

Description

Title: BRAKE PARTICLE TRAPPING SYSTEM

Technical field

5 [1] This disclosure relates to the field of vehicular braking devices (automobile or rail) or industrial braking systems. The context specifically targets aspects of environmental protection related to the suctioning of brake particles emitted by friction brakes, particularly disc brakes.

Prior art

10 [2] Document FR 3 057 040 A1 describes a disc brake lining equipped with a collection groove and a through-hole, fluidly connected to suction means. This lining allows an efficient suctioning of brake dust along the entire radial height of the lining. The suction means comprise a fan that generates negative pressure that suctions the dust in order to draw it towards a collection filter.

[3] Documents DE 198 46 887 A1 and DE 196 43 869 A1 illustrate two examples of controlling the suction means to have the maximum amount of suction during braking.

15 [4] Document FR 3 088 395 A1 introduces the concept of suction compensation on the basis of the collection filter's fill level: to ensure satisfactory suction throughout the filter's service life, the suction power can be increased as needed.

20 [5] Another example is found in document CH 687 013 A5, which distinguishes between braking performed while the vehicle is moving at low speeds (< 20 km/h) and during which no suction is applied, and braking performed while the vehicle is moving at higher speeds (> 20 km/h), during which the suction of brake dust is activated.

[6] The existing systems thus systematically recommend that suction is activated during the braking phases and is deactivated after the braking phases. However, as explained below, the inventors of this disclosure have uncovered the fact that, surprisingly, brake particles can be emitted outside of braking phases.

25 Summary

[7] This disclosure thus proposes a particle trapping system, and related methods, which substantially increase the amount of brake particles recovered.

30 [8] A brake particle trapping system for trapping particles emitted by a disc brake is proposed, the trapping system comprising: particle suction means, capable of adopting a first state in which the suction means produce a first level of suction, and a second state in which the suction means produce a second level of suction that is higher than the first level of suction; and a control unit that regulates the state of the suction means, the system being noteworthy in that the control unit is configured to switch the suction means from the first state to the second state when a disc rotational speed signal representing the rotational speed of the disc of the brake, received by the control unit,
35 indicates that the disc, which is in an acceleration phase, has exceeded a first threshold rotational speed.

[9] The inventors have demonstrated that particles can be emitted even outside of braking phases, and in particular during acceleration beyond a certain speed. Without wishing to be bound by this theory, the emission of these particles was attributed to centrifugal acceleration at the surface of the disc, ejecting particles that remained there after the suctioning that took place during a prior braking phase. Aerodynamic instabilities (turbulence) generated by rotation of the disc and/or by movement of the vehicle may also play a role.

[10] The inventors have thus identified a peak in particle emissions during acceleration. It would seem that after these particles are discharged, the emission level decreases, presumably due to depletion of these particles.

10 [11] Thus, by commanding an increased level of suction at the time of the peak in emissions, the capture of particles is substantially increased. A 10-point increase in the number of particles captured is observed in comparison to a system that does not increase its level of suction during the peak. The threshold rotational speed at which suction is triggered may depend on the design of the parts, the materials involved, the type of vehicle, etc. It may be defined empirically for each vehicle or for each industrial machine, or may be obtained through modeling or extrapolation after experimentation.

[12] The intended application includes disc brakes in motor or rail vehicles, or industrial disc brakes. In this type of brakes, one or more linings come into contact with one or more discs. It is understood that the particle trapping system of the present disclosure is also capable of trapping particles from other types of brakes, including drum brakes.

20 [13] The term "level of suction" is understood to mean a measurable physical parameter related to suction, which may be the negative pressure (the absolute value of the negative pressure), the velocity of the suction flow, or the flow rate of the suction flow. Thus, a higher level of suction has a greater negative pressure, a greater suction flow velocity, and/or a greater suction flow rate. In this disclosure, one level is considered higher than another when the measurable parameters of the two levels differ significantly, for example by a relative value of at least 1%, or at least 5%, or at least 10% of one of these parameters. In certain examples in this disclosure, this difference may be as high as 100%, with one level being twice the other, or with one level having no suction at all.

