

DESCRIPTION

CLEANING DEVICE, PARTICULARLY HOUSEHOLD VACUUM CLEANER

AREA OF TECHNOLOGY

[0001] The invention relates to a cleaning device, in particular to a household vacuum cleaner, with a fan and a pressure sensor for determining a negative pressure generated by the fan.

[0002] In addition, the invention relates to a method for operating such a cleaning device.

PRIOR ART

[0003] Cleaning devices of the aforementioned kind are known in prior art. In addition, the latter can have a device for varying the fan power of the fan, so as to remove suction material from a surface to be cleaned as best as possible. It is here also known to vary the fan power as a function of a flow resistance of an attachment of the cleaning device, so that moving the cleaning device over the surface to be cleaned requires the least possible sliding force so as to achieve the best possible cleaning result. The sliding force to be applied here depends among other things on the floor covering, for example a hard floor or a carpeted floor.

[0004] Differential pressure sensors are used in prior art to measure the negative pressure generated by the fan. The disadvantage here is that the absolute pressure that also contributes to the flow resistance of the attachment is not taken into account. This adversely affects the cleaning result.

[0005] Therefore, the object of the invention is to provide a cleaning device that achieves the best possible cleaning result at the lowest possible flow resistance of the attachment.

SUMMARY OF THE INVENTION

[0006] In order to achieve the aforementioned object, the invention proposes a cleaning device in which the pressure sensor is an absolute pressure sensor.

[0007] According to the invention, the pressure sensor now measures an absolute pressure, which can vary depending on where the cleaning device is used above sea level, and also on the weather conditions. As a result, fluctuations in absolute pressure are taken into account, and not erroneously interpreted as a pressure difference generated by the fan.

[0008] The absolute pressure sensor advantageously has a detection area allocated to a suction area of the fan arranged in a connection area for an attachment, i.e., an area exposed to the suction force of the fan. This suction area in the cleaning device is usually located where an attachment is connected to the cleaning device. In this detection area, the absolute pressure sensor on the one hand measures the ambient pressure during a first measurement with the fan turned off, i.e., without exposing the detection area to the suction air stream generated by the fan, and on the other hand measures the absolute pressure during a second measurement with the fan turned on. The pressure difference calculated from these two absolute pressures is adjusted for the current ambient temperature, so that the cleaning result is optimal independently of the current ambient temperature.

[0009] In an especially simple embodiment, the detection area of the absolute pressure sensor is allocated to the suction area by arranging the absolute pressure sensor directly in the suction area of the connection area.

[0010] As an alternative, however, it can also be provided that the pressure sensor be arranged in a fan area of the fan, in particular on a circuit board arranged in the blow-out area of the fan, wherein a measuring channel is formed between the pressure sensor and detection area, its first end area being allocated to the pressure sensor, and its second end area emptying into the suction area. In this embodiment, the location of the detection area and the location of the pressure sensor are different. As a result, the pressure sensor in the blow-out area of the fan can be cooled by the blow-out air of the fan. The absolute pressure in the suction area is here measured via the measuring channel. To this end, the measuring channel has a first and a second end area, wherein the first end area is led to the pressure sensor, and in particular contacts the circuit board in such a way that the pressure sensor protrudes into the measuring channel, and wherein the second end area protrudes into the suction area, in particular into a flow path of the suction air stream generated by the fan from the attachment to the fan.

[0011] It is proposed that the measuring channel be a hose section. The first end area of this hose section can be adhesively bonded to the circuit board or be joined with the circuit board in some other way. The open front side of the measuring channel is especially advantageously covered by a partial area of the circuit board, so that the measuring channel is joined with the circuit board as fluid tightly as possible. The hose section, in particular designed as a flexible hose section, is guided into the suction area, wherein the second end area there is advantageously also fluid tightly joined with a suction

channel of the connection area. As an alternative to designing the measuring channel as a hose section, however, it is also possible that a partial area of the housing of the cleaning device be designed as a measuring channel. For example, the measuring channel can be molded into the housing of the cleaning device, advantageously in an injection molding process. This simultaneously also makes it possible to form a receptacle for the circuit board carrying the pressure sensor, so that when the circuit board is arranged in the receptacle, the first end area of the measuring channel can also contact the circuit board.

