

Description

Title: Limitation of a machine by a system for capturing braking particles

5 **[1]** This invention relates to a system for capturing braking particles from a friction brake system of a machine, which comprises a vacuum source, a pneumatic circuit which connects the friction brake system to the vacuum source, and a filter located on the pneumatic circuit and mounted on a support.

10 **[2]** Such friction brake systems may equip road or rail vehicles. Such friction brake systems may also equip stationary rotor devices such as wind turbines or industrial machines.

15 **[3]** In such systems, there is provided a vacuum source (for example a suction turbine driven by a motor) which is connected by a pneumatic circuit to the friction brake system, and a filter for collecting particles emitted by the brake system. This filter is placed upstream of the vacuum source, and prevents the passage of particles through the vacuum source and their release into the atmosphere. However, in certain situations, this filter is clogged beyond a predefined acceptable threshold, or the filter clogging detection system does not work, for example because it is disconnected, deliberately or inadvertently. The operation of the machine is inefficient in these situations.

20 **Description of the invention**

[4] The invention aims to remedy these disadvantages.

25 **[5]** The aim of the invention is to propose a system for capturing braking particles which makes it possible to limit the operation of the vehicle, or of the stationary device, when the filter is clogged or when the filter clogging detection system does not work.

[6] This object is achieved due to the fact that the capturing system comprises a control unit, a control device for the machine, and a clogging detection device for the filter which is capable of sending at least one signal to the control unit when the filter is clogged, the control unit being capable of determining the clogging of the

filter, on the basis of this signal, and being capable of determining whether the detection device is inoperative, the control unit being capable of activating the control device to limit the operation of the machine when the filter is clogged or when the detection device is inoperative, and being capable of informing a user of the clogging of the filter.

[7] Due to these arrangements, a clogging of the filter on the pneumatic circuit is detected and determined, and in this case the operation of the machine is limited. In addition, the control unit is able to determine if the clogging detection device is inoperative, and to limit the operation of the machine in this case as well.

[8] Advantageously, the user is informed by the control unit of the clogging of the filter or of the malfunction of the detection device.

[9] Advantageously, the detection device comprises a pressure sensor which is located on the pneumatic circuit upstream of the filter, the detection device being capable of sending in a signal to the control unit a measurement of the pressure P_1 in the pneumatic circuit upstream of the filter, the control unit, upon receiving this signal, being capable of comparing the measured pressure P_1 with a reference pressure P_R which is the pressure in the pneumatic circuit for a determined clogging threshold of the filter for the reference operating state E_R of the vacuum source during the measurement of pressure P_1 by the pressure sensor, the control unit being capable of limiting the operation of the machine when the measured pressure P_1 is substantially equal to or greater than the reference pressure P_R .

[10] Clogging of the filter is thus reliably determined.

[11] Alternatively, the detection device comprises a first pressure sensor which is located on the pneumatic circuit upstream of the filter, the detection device being capable of sending in a signal to the control unit a measurement of the first pressure P_1 in the pneumatic circuit upstream of the filter, and a second pressure sensor which is located on the pneumatic circuit downstream of the filter, the detection device being capable of sending in a signal to the control unit a measurement of the second pressure P_2 in the pneumatic circuit downstream of the filter, the control unit, upon receiving the at least one signal, being capable of comparing the first measured pressure P_1 and the second measured pressure P_2 , the control unit being

capable of limiting the operation of the machine when the difference ($P_1 - P_2$) between the first measured pressure P_1 and the second measured pressure P_2 is substantially equal to or greater than a threshold pressure difference ΔP which corresponds to a determined clogging threshold of the filter.

5 **[12]** Clogging of the filter is thus reliably determined.

[13] The invention also relates to a machine comprising a capturing system according to the invention.

[14] The invention also relates to a method for detecting the clogging of a filter in a system for capturing braking particles from a friction brake system of a machine,
10 this capturing system comprising a vacuum source, a pneumatic circuit which connects the friction brake system to the vacuum source, and a filter located on the pneumatic circuit and mounted on a support.