[14] It is understood that the system in this disclosure contains *at least* two different levels of suction outside of the braking phases. It may therefore comprise more than two levels, and the suction means may be switched between these more than two levels according to the disc's rotational speed. In the same manner as a rotational speed threshold during acceleration triggers switching the suction means from a first level to a second level, another threshold may be used to switch from the second level of suction to a third level that is higher or lower than the second level and higher or lower than the first level. The levels of suction outside of braking phases may differ from the level of suction applied during braking. Other parameters, such as the detection *in situ* of emitted particles, by a detector, may be taken into account for the switchover from one level of suction to another.

[15] The "suction means" comprise one or more elements configured to create a negative-pressure flow in the vicinity of the interface between the disc and the friction lining. The documents cited above

give examples of structures that can generate this negative-pressure flow. These include, in particular, a caliper cover, a suction nozzle, and a lining having a groove and a through-hole. The negative-pressure source may consist of a fan. The level of suction may be adjusted by acting directly on the negative-pressure source, for example by increasing or decreasing the current supplied to the fan in order to increase or decrease its rotational speed. Additionally or alternatively, the level of suction may be adjusted indirectly: a valve may be interposed between the negative-pressure source and the interface between disc/lining, this valve filtering out some or all of the suction power of the negative-pressure source.

[16] The term "control unit" is understood to mean a hardware and/or software component dedicated to controlling the sensor system or integrated into one of the main controllers of the vehicle (ICAN, ECU, EMS, etc.) or of the industrial machine.

[17] The "disc rotational speed signal" may originate from a sensor that directly measures the disc's rotational speed (tachometer, revolution counter, optical, magnetic, or electrical sensor, ESP, ABS, etc.). Alternatively, the disc rotational speed may be measured indirectly: for a vehicle, it may be measured at the crankshaft; for an industrial machine, it may be estimated by measuring the power output.

[18] The triggering rotational speed threshold is a threshold detected during an acceleration phase, i.e., when the disc's rotational speed is increasing while the brake remains disengaged. It should be noted that the present disclosure relates to a normal use of a device and that brake activation is considered here to be incompatible with acceleration.

[19] The acceleration phase may or may not follow a braking operation.

[20] During a braking operation, the suction means may adopt a "zero" state in which the (non-zero) level of suction may correspond to the second level, and/or may correspond to the maximum suction that the suction means can produce, and/or may be lower than the second level, and/or may be higher than the second level.

[21] According to one advantageous embodiment, the first level of suction corresponds to no suction. Thus, the first level of suction may correspond to a deactivated negative-pressure source (for example, a fan that is stopped or a closed valve in a hose fluidly connecting a fan to the brake). A no-suction first level allows increasing the system's contribution to protecting the environment by consuming less energy.

[22] According to one advantageous embodiment, the control unit is configured to maintain the suction means in the second state, after switching into it, for a time interval of between 5 and 30 seconds, preferably between 10 and 15 seconds, and then, after this time interval, to switch the suction means back to the first state. Suction can thus be controlled independently of the disc's rotational speed, since only a few seconds are sufficient to ensure an ideal suction, even if the disc's rotational speed were to remain close to the first threshold speed.

[23] According to one advantageous embodiment, the control unit is configured to switch the suction means from the second state to the first state if the following two conditions are met: a disc rotational

speed signal, received by the control unit, indicates that the disc, which is in a deceleration phase, has fallen below a second threshold rotational speed which is possibly equal to the first threshold rotational speed; and the brake is inactive, the suction system switchover from the second state to the first state potentially occurring after a delay of 10 to 15 seconds during which both conditions
5 remain satisfied. Indeed, if the disc decelerates after acceleration, the phenomena which result in particle emission may cease, and it would be inefficient to maintain the second level of suction since particles would no longer be shed and the energy would thus be wasted. When the brake is mounted on a vehicle, the disc speed can be obtained via the tachometer, as the disc's rotational speed is proportional to that of the vehicle.