[0012] The invention further proposes that a temperature sensor also be arranged in the connection area. The temperature sensor serves to measure the current temperature in the connection area, which can be drawn upon for calculating the current air density. The air density in turn is used for calculating the volume flow of the fan, which in combination with the negative pressure generated by the fan makes it possible to determine the current flow resistance of the attachment. Taking the current temperature inside of the suction area into account thus enables an even more reliable determination of the flow resistance.

[0013] It is further provided that the cleaning device have an evaluator and controller, which is designed to regulate a resultant suction power of the cleaning device as a function of a negative pressure determined by the pressure sensor, a current fan power, and a current speed of the fan. The negative pressure determined from the absolute pressures and the volume flow of the fan corresponding thereto, which can be derived from the fan characteristic of the fan, determine the flow resistance of the attachment, and thus also the sliding force to be applied for moving the attachment. This flow resistance is drawn upon by the evaluator and controller to regulate the

resultant suction power of the cleaning device in such a way as to keep the flow resistance as low as possible on the one hand and achieve the best possible cleaning result on the other. The evaluator and controller can here be set up in particular for regulating a constant suction power. The volume flow through the fan depends (among other things) on the current fan power, which can be determined from the current and voltage draw of the fan. For example, the current and voltage of the fan are measured by corresponding devices on a circuit board of the fan. The speed of the fan is additionally measured in a conventional manner by a tachometer. As a consequence, the evaluator and controller can use the aforementioned measuring data and known characteristics of the fan to determine the flow resistance, which serves to regulate the suction power of the cleaning device.

[0014] It can further be provided that the evaluator and controller be designed to also regulate the suction power as a function of a temperature measured by the temperature sensor. This adjusts the evaluation for the air density that depends on the temperature as well, which contributes to an optimal regulation of the suction power of the fan. This in particular since the air density, and hence also the negative pressure generated by the fan, change as a function of the temperature.

[0015] Apart from the cleaning device described above, the invention also proposes a method for operating a cleaning device, wherein a suction power of the cleaning device is varied as a function of a

determined flow resistance of an attachment of the cleaning device, with the following procedural steps:

- Measuring an absolute pressure in a suction area of the fan with the fan turned off,
- Measuring an absolute pressure in a suction area of the fan with the fan turned on,
- Determining the negative pressure generated by the fan from the difference between the measured absolute pressures,
- Determining a fan power of the fan,
- Measuring a speed of the fan,
- Determining the flow resistance of the attachment from the negative pressure, fan power and speed through comparison with known fan characteristics of the fan,
- Regulating the suction power of the cleaning device by varying the speed of the fan and/or the fan power as a function of the determined flow resistance.

[0016] In the method according to the invention, a first absolute pressure measurement is performed before turning on the fan, and a second absolute pressure measurement after the fan has been turned on. The first absolute pressure measurement takes place in so short a time span, for example 300 milliseconds, that the user of the cleaning device registers no delay in turning on the fan. After the fan has been turned on, more absolute pressure measurements can be performed at preferably regularly repeating intervals, for example 10 to 20 times per second. The negative pressure generated by the fan is determined from the respective absolute pressure determined with the fan

running and the first absolute pressure measured with the fan turned off. In addition, the electrical power consumed by the fan is determined, which regularly takes place by measuring the current and voltage required by the fan. In addition, the speed of the fan is measured. All measured values, i.e., both the negative pressure, fan power and speed of the fan, are involved in determining the flow resistance of the attachment. In practice, the user perceives the flow resistance of the attachment as a sliding force to be applied for moving the cleaning device or attachment over the surface to be cleaned. Given a very high flow resistance, the user will only be able to guide the cleaning device or attachment over the surface to be cleaned by exerting a high level of force. This is accompanied by a low volume flow through the fan, and hence a low suction power. The measuring data are then compared with known fan characteristics of the fan, from which the volume flow arising at the respective flow resistance and the pressure difference can be derived. If one of the known fan characteristics coincides with the measuring data or comes as close as possible to it, the currently measured suction power is regulated in such a way as to produce a best possible cleaning result. To regulate the suction power, the speed of the fan and/or the fan power can be varied. The suction power is here preferably regulated to a constant amount.