[15] According to the invention, the method comprises the following steps:

- (a) A control unit, a control device for the machine, and a clogging detection device
15 for the filter are provided, which are part of the capturing system;
- (b) The control unit determines if the detection device is inoperative;
- (c) The detection device sends at least one signal to the control unit when the filter is clogged, if the detection device is operational;
- (d) The control unit determines whether the filter is clogged, on the basis of the
20 signal;
- (e) The control unit activates the control device to limit the operation of the machine when the filter is clogged or when the detection device is inoperative.

[16] Advantageously, the method further includes the following step:

- (f) The control unit notifies a user of the clogging of the filter or of the malfunction of
25 the detection device.

[17] The invention will be better understood and its advantages will be more apparent upon reading the following detailed description of some embodiments represented by way of non-limiting examples. The description refers to the accompanying drawings, in which:

30 **[18]** [Fig. 1] FIG. 1 is a schematic view of a capturing system according to the invention,

[19] [Fig. 2] FIG. 2 is a perspective view of a housing carrying a filter, and of a clogging detection device for this filter in the capturing system of FIG. 1,

[20] [Fig. 3] FIG. 3 is a perspective view of a housing carrying a filter, and of an alternative clogging detection device for this filter in the capturing system of FIG. 1.

5 **Detailed description of the invention**

[21] FIG. 1 schematically shows a system 1 for capturing particles according to the invention, these particles being emitted by a friction brake system 10.

[22] This friction brake system 10 comprises a brake pad 11 for braking a machine 90. This machine is either a vehicle or a stationary device. This pad 11
10 comprises a backing plate 12 and a lining 13 made of friction material fixed to the backing plate 12. In FIG. 1, the pad 10 is viewed from underneath, the backing plate 12 being in the foreground.

[23] The pad 11 (first pad) is facing a disc 9 which is driven in rotation by the machine 90, for example by the wheel of the vehicle when this machine is a vehicle.
15 A second identical pad (not visible) is located on the other side of the disc 9 and opposite the first pad 11 so that these two pads sandwich the disc 9. The braking of the disc 9 is achieved by friction of the two linings (13) against the disc 9 when these two pads approach the disc 9.

[24] The capturing system 1 comprises a pneumatic circuit 30 and a vacuum
20 source 20. The pad 11 and the second pad are connected to the vacuum source 20 via this pneumatic circuit 30. For example, the vacuum source 20 comprises an electric motor 21 and a suction turbine 22 which is driven by this electric motor 21.

[25] In operation, the vacuum source 20 is capable of suctioning in the particles upon their emission by the linings (13), through the pneumatic circuit 30. The
25 direction of circulation of the air and particles during normal operation is indicated by the arrow F in FIG. 1. The arrow F therefore indicates a flow from upstream to downstream. The capturing system 1 further comprises a filter 40 which is located on the circuit 30, meaning that the air which circulates within the circuit 30 passes through the filter. This filter 40 is mounted on a support 41 which is fixed to the pipe
30 30. For example, the support 41 is a housing which houses the filter 40 therein, as shown in the figures. The filter 40 thus separates the housing 41 into an upstream

portion and a downstream portion. The air coming from the upstream portion of the circuit 30 enters the housing 41 at the upstream end of the housing 41, passes through the filter 40, and exits the housing 41 at the downstream end of the housing 41 to enter the downstream portion of the circuit 30.

5 **[26]** The capturing system 1 further comprises a control unit 60, a control device 70 for the machine 90, and a detection device 50 for the filter 40. This control unit 60 and this detection device 50 are used to determine a clogging of the filter 40 beyond a certain clogging threshold. The control unit 60 receives signals from the detection device 50 (which comprises an element for generating and sending these
10 signals), and is also capable of controlling the vacuum source 20 and receiving information therefrom, and controlling the control device 70 for the machine 90. These interactions between the control unit 60, the control device 70, the detection device 50, and the vacuum source 20 are represented schematically in FIG. 1 by solid lines. These interactions may be implemented by electric lines. The operation
15 of this control unit 60, the control device 70, and this detection device 50 is described below.