10 **[24]** According to one advantageous embodiment, the control unit is configured to maintain the suction means in the second state from the moment the disc rotational speed signal indicates that the disc is rotating at a speed exceeding a third threshold rotational speed which is preferably equal to the first and/or second threshold rotational speed. Indeed, certain conditions may lead to choosing to *maintain* the second level of suction when a speed threshold is exceeded. This operating mode
15 may be an alternative to the aforementioned activation duration, or it may be selectable by a user, with the control unit being provided with a dedicated interface for that purpose.

[25] The invention also relates to a motor vehicle or rail vehicle comprising: a disc brake; a brake particle trapping system for trapping particles emitted by the disc brake; and means for detecting the speed of the vehicle, the trapping system comprising: particle suction means, capable of adopting a
20 first state in which the suction means produce a first level of suction, and a second state in which the suction means produce a second level of suction that is higher than the first level of suction; and a control unit that regulates the state of the suction means; the vehicle being noteworthy in that the control unit is configured to switch the suction means from the first state to the second state when a speed signal emitted by the means for detecting the speed and received by the control unit indicates
25 that the vehicle, which is in an acceleration phase, has exceeded a speed of between 40 km/h and 60 km/h. Indeed, although the threshold speed mentioned in the above examples concerning the trapping system is dependent on certain specific characteristics related to the materials used for the brake lining and to the brake design, it appears that, for the vast majority of vehicles, the emissions peak begins between 40 km/h and 60 km/h. Thus, a control unit configured with a speed selected
30 within this range constitutes a good compromise for trapping particles and protecting the environment on a large scale and in an efficient manner, as it does not require specific calibration for each vehicle.

[26] The invention also relates to a method for calibrating a particle trapping system according to one of the above embodiments, the method comprising, in this order: providing a disc brake comprising a disc, a pair of linings, and a caliper; causing the disc to rotate; activating the brake by
35 applying force to the linings in contact with the disc; stopping the activation of the brake; accelerating the disc, during which the particles emitted by the brake are detected and the disc's rotational speed is measured; determining the variations in particle emission as a function of the disc's rotational speed; identifying a peak in particle emissions over these variations; determining a specific value for

the disc's rotational speed that corresponds to the emission peak; and configuring the control unit of the trapping system with said specific value as the first threshold rotational speed.

5 **[27]** The specific value of the rotational speed corresponding to the emission peak may be a speed value at which the maximum emissions are produced. Alternatively, the specific value may be a characteristic speed value at the beginning of the peak, for example when the curve of emissions as a function of time or as a function of rotational speed increases abruptly. A margin of tolerance, for example 10% of this value, may be applied to ensure that the emission peak does not even begin and that the particles are aspirated before this peak appears.

10 **[28]** Optionally, calibration may lead to creating a database containing the following triplets: disc, lining, and caliper (their design, material, etc.), as well as the threshold rotational speed value associated with each triplet. The control unit can access this database, identify the disc, linings, and caliper in order to identify the triplet in question, and retrieve the threshold rotational speed value to be taken into account in controlling the suction means.

15 **[29]** According to one advantageous embodiment, the method further comprises: measuring a residual braking torque when the brake is inactive; and configuring the control unit according to the following principles: if the residual braking torque is greater than a threshold value for residual braking torque, the control unit is configured to maintain the suction means in the second state from the moment the disc rotational speed signal indicates that the disc is rotating at a speed greater than a threshold rotational speed; and if the residual braking torque is less than the threshold value for
20 residual braking torque, the control unit is configured to maintain the suction means in the second state, after the switchover from the first state, for a time interval of between 5 and 30 seconds, preferably between 10 and 15 seconds, and then, after this time interval, to switch the suction means back to the first state.