[0017] It is additionally proposed that it not be possible to further increase the fan power once a defined maximum flow resistance of the attachment has been reached. As a result, a maximum power consumption is given in view of the arising flow resistance. The fan power cannot be raised beyond a corresponding maximum flow resistance to increase the volume flow. The maximum permissible flow resistance, and hence the sliding force to be applied to move the attachment, can be provided at 20 N. This serves to protect the fan against an overload.

[0018] It is further proposed that the flow resistance of the currently used attachment also be determined as a function of a temperature currently measured in the connection area. As already explained in relation to the cleaning device, including the currently measured temperature enables the achievement of an optimal cleaning result at the lowest possible flow resistance.

[0019] Finally, it is proposed that a fill level of a filter arranged in a suction area of a fan be determined by comparing the determined flow resistance of the attachment with reference values, which are each allocated to a specific fill level of the filter. In order to infer the fill level from the flow resistance, empirical characteristic lines or characteristic values are stored for various operating modes, which each are allocated to a specific fill level of the filter. The suction power is preferably also to be held constant independently of the currently determined fill level of the filter.

[0020] Finally, the user can operate the cleaning device via a selection means, for example a slide switch. For example, a first position of the slide switch is allocated to an automatic operation of the cleaning device. In this position, the evaluator and controller automatically regulates the fan power required in view of the determined negative pressure, so as to achieve a specific suction power or specific volume flow. In addition, power stages with a constant fan power can be provided, for example a power stage with a constant fan power of 50 W and another power stage with a higher fan power of 300 W. In addition, another power stage can be provided as the maximum power stage. In this maximum power stage, the fan power can be controlled as a function of a detected floor covering, i.e., for example a hard floor or carpeted floor, e.g., 700 W for cleaning carpeted floors and 450 W for cleaning hard

floors. This can here involve pure control, i.e., only the aforementioned constant fan powers are provided. No flow resistance-dependent adjustment takes place. However, it would alternatively also be possible to provide a dependence on the arising flow resistance (sliding force) in this operating mode in addition to the dependence on the respective floor covering.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The invention will be explained in more detail below based on exemplary embodiments. Shown on:

Fig. 1 is perspective, exterior view of a cleaning device with an attachment,

Fig. 2 is a longitudinal section through the cleaning device and attachment.

DESCRIPTION OF THE EMBODIMENTS

[0022] Fig. 1 shows a cleaning device 1, which is here designed as a conventional household upright vacuum cleaner. The cleaning device 1 has a base device 15, which incorporates a fan 2 and a filter chamber with a filter 14. An attachment 7 is hooked up to a connection area 5 of the base device 15, and serves to process a surface, such as a hard floor or carpeted floor. With the fan 2 turned on, suction material is guided through the attachment 7 into the filter 14.

[0023] A guide rod 19 for handling the cleaning device 1 is arranged on the base device 15. The guide rod 19 has a hand grip element 20 at the end. The hand grip element 20 carries an operating element 16, with which the user can select various operating modes of the cleaning device 1. The operating element 16 has a slide switch 17 and a key

18. Specifically, the slide switch 17 enables four different positions, to which four different operating modes are allocated.

[0024] In a first position of the slide switch 17, an automatic mode can be set for the cleaning device 1. In this operating mode, the cleaning device 1 automatically regulates a power of the fan 2 as a function of the negative pressure generated by the fan 2, so as to achieve a specific suction power, i.e., a specific volume flow through the attachment 7. In this operating mode, a maximum value is provided for the required fan power, so as to protect the fan 2 against an overload. The power of the fan 2 cannot be raised beyond this maximum value. For example, the maximum value for the fan power can be rated for a maximum flow resistance of the attachment 7 measuring 20 N. This flow resistance corresponds to the maximum sliding force that must be expended to guide the attachment 7 over the surface to be cleaned. The correlation between the negative pressure generated by the fan 2, the volume flow through the attachment 7 and the sliding force or flow resistance of the attachment 7 can be derived from the characteristic curves of the fan 2 for the currently used attachment 7.

[0025] In addition to the automatic mode, the slide switch 17 is also used to set two operating modes, in which a constant power of the fan 2 is used. The power of the fan 2 can measure 50 W in one operating mode, for example, and 300 W in another operating mode, for example.

