System for suctioning braking particles with optimized control

Technical field

The invention relates to systems for suctioning braking particles in friction braking systems. Such friction braking systems can be fitted to road or rail vehicles. Such friction braking systems can also be fitted to stationary rotor machines such as wind turbines or industrial machines.

Background and Prior Art

In such systems, as described for example in document DE4240873, a suction turbine and a particle collection filter are provided. The particles from abrasion are thus gradually accumulated in the collection filter. This results in progressive clogging of the filter. This progressive clogging requires a suction power sized for the case where the filter causes a high in-line loss, in order to continue to collect the particles correctly even in the case where the filter has a high level of clogging.

Conversely, when the filter is new, with very little loss in the pneumatic line, the suction power may prove to be oversized and the concomitant noise generated by the turbine rotating at high speed may prove to be annoying.

The object of the present invention is to provide an improved solution relating to the progressive clogging of the filter.

Summary

To this end, in an aspect, a system for suctioning braking particles from a friction braking system of a vehicle is proposed, the suction system comprising:
at least one negative-pressure source (for example a turbine or other means), at least one suction mouth connected by a pneumatic circuit to the negative-pressure source, and a control unit configured to control the negative-pressure source,
characterized in that the suction system further comprises a device for determining the current airflow conditions prevailing in the pneumatic circuit,
and in that the control unit controls the negative-pressure source so that the current airflow conditions in the pneumatic circuit reach or tend to meet at least one setpoint for the airflow conditions.

The term *"setpoint for the airflow conditions"* is to be understood to mean a predetermined value, but without excluding this setpoint from being a function of time or of operational conditions (see below).

The term *"device for determining current airflow conditions"* is to be understood to mean either a pressure sensor, a flow sensor, or an electrical measurement device measuring a quantity representative of at least one airflow condition of interest.

As for the term "pneumatic circuit which connects the suction mouth to the negative-

Aside from the solution of a pressure sensor, it is possible to use a flow sensor to measure the airflow conditions of interest in the pneumatic circuit, or else an electrical measurement device measuring a quantity representative of at least one airflow condition of interest.

The term "negative-pressure setpoint" is to be understood to mean a predetermined value, but without excluding this negative-pressure setpoint from being a function of time or of operational conditions.

In various examples relating to the system, use may possibly be made of one or more of the following arrangements, individually or in combination.

According to a preferred option, the negative-pressure source is formed by a turbine driven by an electric motor. In this manner, it is provided that the control unit controls the speed of rotation of the electric motor in order to manage the negative pressure created by the turbine. In the case of an electric motor controlled by DC voltage, 12V, 24V, or 72 V for example, provision may be made for the control logic to make use of a control signal modulated by PWM.

According to an alternative option, the negative-pressure source is formed by a negative-pressure source preexisting in the vehicle, in particular, for the case of the automotive sector, a negative-pressure source induced by the operation of the vehicle's engine, for example a bypass from the air intake, or in another example by the use of a Venturi effect on an outflowing stream of gas, for example exhaust gases. In the case of the railway sector, the negative-pressure source may be derived from the pneumatic braking system or from some other auxiliary system of the railway vehicle.

According to one option, the pressure sensor is arranged adjacent to or integrated with the filter. In this manner, a compact mechatronic solution and a simplified assembly are offered.

According to one option, the system can comprise at least one filter for collecting the suctioned particles.

According to one option, the system comprises a centralized filter and turbine, which are connected to four or more suction mouths. In this manner, the cost of the complete solution is optimized. It is possible to provide a single pressure sensor (respectively a single sensor of airflow conditions) to carry out the complete function.

According to one option, the system comprises a decentralized filter and turbine, namely for each suction mouth or pair of suction mouths. In this manner, the power of the negative-pressure source, in particular the speed of rotation of the turbine, is specifically adapted for each of the braking means. It is even possible to have a filter, a turbine, and a suction mouth per pad, or per side of the disc, such as for example in the railway sector.