25 **[30]** Indeed, the inventors' investigations have established that a residual braking torque due to continuous contact of the brake linings on the disc even in the absence of a braking force, can have a significant impact on particle emissions. In extreme situations, over the total lifespan of the linings, 30 to 40% of particle emissions could be due to this residual torque. Thus, when the residual torque induced by the disc/lining/caliper triplet exceeds a predetermined threshold, it may be advantageous to configure the control unit to maintain suction independently of the disc's rotational speed.

30 **[31]** The invention also relates to a method for controlling a brake particle trapping system for trapping brake particles from a disc brake, the trapping system comprising particle suction means, the method comprising: detecting the disc's rotational speed; and when the disc's rotational speed exceeds a first threshold rotational speed, switching the state of the suction means from a first state in which the suction means produce a first level of suction, to a second state in which the suction
35 means produce a second level of suction that is higher than the first level of suction.

[32] Optionally, the particle trapping system used in this method is in accordance with one of the embodiments described above and/or is calibrated by one of the calibration methods described above.

[33] Thus, the various aspects of this disclosure make it possible to protect the environment. While a conventional suction system that operates only during braking provides a trapping efficiency of around 62%, activating a certain level of suction beyond a threshold speed allows this value to exceed 71%.

5 **Brief description of drawings**

[34] Other features, details, and advantages will become apparent from the detailed description below and the accompanying drawings, in which:

[35] FIG. 1 shows a vehicle, a disc brake, and a particle trapping system.

[36] FIG. 2 shows a first particle emission reading.

10 [37] FIG. 3 shows a second particle emission reading.

[38] FIG. 4 shows a third particle emission reading.

[39] FIG. 5 shows a fourth particle emission reading.

[40] FIG. 6 shows a fifth particle emission reading.

[41] FIG. 7 shows a sixth particle emission reading.

15 [42] FIG. 8 shows a method.

Description of embodiments

[43] The figures schematically represent various aspects of the invention. Unless explicitly stated otherwise, each aspect shown in a figure can be combined with other aspects shown in other figures, in any technically feasible combination.

20 [44] FIG. 1 illustrates one possible application for this disclosure. A vehicle 1, whether a motor vehicle (car, van, truck, etc.) or a rail vehicle (train, tram, subway, etc.), comprises a braking device 2 of the disc brake type. It is understood that the invention is not limited to this type of vehicle or this type of brake: indeed, a person skilled in the art will be able to adapt the invention for other vehicles (motorcycles, bicycles, etc.) or for other types of brakes (drum, multi-disc, etc.).

25 [45] The brake 2 consists essentially of a disc 4 securely attached to a wheel of the vehicle 1 and rotating at a speed denoted W about an axis 6. The rotational speed W is proportional to the linear speed V of the vehicle 1. A caliper 8, partially overlapping the periphery of the disc 4, encloses two linings 10, 12. Applying a force parallel to the axis 6 by means of one or more pistons generates a braking torque via the friction of the linings 10, 12 on the respective faces of the disc 4.

30 [46] During braking, the friction of the linings 10, 12 on the disc 4 generates particles (dust, PM10, PM25, etc.). These particles are harmful to the environment: their composition may contain elements that are difficult for the environment to assimilate and are harmful to the respiratory functions of people repeatedly exposed to them.

[47] A particle trapping system 20 is therefore provided for recovering the particles. Such a system
35 20 may, for example, be in the form shown in document FR 3 057 040 A1 or in some other form, in

particular according to the examples in the patent literature published in the name of the Tallano company.

5 **[48]** The trapping system 20 may thus comprise a negative-pressure source 22, here represented as a fan, which is fluidically connected, for example by means of a (flexible) hose 24, to an area near the interface between the linings 10, 12 and the disc 4. In one example, the linings 10, 12 may be provided with a through-hole and the hose 24 may be connected to the rear face of the linings 10, 12. The hose 24 may comprise a filter 26 or a particle collection tank. This filter 26 may, for example, be sized to require no maintenance and to be replaced simultaneously with the replacement of the linings 10, 12. The filter 26 may be located upstream or downstream of the fan 22.