[0026] Finally, the slide switch 17 can also be used to select an operating mode relating to a floor type-dependent maximum power stage of the fan 2. In this operating mode, the fan power is automatically set as a function of the type of surface to be cleaned, for example a constant fan power of 700 W for carpeted floors, and a constant fan

power of 450 W for hard floors. Not provided here, for example, is an automatic adjustment of these fan powers as a function of an arising sliding force, i.e., of a flow resistance of the attachment 7.

[0027] In addition, the operating element 16 has a key 18, which can be used to manually switch between the adjustment to hard floors and carpeted floors proceeding from the operating mode "floor type-dependent maximum power". For example, actuating the key 18 makes it possible to force a setting of the attachment 7 usually only employed for carpeted floors for also cleaning hard floors.

[0028] Fig. 2 shows a longitudinal section of the cleaning device 1. The base device 15 has the fan 2 and the filter chamber with the filter 14. The connection area 5 of the base device 15 incorporates the attachment 7. Air aspirated by the fan 2 passes through the attachment 7 and filter 14 and gets to the fan, and then to the environment. The connection area 5 has a suction area 6, in which the air getting to into the base device 15 through the attachment 7 is aspirated into the filter 14. A temperature sensor 13 is arranged in this suction area 6. Situated in a blow-out area 8 of the fan 2, i.e., in the flowing direction of the suction air behind the fan 2, is a circuit board 9, which can be cooled by the blow-out air of the fan 2. Arranged on this circuit board 9 is a pressure sensor 3, which is an absolute pressure sensor. The pressure sensor 3 further has allocated to it a measuring channel 10, the first end area 11 of which envelops the pressure sensor 3 on the circuit board 9, and the second end area 12 of which passes by the fan 2 and filter 14 and protrudes into the suction area 6. The second end area 12 defines a detection area 4 of the pressure sensor 3. With the help of the measuring channel 10, the pressure sensor 3 arranged in the blow-out area 8 of the fan 2 can measure the pressure in the suction area 6 formed in front of the filter 14.

[0029] In addition, the cleaning device 1 has an evaluator and controller (preferably also arranged on the circuit board 9), which serves to regulate the suction power of the cleaning device 1. As has yet to be explained below, this regulation takes place as a function of the measured values of the pressure sensor 3, possibly of the temperature sensor 13, and a recorded electrical power of the fan 2, as well as a speed of the fan 2.

[0030] The invention will now be explained with regard to the "automatic" operating mode. In order to set the automatic mode, the slide switch 17 is of the operating element 16 is brought into the corresponding position.

[0031] Moving the slide switch 17 into the "automatic" position initiates a first absolute pressure measurement by the pressure sensor 3. This pressure measurement takes place with the fan 3 turned off. If the cleaning device 1 operated in another operating mode up to this point in time, the fan 2 is initially turned off, if need be.

[0032] The initial absolute pressure measurement requires only a slight timespan, for example 300 milliseconds, so that the user of the cleaning device 1 is unable to perceive any time delay up to the time at which the fan 2 is turned on. After this first absolute pressure measurement has concluded, the fan 2 is automatically turned on by the evaluator and controller of the cleaning device 1. An absolute pressure that forms in the suction area 6 is subsequently determined during operation. This measurement with the fan 2 turned on is then advantageously repeated 10 to 20 times per second, for example. The difference between the absolute pressure measured with the fan 2 turned on and the initially measured absolute pressure with the fan 2 turned off is then determined, so that the negative pressure generated by the fan 2 is known.

[0033] In addition, a current and a voltage are measured in the usual way on the electrical supply lines of the fan 2, from which the electrical power consumed by the fan 2 is determined. A tachometer additionally measures the speed of the fan 2. The volume flow through the fan 2 is then determined from the determined fan power of the fan 2, the speed of the fan 2, the absolute pressure measured with the fan 2 turned off, and potentially the temperature measured by the temperature sensor 13. Based on this volume flow and the negative pressure generated by the fan 2, the flow resistance of the attachment 7 can be determined by comparing the measuring data with known characteristic curves of the fan 2. The determined flow resistance corresponds to the sliding force to be applied by a user of the cleaning device 1 to move the attachment 7 over the surface to be cleaned. This flow resistance or this sliding force is drawn upon to regulate the suction power of the cleaning device 1, wherein the suction power is regulated by varying the speed and/or fan power. The suction power is here preferably regulated to a constant value. This also takes place independently of a fill level of the filter 14. The method described involves a real regulation of the suction power, and does not relate to mere control.