20 **[27]** During operation of the capturing system 1, the detection device 50 sends at least one signal to the control unit 60 if the detection device 50 is operational. “At least one signal” is understood to mean the sending of either a continuous signal or a signal at regular intervals. This signal contains information which directly or indirectly concerns the clogging of the filter 40, i.e. a level of effective clogging of the filter 40. It is considered that the filter 40 is effectively clogged when the filter 40 is clogged beyond a certain clogging threshold, this threshold being predefined. The control unit 60 determines a clogging of the filter 40 on the basis of this signal, by
25 comparing the level of effective clogging of the filter 40 and the predefined clogging threshold.

30 **[28]** It is also possible that the detection device 50 is inoperative (operation malfunction). This is the case for example because it is defective, or because it is disconnected, deliberately or inadvertently. In this situation, the detection device 50 is not capable of detecting the clogging of the filter 40, and is not able to send a signal to the control unit 60. This absence of sending the signal occurs either as an interruption of the signal when this signal is continuous, or by an absence of sending

the signal at a time when it should have been sent, when this signal is periodic. Thus, an operating malfunction of the detection device 50 is determined by the control unit 60 based on the fact that the control unit 60 is no longer receiving a signal from the detection device 50.

5 **[29]** In the above two cases (case of clogging of the filter 40 beyond a certain clogging threshold, and case of an inoperative detection device 50), the control unit activates the control device 70 of the machine 90 to limit the operation of the machine 90, for example limiting the speed of rotation of a disk on which the friction
10 brake system 10 is mounted. In the case where the machine 90 is a vehicle, this limitation is a limitation of the vehicle's speed of movement. If the machine 90 is stationary, this operation limitation may be preventing the machine 90 from starting. In the case where the machine 90 is a vehicle, the vehicle then remains stationary.

15 **[30]** According to one embodiment, the control unit 60 informs a user of the clogging of the filter 40 (or of the operation malfunction of the control device 70). This information may be provided by any means, for example by displaying text on the dashboard of the vehicle such as "Filter clogged", "Filter detection inoperative", or a logo or an indicator light, and/or for example by stimulation of the user by vibrations via a vibratory system located in the seat and controlled by the control unit 60.

20 **[31]** An embodiment of the detection device 50 for the filter 40 is described below, with reference to FIG. 2. FIG. 2 is a more detailed view of the support 41, filter 40, and detection device 50.

25 **[32]** The detection device 50 comprises a (first) pressure sensor 51 which is located on the pneumatic circuit 30, upstream of the filter 40. Ideally, the pressure sensor 51 is located sufficiently close to the filter 40 so that the pressure measured by the pressure sensor 51 is identical to the pressure at the location where the filter 40 is, or where it would be if it were present. Thus, the pressure sensor 51 is located either on the pneumatic circuit 30 close to the support 41 of the filter 40, or in the support 41 of the filter 40 as represented in FIG. 2. "Located in the support 41" is
30 understood to mean that the pressure sensor is located on the support, or in the support if this support is a housing, and in all cases this sensor measures the pressure at the location of this support 41.