10 **[49]** The operation of the fan 22 may be controlled, via a connection 28, by a control unit 30. The control unit 30 is represented schematically here. It may comprise a memory, a processor, and communication buses. It may be in the form of hardware and/or software components dedicated to controlling the sensor system or may be integrated into one of the main controllers of the vehicle (ICAN, ECU, EMS, etc.) or of the industrial machine.

15 **[50]** A sensor 32 is able to detect the rotational speed of the disc 4. This sensor 32 may be integrated into an assembly arranged locally near the disc 4, for example such as an ABS (Anti-lock Braking System) or an ESP (Electronic Stability Program). The sensor 32 may alternatively be an indirect sensor, for example which detects the rotational speed of the crankshaft and uses this to deduce the rotational speed of the disc and/or the linear speed of the vehicle's forward motion. For industrial
20 machines, the disc speed may be obtained by any suitable means.

[51] The sensor 32 communicates a signal 34 to the control unit 30. The signal 34 may be an electric potential that corresponds to a representation of the rotational speed of the disc 4. The assembly is calibrated so that the control unit 30 is able to translate the electric potential of the signal 34 into a value for the rotational speed of the disc 4.

25 **[52]** The control unit 30 is configured to detect an acceleration, i.e., a positive change in the rotational speed of the disc 4, and to estimate when the speed of the disc 4 exceeds a threshold. As explained with reference to the following figures, detection of this threshold causes the control unit 30 to switch the operation of the fan 22 in order to increase its level of suction, for example by increasing the supply of power to the fan. The level of suction can take any value between zero suction and the
30 maximum suction of the fan 22.

[53] FIG. 2 illustrates a reference test in which no particle capture is performed during an acceleration.

[54] The x-axis represents time (e.g., in seconds). The y-axis represents (1) the rotational speed of the disc W (e.g., in revolutions per minute); (2) the level of suction p (e.g., in bar); and (3) the amount of CPC (condensation particle counter) particles released into the environment, i.e., the particles
35 produced by the brake that are not captured by the trapping system. As mentioned above, other physical measurements may be used to characterize the level of suction or the amount of particles emitted.

[55] The disc rotational speed may be proportional to the physical concepts in which the system is used. For a vehicle, this could be the vehicle's linear speed ($V=RW$ where R is the radius of the vehicle's wheel). Thus, in all examples in this disclosure, when the brake is a vehicle brake, the expression "disc rotational speed" can be replaced by "vehicle speed." For an industrial machine,
5 the physical concept in question can be the delivered power (power = torque x W) when the torque is constant over a sufficiently wide range of values for the disc rotational speed. Thus, in all examples in this disclosure, when the brake is a brake of an industrial machine, the expression "disc rotational speed" can be replaced by "machine power."

[56] The curve in FIG. 2 shows a braking operation taking place between time $Tf1$ and time $Tf2$.
10 During this braking operation, the speed W decreases. Suction is activated with a braking suction pressure denoted pf . Despite the suction, a temporary increase in particle emissions may occur, as the trapping system cannot guarantee that all particles produced during braking are trapped.

[57] In this illustration, the disc accelerates after $Tf2$. Suction is deactivated and becomes zero after $Tf2$. For simplicity, the rotational speed is described as evolving linearly, but identical results are
15 obtained for a rotational speed that evolves differently.

[58] This figure shows that few particles are emitted at low speeds, and that a peak appears for a certain range of speed values. Speed Wa , reached at time Ta , indicates the start of the peak. This start may be determined analytically by an abrupt increase in the amount of particles emitted, i.e. a derivative signal (derived as a function of time or as a function of speed) exceeding a threshold value.
20 The peak ends at speed Wb , reached at time Tb . While not bound to this theory, the end of the peak is considered to be equivalent to the depletion of particles present at the interface between lining/disc. A speed Wc , reached at time Tc , can be defined as the speed at which the greatest amount of particles is emitted.