[0034] If a situation arises during operation of the cleaning device 1 where the determined flow resistance exceeds a defined maximum value, for example because the attachment 7 has become attached to the surface to be cleaned or the filter 14 is completely filled, the fan power is not further increased to avoid overloading the fan 2. The defined maximum flow resistance or the corresponding maximum sliding force can be set at 20 N, for example.

[0035] In order to further determine a fill level of the filter 14, the determined flow resistance of the attachment 7 can be compared with reference values, which each are

characteristic for a specific fill level of the filter 14. For example, empirically determined characteristic lines or characteristic curves for different fill levels of the filter 14 are drawn upon for evaluation purposes, for example, if necessary also in relation to various operating modes or power stages of the fan 2.

REFERENCE LIST

- 1 Cleaning device
- 2 Fan
- 3 Pressure sensor
- 4 Detection area
- 5 Connection area
- 6 Suction area
- 7 Attachment
- 8 Blow-out area
- 9 Circuit board
- 10 Measuring channel
- 11 First end area
- 12 Second end area
- 13 Temperature sensor
- 14 Filter
- 15 Base device
- 16 Operating element
- 17 Slide switch
- 18 Key
- 19 Guide rod
- 20 Hand grip element

CLAIMS

1. A cleaning device (1), in particular a household vacuum cleaner, with a fan (2) and a pressure sensor (3) for determining a negative pressure generated by the fan (2), characterized in that the pressure sensor (3) is an absolute pressure sensor.
2. The cleaning device (1) according to claim 1, characterized in that the pressure sensor (3) has a detection area (4) allocated to a suction area (6) of the fan (2) arranged in a connection area (5) for an attachment (7).
3. The cleaning device (1) according to claim 2, characterized in that the pressure sensor (3) is arranged in a blow-out area (8) of the fan (2), in particular on a circuit board (9) arranged in the blow-out area (8) of the fan (2), wherein a measuring channel (10) is formed between the pressure sensor (3) and detection area (4), its first end area (11) being allocated to the pressure sensor (3), and its second end area (12) emptying into the suction area (6).
4. The cleaning device (1) according to one of the preceding claims, characterized in that a temperature sensor (13) is arranged in the connection area (5).
5. The cleaning device (1) according to one of the preceding claims, characterized by an evaluator and controller, which is designed to regulate a resultant suction power of the cleaning device (1) as a function of a negative pressure determined by the pressure sensor (3), a current fan power, and a current speed of the fan (2).

6. The cleaning device (1) according to claim 5, characterized in that the evaluator and controller is designed to also regulate the suction power as a function of a temperature measured by the temperature sensor (13).
7. A method for operating a cleaning device (1), in particular a household vacuum cleaner, wherein a suction power of the cleaning device (1) is varied as a function of a determined flow resistance of an attachment (7) of the cleaning device (1), characterized by the following procedural steps:
 - Measuring an absolute pressure in a suction area (6) of the fan (2) with the fan (2) turned off,
 - Measuring an absolute pressure in a suction area (6) of the fan (2) with the fan (2) turned on,
 - Determining the negative pressure generated by the fan (2) from the difference between the measured absolute pressures,
 - Determining a fan power of the fan (2),
 - Measuring a speed of the fan (2),
 - Determining the flow resistance of the attachment (7) from the negative pressure, fan power and speed through comparison with known fan characteristics of the fan (2),
 - Regulating the suction power of the cleaning device (1) by varying the speed of the fan (2) and/or the fan power as a function of the determined flow resistance.

8. The method according to claim 7, characterized in that the fan power cannot be further increased once a defined maximum flow resistance of the attachment (7) has been reached.
9. The method according to claim 7 or 8, characterized in that the flow resistance of the currently used attachment (7) is also determined as a function of a temperature currently measured in the connection area (5).
10. The method according to one of claims 7 to 9, characterized in that a fill level of a filter (14) arranged in a suction area (6) of a fan (2) is determined by comparing the determined flow resistance of the attachment (7) with reference values, which are each allocated to a specific fill level of the filter (14).