According to one option, the control unit is configured to detect a predetermined level of clogging of the filter, and to transmit a message to a user. This allows informing the user in question of the need to replace the filter, whether the owner, driver, or person responsible for maintenance of the vehicle in question. In practice, the control unit may transmit a message to a vehicle dashboard or to a remote server in charge of managing the maintenance of the vehicle. Note that when the engine reaches maximum speed, the clogging indicator will be activated when the negative pressure has reached a minimum level which is not the desired setpoint. One will note here that the noise level emitted by the turbine can also serve as an end-of-service-life indicator.

According to one option, the predetermined negative-pressure setpoint is selected within a range of 20 to 40 millibars below ambient pressure. Advantageously, this is an optimal range for efficiently capturing braking particles while maintaining a reasonable and inexpensive sizing and moderate dimensions for the elements of the system.

In another aspect, the present disclosure also relates to a method for controlling a system for suctioning friction braking particles from a braking system of a vehicle, the suction system comprising:

at least one negative-pressure source (a turbine or other), at least one suction mouth (83) connected by a pneumatic circuit (3,30) to the negative-pressure source, a control unit (6), and a device for determining the current airflow conditions prevailing in the pneumatic circuit,

the control unit is configured for:

a- controlling the negative-pressure source (for example the rotation of the turbine), according to predetermined activation conditions,

b- measuring the current airflow conditions prevailing in the pneumatic circuit,

c- determining a difference between current airflow conditions and at least one setpoint for the airflow conditions,

d- adjusting the control signals used, in order to adjust the power of the pressure source or to rotate the turbine as a function of said difference.

In the typical case of a pressure measurement, a method is proposed for controlling a system for suctioning friction braking particles from a braking system of a vehicle, the suction system comprising:

at least one negative-pressure source (a turbine or other), at least one suction mouth (83) connected by a pneumatic circuit (3,30) to the negative-pressure source, a control unit (6), and a pressure sensor (22),

the control unit is configured for:

a- controlling the negative-pressure source (for example the rotation of the turbine), according to predetermined activation conditions,

b- measuring the pressure in the pneumatic circuit, by means of the pressure sensor,

c- determining a difference between the current pressure and a negative-pressure setpoint,

d- adjusting the control signals used, in order to adjust the power of the pressure source or to rotate the turbine as a function of said difference.

In various examples relating to the method, use may possibly be made of one or more of the following arrangements, individually or in combination.

According to one option, the control unit is further configured to detect a predetermined level of clogging of the filter, when the control setpoint for the negative-pressure source exceeds a predetermined threshold so that the current airflow conditions reach the setpoint for the airflow conditions.

In the typical case of a pressure sensor, the control unit is configured to detect a predetermined level of clogging of the filter when the control setpoint for the negative-pressure source exceeds a predetermined threshold so that the pressure reaches the predetermined negative-pressure setpoint, or so that the setpoint is not reached despite a command for maximum power of the negative-pressure source.

In the typical case of a pressure sensor and an electrically controlled turbine, the control unit is further configured to detect a predetermined level of clogging of the filter when the control setpoint for rotation of the turbine exceeds a predetermined threshold so that the pressure reaches the predetermined negative-pressure setpoint.

According to one option, the control unit is further configured to transmit a message to a user when a clogging condition is determined. Thus the owner, the driver, or the person in charge of maintenance of the vehicle in question, can be informed of the need to replace the filter.

According to one option, the setpoint (negative pressure or more generally airflow conditions) is not a constant value but can be determined according to various operating conditions (temperature, humidity, vehicle speed). In addition, the setpoint can be a function over time of the braking phase. It is thus possible to refine the management and feedback control of the negative pressure to only what is essential.