[33] The pressure sensor 51 is capable of measuring the (first) pressure P_1 in the pneumatic circuit 30 upstream of the filter 40, and the detection device 50 is capable of sending this measurement in a signal to the control unit 60. During this measurement, the vacuum source 20 operates in an operating state called the reference operating state E_R . This operating state is characterized by a parameter which is for example the speed of rotation V of the suction turbine 22. Thus, in the reference operating state E_R , the suction turbine 22 rotates at a speed of rotation V_R . The control unit 60 has a reference pressure P_R in memory, which is the pressure generated in the pneumatic circuit 30 for a determined clogging threshold of the filter 40 for the reference operating state E_R of the vacuum source 20. It is understood that this reference pressure P_R varies as a function of this reference operating state E_R . Thus, the reference pressure P_R varies as a function of the speed of rotation V_R of the turbine 22. The control unit 60, upon receiving the signal comprising the pressure P_1 measured in the pneumatic circuit 30, compares this measured pressure P_1 with the reference pressure P_R . This reference pressure P_R corresponds to the pressure in the pneumatic circuit 30 for a determined clogging threshold of the filter 40 for the reference operating state E_R of the vacuum source 20, and the measurement of the first pressure P_1 by the pressure sensor 51 is performed during this reference operating state E_R . Consequently, if the first pressure P_1 is substantially equal to or is greater than the reference pressure P_R , this means that the filter 40 is clogged above the clogging threshold. "Substantially equal" is understood to mean that the pressure is within a restricted interval around the reference pressure. For example, this interval is $\pm 1\%$, or $\pm 2\%$, or $\pm 5\%$, or $\pm 10\%$ of the reference pressure value. Thus, in the situation where P_1 is substantially equal to or greater than P_R , the control unit 60 limits the operation of the machine 90.

[34] A variant of this embodiment is described below, in which the detection device 50 comprises a second pressure sensor 52 in addition to the first pressure sensor 51. This variant is illustrated in FIG. 3. The first pressure sensor 51 is located upstream of the filter 40, on the circuit 30. The second pressure sensor 52 is located downstream of the filter 40, on the circuit 30. For example, the first sensor 51 and second sensor 52 are located in the support 41, as illustrated in FIG. 3. The first

pressure sensor 51 is capable of measuring a first pressure P_1 in the pneumatic circuit 30 upstream of the filter 40, and the detection device 50 is capable of sending this measurement in a signal to the control unit 60. In parallel, for example simultaneously, the second pressure sensor 52 is capable of measuring a second pressure P_2 in the pneumatic circuit 30 downstream of the filter 40, and the detection device 50 is capable of sending this measurement in a signal to the control unit 60. For example, the measurement of the first pressure P_1 and the measurement of the second pressure P_2 are sent in the same signal. The control unit 60, upon receiving this or these signals, is capable of comparing the first pressure P_1 with the second pressure P_2 . If the difference $(P_1 - P_2)$ between the first measured pressure P_1 and the second measured pressure P_2 is substantially equal to or is greater than a threshold pressure difference ΔP , this means that the filter 40 is clogged above the clogging threshold. The control unit 60 has in memory this threshold pressure difference ΔP , which is valid for the operating state of the vacuum source 20 during the measurements of the first pressure P_1 and second pressure P_2 . Thus, in the situation where $(P_1 - P_2)$ is substantially equal to or greater than ΔP , the control unit 60 limits the operation of the machine 90.

[35] The above embodiment and its variant may be combined. Thus, the control unit is capable of both comparing $(P_1 - P_2)$ with ΔP and comparing P_1 with P_R .

[36] The invention also relates to a machine comprising a capturing system 1 as described above.

[37] The invention also relates to a method for detecting the clogging of a filter 40 in a system 1 for capturing braking particles from a friction brake system 10 of a machine 90. As described above, this capturing system 1 comprises a vacuum source 20, a pneumatic circuit 30 which connects the friction brake system 10 to the vacuum source 20, and a filter 40 which is located on the pneumatic circuit 30 and which is mounted on a support 41. The method comprises the following steps:

- (a) A control unit 60, a control device 70 for the machine 90, and a detection device 50 for the filter 40 are provided, which are part of the capturing system 1;
- (b) The control unit 60 determines if the detection device 50 is inoperative;
- (c) The detection device 50 sends at least one signal to the control unit 60 when the filter 40 is clogged, if the detection device 50 is operational;

(d) The control unit 60 determines whether the filter 40 is clogged, on the basis of the signal;

(e) The control unit 60 activates the control device 70 to limit the operation of the machine 90 when the filter 40 is clogged or when the detection device 50 is inoperative.

[38] In addition, the method includes step (f) below, which immediately precedes or follows step (e):

(f) The control unit 60 notifies a user of the clogging of the filter 40 or of the malfunction of the detection device 50.