[59] It is important to note that the inventors' identification of this peak resulted from extensive
25 experimentation and that the appearance of this peak is neither intuitive nor expected by a person skilled in the art. On the contrary, the literature as a whole recommends particle suction during braking, considering that this is the moment when particles are detached from the brake linings and that suction should therefore be carried out simultaneously with a braking operation.

[60] In comparison to FIG. 2, FIG. 3 shows a test with a similar variation in speed, during which the
30 particle trapping system is activated at the beginning of the peak: at time $T1$, the suction means are switched from a low or zero level of suction ($p1$) to a higher level of suction ($p2$). $T1$ may be time Ta in FIG. 2, at the beginning of the peak ($W1=Wa$ in FIG. 2). It should be noted that other choices may be made for switching the suction means to their second state, for example at Tc , or a few seconds before Ta , or before the disc reaches speed Wa , for example when the disc reaches a speed 10%
35 lower than Wa .

[61] The change of state of the suction means is characterized by the transition from a negative pressure $p1$ (which may be zero) to a negative pressure $p2$ that is greater (in absolute value) than

p1. As mentioned above, other parameters (flow velocity, flow rate) may be used to define the distinction between the first and second levels of suction.

[62] In this example, the value of p2 is less than the value of pf (the negative pressure of the suction during braking).

5 **[63]** One will note that the peak in particle emissions, which is present in FIG. 2 in the absence of suction, is considerably flattened when suction is increased starting at speed value W1. The timing of this suction allows compromising between continuous suction (and therefore energy consumption without environmental benefit) and the absence of suction (and therefore the release of emissions into the environment).

10 **[64]** FIG. 3 also shows that, when so controlled by the control unit, the fan can switch back to the first state after a certain time interval Dt, i.e. at time T1+Dt. The time interval Dt may be between 5 and 30 seconds, preferably between 10 and 15 seconds.

[65] One will note that the increase in emissions during braking remains unchanged between FIG. 2 and FIG. 3, since the suction is the same in both.

15 **[66]** FIG. 4 illustrates the fact that when the speed drops below a certain threshold W2, which may be equal to W1, the control unit switches the suction means to the first state (lower level of suction). This switchover may (as shown) occur before the time interval Dt has elapsed. Indeed, since particle emission ceases with the decrease in speed, it is no longer necessary to maintain a high level of suction.

20 **[67]** FIG. 5 shows a variant in which the level of suction is kept high as long as the speed remains above a threshold W3, which may be equal to W1.

[68] FIG. 6 shows a comparison between system "a" and system "b". Axis C represents the friction torque (e.g., in N·m) of the brake linings on the disc. During braking, the torque has a value Cf, the braking torque. Outside of the braking phase, by design, the linings remain in contact with the disc
25 but without applying sufficient force to slow the disc. This contact can generate a so-called residual torque, its magnitude specific to the disc, lining, and caliper triplet. Thus, brake "a," for example, will have a lower residual torque Ca than system "b" which has a residual torque Cb.

[69] The inventors have uncovered the impact of the residual torque value on particle emission: FIG. 6 shows that system "b," which has the highest residual torque, causes the emission of a greater
30 number of particles CPCb than system "a," which emits fewer particles CPCa. The difference between the two curves can disappear at the emission peaks: indeed, the emission peaks in the braking phases or near the threshold speed may be at equivalent levels that are independent of the level of residual torque.

[70] FIG. 7 shows that the rule for controlling the level of suction may be chosen to be different for a
35 system having high residual torque (above a given threshold): for system b, the negative pressure remains at a level p2 after exceeding speed W1, whereas the level may drop back to p1 for system a having low residual torque.

[71] In the example methods of suction control given in FIGS. 2 to 7, it is understood that if, after the braking phase, a new braking phase occurs, suction is reactivated at level pf.

[72] The threshold speed W1 may correspond to a vehicle speed 1 that is between 40 km/h and 60 km/h.