According to one option, the negative-pressure source being a turbine, it is provided that when the control signals used to cause the turbine to rotate exceed a predetermined value, the noise level emitted by rotation of the turbine exceeds a certain audible threshold, and can thus be perceived by a user. In other words, the whistling of the turbine is an audible alert which serves as an indicator prompting the user to replace the filter.

Description of figures

Other features, aims and advantages of the invention will be apparent from reading the following description of an embodiment of the invention, given as a non-limiting

CLAIMS

1. System for suctioning braking particles from a friction braking system, the suction system comprising:

at least one negative-pressure source, at least one suction mouth, connected by a pneumatic circuit to the negative-pressure source, and a control unit configured to control the negative-pressure source,

characterized in that the suction system further comprises a device for determining the current airflow conditions prevailing in the pneumatic circuit,

and in that the control unit controls the negative-pressure source so that the current airflow conditions in the pneumatic circuit reach or tend to meet a setpoint for the airflow conditions.

2. System according to claim 1, wherein the device for determining the current airflow conditions prevailing in the pneumatic circuit is a pressure sensor for measuring the pressure prevailing in the pneumatic circuit and the pressure representing the current airflow conditions, and the control unit controls the negative-pressure source so that the pressure in the pneumatic circuit reaches or tends to meet a predetermined negative-pressure setpoint (DPR).

3. System according to one of claims 1 to 2, wherein the negative-pressure source is formed by a turbine driven by an electric motor.

4. System according to one of claims 1 to 3, further comprising at least one filter for collecting the suctioned particles.

5. System according to claim 2, wherein the negative-pressure source is formed by a turbine driven by an electric motor and wherein the pressure sensor is arranged adjacent to or integrated with the filter.

6. System according to one of claims 1 to 4, such that the system comprises a centralized filter and turbine, which are connected to four or more suction mouths.

7. System according to one of claims 1 to 4, such that the system comprises a decentralized filter and turbine, namely for each suction mouth or pair of suction mouths.

8. System according to one of claims 1 to 7, wherein the control unit is configured to detect a predetermined level of clogging of the filter, and to transmit a message to a user.

9. System according to one of claims 1 to 8, wherein the predetermined negative-pressure setpoint (DPR) is selected within a range of 20 to 40 millibars below ambient pressure.

10. Method for controlling a system for suctioning friction braking particles from a braking system of a vehicle, the suction system comprising:
at least one negative-pressure source (a turbine or other), at least one suction mouth connected by a pneumatic circuit to the negative-pressure source, a control unit, and a device for determining the current airflow conditions prevailing in the pneumatic circuit, the control unit is configured for:
a- controlling the negative-pressure source (such as the rotation of the turbine), according to predetermined activation conditions,
b- measuring the current airflow conditions prevailing in the pneumatic circuit,
c- determining a difference between current airflow conditions and at least one setpoint for the airflow conditions,
d- adjusting the control signals used, in order to adjust the power of the pressure source or to rotate the turbine as a function of said difference.

11. Method according to claim 10, wherein the device for determining the current airflow conditions prevailing in the pneumatic circuit is a pressure sensor for measuring the pressure prevailing in the pneumatic circuit, the pressure then representing the current airflow conditions, and steps b- and c- then become:
b- measuring the pressure in the pneumatic circuit, by means of the pressure sensor,
c- determining a difference between the current pressure and a negative-pressure setpoint.

12. Method according to one of claims 10 to 11, wherein the control unit is further configured to detect a predetermined level of clogging of the filter, in particular when the

control setpoint for the negative-pressure source exceeds a predetermined threshold, so that the current airflow conditions reach the value of the predetermined setpoint for the airflow conditions.

13. Method according to one of claims 10 to 12, wherein the control unit is further configured to transmit a message to a user when a clogging condition is determined.

14. Method according to one of claims 10 to 12, wherein the pressure source is a turbine and wherein it is provided that when the control signals used to cause the turbine to rotate exceed a predetermined value, the noise level emitted by rotation of the turbine exceeds a certain audible threshold, and can thus be perceived by a user.