Claims

1. System (1) for capturing braking particles from a friction brake system (10) of a machine (90), which comprises a vacuum source (20), a pneumatic circuit (30) which connects said friction brake system (10) to said vacuum source (20), a filter (40) located on said pneumatic circuit (30) and mounted on a support (41), characterized in that said capturing system (1) comprises a control unit (60), a control device (70) for said machine (90), and a clogging detection device (50) for said filter (40) which is capable of sending at least one signal to said control unit (60) when the filter (40) is clogged, said control unit (60) being capable of determining the clogging of said filter (40), on the basis of this signal, and being capable of determining whether said detection device (50) is inoperative, said control unit (60) being capable of activating said control device (70) to limit the operation of the machine (90) when said filter (40) is clogged or when said detection device (50) is inoperative.
2. Capturing system (1) according to claim 1, wherein the control unit (60) is capable of informing a user of the clogging of the filter (40) or of the malfunction of the detection device (50).
3. Capturing system (1) according to claim 1 or 2, wherein said detection device (50) comprises a pressure sensor (51) which is located on said pneumatic circuit (30) upstream of said filter (40), said detection device (50) being capable of sending in a signal to said control unit (60) a measurement of the pressure P_1 in said pneumatic circuit (30) upstream of said filter (40), said control unit (60), upon receiving said signal, being capable of comparing said measured pressure P_1 with a reference pressure P_R which is the pressure in said pneumatic circuit (30) for a determined clogging threshold of said filter (40) for the reference operating state E_R of said vacuum source (20) during said measurement of pressure P_1 by said pressure sensor (51), said control unit (60) being capable of limiting the operation of the machine (90) when said measured pressure P_1 is substantially equal to or greater than said reference pressure P_R .
4. Capturing system (1) according to claim 1 or 2, wherein said detection device (50) comprises a first pressure sensor (51) which is located on said

pneumatic circuit (30) upstream of said filter (40), said detection device (50) being capable of sending in a signal to said control unit (60) a measurement of the first pressure P_1 in said pneumatic circuit (30) upstream of said filter (40), and a second sensor pressure (52) which is located on said pneumatic circuit (30) downstream of said filter (40), said detection device (50) being capable of sending in a signal to said control unit (60) a measurement of the second pressure P_2 in said pneumatic circuit (30) downstream of said filter (40), said control unit (60), upon receiving said at least one signal, being capable of comparing said first measured pressure P_1 and said second measured pressure P_2 , said control unit (60) being capable of limiting the operation of the machine (90) when the difference ($P_1 - P_2$) between said first measured pressure P_1 and said second measured pressure P_2 is substantially equal to or greater than a threshold pressure difference ΔP which corresponds to a determined clogging threshold of said filter (40).

5. Machine (90) comprising a capturing system (1) according to any one of the preceding claims.

6. Method for detecting the clogging of a filter (40) in a system (1) for capturing braking particles from a friction brake system (10) of a machine (90), this capturing system (1) comprising a vacuum source (20), a pneumatic circuit (30) which connects said friction brake system (10) to said vacuum source (20), and a filter (40) located on said pneumatic circuit (30) and mounted on a support (41), said method being characterized in that it comprises the following steps:

- (a) A control unit (60), a control device (70) for said machine (90), and a clogging detection device (50) for said filter (40) are provided, which are part of said capturing system (1);
- (b) Said control unit (60) determines if said detection device (50) is inoperative;
- (c) Said detection device (50) sends at least one signal to said control unit 60 when the filter 40 is clogged, if the detection device (50) is operational;
- (d) Said control unit (60) determines whether said filter (40) is clogged, on the basis of said signal;
- (e) Said control unit (60) activates said control device (70) to limit the operation of the machine (90) when said filter (40) is clogged or when said detection device (50) is inoperative.

7. Detection method according to claim 6, further comprising the following step:

(f) Said control unit (60) notifies a user of the clogging of the filter (40) or of the malfunction of the detection device (50).