5 **[73]** FIG. 8 illustrates a calibration method 1000 for a particle trapping system, which may be the system described above in relation to FIG. 1 and/or controlled as described in relation to one or more of FIGS. 2 to 7.

[74] Step 100 consists of providing a disc brake, for example of the type shown in FIG. 1. In step 200, the disc is made to rotate. For example, in a vehicle, the discs are made to rotate indirectly by
10 the engine. Step 300 constitutes a braking phase, by applying force on the brake linings. Braking reduces the speed of the disc to a speed that may not be zero. Step 400 marks the end of the brake activation.

[75] During step 500, the disc is accelerated, its rotational speed is monitored, and the emitted particles are measured. The rotational speed may be detected directly by a dedicated sensor, which
15 may be integrated into a braking assistance or electronic stability system. Alternatively, the rotational speed may be measured indirectly. The emitted particles may be detected by a suitable sensor, for example a CPC.

[76] The particle emission and speed data are recorded at each instant. A curve can then be plotted 600, showing the variations in particle emissions as a function of the disc's rotational speed.

20 **[77]** These variations include a peak, which is identified in step 700.

[78] The specific speed at which this peak occurs is identified in step 800. As illustrated in FIGS. 2 and 3, the specific speed may be chosen to be the speed at which the peak begins, or a slightly lower speed, for example 10% lower than the start of the peak, in order for the suction to anticipate the appearance of the peak.

25 **[79]** Optionally, as discussed in relation to FIGS. 6 and 7, the residual braking torque may be measured 550 at a time when the brake is not activated.

[80] Step 900 consists of configuring the control unit. This involves, in particular, storing the value of the specific speed at the peak in a control unit memory that is dedicated to the threshold speed value W1.

30 **[81]** The configuration step 900 may also consist of defining a suction strategy, particularly in relation to the measured residual torque. Thus, if the residual braking torque is greater than a threshold value, the control unit may be configured to maintain the suction means at a high level of suction as soon as the disc rotational speed signal indicates that the disc is rotating at a speed greater than a threshold speed; and if the residual braking torque is less than the threshold value, the control unit
35 may be configured to maintain the suction means in the second state, after the switchover from the first state, for a time interval of between 5 and 30 seconds, preferably between 10 and 15 seconds, and then, after this time interval, to switch the suction means back to the first state.

Claims

[Claim 1] A brake particle trapping system (20) for trapping brake particles emitted by a disc brake (2), the trapping system (20) comprising:

- 5 - particle suction means (22, 24, 26), capable of adopting a first state in which the suction means (22, 24, 26) produce a first level of suction (p1), and a second state in which the suction means produce a second level of suction (p2) that is higher than the first level of suction (p1); and
- a control unit (30) that regulates the state of the suction means (22, 24, 26),

10 the system (20) being characterized in that the control unit (30) is configured to switch the suction means (22, 24, 26) from the first state to the second state when a signal (34) for the rotational speed of the disc (4) of the brake (2), received by the control unit (30), indicates that the disc (4), which is in an acceleration phase, has exceeded a first threshold rotational speed (W1).

[Claim 2] Trapping system (20) according to claim 1, wherein the first level of suction (p1) corresponds to no suction.

15 **[Claim 3]** Trapping system (20) according to any one of the preceding claims, wherein the control unit (30) is configured to maintain the suction means (22, 24, 26) in the second state, after switching into it, for a time interval (Dt) of between 5 and 30 seconds, preferably between 10 and 15 seconds, and then, after this time interval (Dt), to switch the suction means (22, 24, 26) back to the first state.

20 **[Claim 4]** Trapping system (20) according to any one of the preceding claims, wherein the control unit (30) is configured to switch the suction means (22, 24, 26) from the second state to the first state if the following two conditions are met:

- 25 - a signal (34) for the rotational speed of the disc (4), received by the control unit (30), indicates that the disc (4), which is in a deceleration phase, has fallen below a second threshold rotational speed (W2) which is possibly equal to the first threshold rotational speed (W1); and
- the brake (2) is inactive,

the switchover of the suction means (22, 24, 26) from the second state to the first state potentially occurring after a delay of 10 to 15 seconds during which both these conditions remain satisfied.

