different paths involves a large number of thresholds which need to be pre-specified. For this reason, in one advantageous implementation, the results of different derivatives are combined into one single threshold. As such, the number of the thresholds which must be pre-specified corresponds to the number of the multiple derivatives, running in parallel, with respect to the different paths. The combination can be realized, by way of example, by an addition of the results of the different derivatives.

In general, higher derivatives are formed from the lower derivatives determined previously. In a further simplification of the method according to the invention, higher derivatives are determined—if this determination is included—for the smallest path in each case for which a lower derivative was already determined. Then, with multiple determinations, running in parallel, of derivatives with respect to different paths, it is possible to determine the higher derivatives in one calculation.

In one advantageous embodiment, there is an adaptive threshold determination in the signal-processing device **11**, wherein the one or the different thresholds are determined adaptively in the device **11** by using one or multiple test clamping processes. In this measure, manufacturing tolerances in the power-actuated components, as well as different geometric relationships for each individual component, are incorporated by means of optimally determining the threshold value.



A further embodiment includes the division of the path traveled by the component into multiple subregions, wherein different thresholds are assigned to each of these subregions. The further refinements of the method and of the device achieved in this manner produce advantages in the detecting of the start of the clamping occurrence, because it is possible to accordingly react more quickly to different dimensions of body parts or objects. In addition, a very wide range of change in force or change in speed of the actuated component is possible [sic] with this measure, wherein optimal thresholds can be determined for the different regions.

An optionally included signal filtering in the signal processing device **11** filters higher frequency interference from the detected parameter, which can be created by mechanical activity influencing the component. If the device is installed in motor vehicles, such interferences are caused by a roadway with potholes, for example. As such, the possibility of a faulty detection, particularly produced in the determination of higher derivatives, is reduced.

A further increase in the operating reliability is produced by the pre-specification of a minimum rotary speed, wherein the device is switched off or the direction of the movement is reversed upon the minimum rotary speed being exceeded. By way of example, an extremely low rotary speed occurs with a stiffness in the drive of the component. A derivative of a parameter with respect to the path is potentially no longer possible without a modification, due to the low change in the rotary speed. In addition, with this measure it is possible to detect a blocking of the drive or of the component at a point as early as the start of the movement from the component resting position.

In one advantageous implementation of the method and of the device according to the invention, there is a correction of the detected rotary speed of an electric motor or gearbox according to the operating voltage. The detected rotary speed is increased or lowered by a rotary speed correction value, which in turn is determined—for example in a memory device of the signal-processing device **11** for the operating voltages which are taken into account for the correction—from the stored functional relationship between the rotary speed and the rotary torque, or from a value which is proportional to the rotary torque which in turn depends on the measured rotary speed and the measured operating voltage at a given rotary torque. The rotary speed – rotary torque characteristic curve of the electric motor **10** needs to be known, wherein the operating voltage thereof is pre-specified as a parameter. In the case of a direct current electric motor **10**, therefore, the correction of the detected rotary speed is possible in a particularly simple manner from the measured operating voltage which is compared to a constant determined from the functional relationship shown in **Fig. 2**. A change in the operating voltage leads to a parallel shift of the linear rotary speed – rotary torque characteristic curve. In addition, the rotary speed has a linear dependence on the operating voltage at a fixed rotary torque. At a given rotary torque, the determination of the constant is possible with only two different rotary speeds. The functional relationship between the rotary torque M and the rotary speed n can be seen in the data sheet of the electric motor used. The rotary speed n can also be obtained with respect to an arbitrary intermediate stage inside the drive.

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