30 **[Claim 5]** Trapping system according to any one of the preceding claims, wherein the control unit (30) is configured to maintain the suction means (22, 24, 26) in the second state from the moment the signal (34) for the rotational speed of the disc (2) indicates that the disc (4) is rotating at a speed greater than a third threshold rotational speed (W3) which is preferably equal to the first and/or second threshold rotational speed (W1, W2).

35 **[Claim 6]** A motor vehicle or rail vehicle (1) comprising:

- a disc brake (2);

- a brake particle trapping system (20) for trapping brake particles emitted by the disc brake (2); and
- means for detecting the speed of the vehicle,

the trapping system (20) comprising:

- 5 - particle suctioning means (22, 24, 26), capable of adopting a first state in which the suction means (22, 24, 26) produce a first level of suction (p1), and a second state in which the suction means produce a second level of suction (p2) that is higher than the first level of suction (p1); and
- a control unit (30) that regulates the state of the suction means (22, 24, 26),
- 10 the vehicle being characterized in that the control unit (30) is configured to switch the suction means (22, 24, 26) from the first state to the second state when a speed signal emitted by the means for detecting the speed and received by the control unit (30) indicates that the vehicle (1), which is in an acceleration phase, has exceeded a speed of between 40 and 60 km/h.

[Claim 7] A method (1000) for calibrating a particle trapping system according to one of
15 claims 1 to 5 or a vehicle according to claim 6, the method comprising, in this order:

- providing (100) a disc brake (2) comprising a disc (4), a caliper (8), and a pair of linings (10, 12);
- causing the disc (4) to rotate (200);
- activating the brake (300) by applying force to the linings (10, 12) in contact with the disc (4);
- 20 - stopping the activation of the brake (400);
- accelerating the disc (500), during which the particles emitted by the brake (2) are detected and the rotational speed (W) of the disc (4) is measured;
- determining (600) the variations in particle emission as a function of the rotational speed (W) of the disc (4);
- 25 - identifying a peak (700) in particle emissions over these variations;
- determining (800) a specific value (Wa) for the rotational speed of the disc (4) that corresponds to the emission peak; and
- configuring (900) the control unit (30) of the trapping system (20) with said specific value (Wa) as the first threshold rotational speed (W1).

30 **[Claim 8]** Calibration method according to claim 7, further comprising:

- measuring (850) a residual braking torque when the brake is inactive; and
- configuring (900) the control unit according to the following principles:
 - o if the residual braking torque (Cb) is greater than a threshold value for residual braking torque, the control unit (30) is configured to maintain the suction means in the second

state from the moment the signal for the rotational speed of the disc indicates that the disc is rotating at a speed greater than a threshold rotational speed (W1); and

- if the residual braking torque (Ca) is less than the threshold value for residual braking torque, the control unit (30) is configured to maintain the suction means in the second state, after the switchover from the first state, for a time interval of between 5 and 30 seconds, preferably between 10 and 15 seconds, and then, after this time interval, to switch the suction means back to the first state.

[Claim 9] A method for controlling a brake particle trapping system (20) for trapping brake particles from a disc brake, the trapping system comprising particle suction means, the method comprising:

- detecting the rotational speed (W) of the disc (4); and
- when the rotational speed of the disc exceeds a first threshold rotational speed (W1), switching the state of the suction means from a first state in which the suction means produce a first level of suction (p1), to a second state in which the suction means produce a second level of suction (p2) that is higher than the first level of suction (p1).

[Claim 10] Method according to claim 9, wherein the particle trapping system (20) is in accordance with one of claims 1 to 5 and/or is calibrated by a calibration method according to claim 7 or 8.