Title: HOOD AND METHOD OF OPERATION THEREOF

Abstract: The invention relates to a hood (1) comprising an inlet section (20) and an outlet section (50) respectively allowing the entry and exit of an air flow (60), fan means (30) filter means, and a control unit (70) operationally connected to said fan means (30) for controlling at least one operating parameter thereof, so as to take a measurement of the flow rate of the air flow (60) following the activation of an electric motor (31) associated with said fan means (30), after the detection of said at least one operating parameter.
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HOOD AND METHOD OF OPERATION THEREOF

DESCRIPTION
The present invention relates to an extraction hood and to a method of operation thereof. As is known, extraction hoods are used in both industrial and household environments, particularly in rooms where food is cooked (kitchens). In fact, during the food cooking process different types of substances are released in the air in the form of fumes, suspensions and the like. These substances often have an intense odour and/or can be harmful for people; therefore, they have to be extracted from the room and treated through a hood as quickly as possible.

For the treatment to be effective, it is important that the substance to be treated is known, because the food cooking process or the industrial treatment may release different types and quantities of substances in the air. For example, a cooking process for fried food will release in the air a greater quantity of volatile aldehydes than a cooking process for boiled food, which in turn will release in the air a greater quantity of water vapour than fried food. It is therefore necessary to adapt the air treatment process in accordance with the type of food to be prepared. One air treatment process variable available in an extraction hood is the air flow rate.

In order to make the air treatment even more effective, it is also important that the filter means of the hood are perfectly efficient; when in operation, in fact, the filter means tend to get clogged at a different rate depending on the type of fumes being treated. For example, a cooking process for fried food will release in the air a greater quantity of fumes than a cooking process for boiled food, which in turn will release in the air a greater quantity of water vapour than fried food. It is therefore necessary to constantly monitor the obstruction state of the filter means of an extraction hood. One variable which is useful to detect said obstruction state is the air flow rate.

Furthermore, for the air treatment to be effective, it is important that the hood is installed correctly; in fact, an improper installation will impair the performance of said hood, hindering the evacuation of the fumes. One variable, which is useful for determining the efficiency of a hood, is the flow rate of the air flow through the hood.

In order to ensure the proper installation of a hood, it is therefore necessary to know the flow rate of the air flow.
In rooms where food is to be cooked, air extractors and/or fans are typically also used, which ensure a certain number of air changes within a given time interval. These extractors/fans perform a task which is very similar to that of a hood, but they cause an increase in the number of apparatuses, and hence higher fixed and/or variable costs related to food cooking.

In order to reduce the number of apparatuses, it is proposed herein to use an extraction hood, in particular of the evacuating type, i.e. connected to the outside of the room where it has been installed, which can ensure a constant air flow so as to allow, in addition to extraction of fumes, also proper air changes in the room where it has been installed. To ensure all this, it is necessary to know the air flow rate.

For the purpose of keeping constant the efficiency of the air treatment process carried out by the filters of a hood, it is important to keep constant the flow of the air flowing therethrough, independently of the obstruction state of the filters. This problem has already been tackled and solved by the invention described in European patent application EP 0 314 085 by FOOD AUTOMATION-SERVICE TECHNIQUES, wherein the air flow rate can be adjusted through the use of a sail switch, which can sense the flow rate downstream of the hood filters.

However, this solution has the drawback that the sail switch might break or get stuck due to dirt, thus preventing the flow rate measurement. In addition, the presence of moving parts requires maintenance cycles at shorter intervals, resulting in higher running costs of said hood.

Furthermore, in order to keep constant the efficiency of the air treatment process carried out by the filter means of a hood, it is important to ensure that the filter means are in such a condition that allows the passage of a sufficient air flow. With the solution proposed in the above-mentioned prior art, it would be possible to check the obstruction state of the filter means, but a failure of the sail switch would make it impossible to know the obstruction state of said means.

By using the prior art, the man skilled in the art could determine the efficiency of the hood, after having also measured the power drawn by the motor fan with instruments well known in the art; however, a failure of the sail switch would make such a computation impossible.

By using the prior art, the man skilled in the art could attain, in the room where the hood
has been installed, a flow rate ensuring a certain number of air changes per time unit, but
a failure of the sail switch would make it impossible to measure the flow rate, and
therefore to be able to ensure a sufficient number of air changes per time unit.
Moreover, in the solution proposed by the prior art the speed of the fan means must
necessarily be variable, and therefore, at certain revolution speeds, a hood might enter into
resonance and cause a considerable increase in the noise emitted in operation. This kind of
selective phenomena may also occur within a frequency range wherein the emitted noise
is lowest, and their presence may be strongly influenced by the type of installation, i.e.
they may be influenced by the length and/or diameter of the exhaust pipe, the number of
bends of the latter, etc.

European patent application EP 0 596 846 A1 by ELECTROLUX AB describes a hood
equipped with an active noise-cancelling device using a loudspeaker. This loudspeaker,
when appropriately driven by a control unit, to which an acoustic sensor is also connected,
can reduce the noise emitted by the hood in operation.
This solution has, however, one drawback: active noise silencing is only effective when
the noise source is clearly identified and limited, e.g. an impeller in operation, whereas if
the noise source extends to the whole body of the hood, as is the case when a selective
phenomenon like resonance occurs, this type of approach can no longer be successfully
applied, because it would be necessary to use a large number of powerful loudspeakers,
which might cause hearing damage.

The present invention aims at solving these and others problems by providing a hood as
set forth in the appended claims.
The idea at the basis of the present invention is to determine and/or estimate a set of
operating variables of a hood following the activation of a fan means associated therewith,
de facto creating a virtual sensor capable of estimating the air flow rate through the hood
without using a real sensor like the one described in the prior art.
Furthermore, the idea at the basis of the present invention is to determine and/or estimate
a set of operating variables of a hood following the activation of a motor comprised in
said hood, de facto creating a virtual sensor capable of estimating the air flow rate
through the hood without using a real sensor like the one described in the prior art. This
allows to keep constant the air flow rate according to the type of cooking to be carried out
and/or to finely adjust the air flow rate within a certain range, when acoustic measurement
means detect a noise increase indicating the occurrence of a selective phenomenon such as resonance.

Further advantageous features of the present invention will be set out in the appended claims.

These features as well as the advantages of the present invention will become more apparent from the following description of an embodiment thereof as shown in the annexed drawings, which are supplied by way of non-limiting example, wherein:

Fig. 1 is a schematic perspective view of a hood according to the invention;

Fig. 2 shows a graph highlighting the relation between the current drawn at a certain revolution speed by the fan means associated with the hood and the flow rate of the air flowing therethrough;

Fig. 3 is a block diagram of a system for estimating the flow rate of an air flow through the hood of Fig. 1;

Fig. 4 is a block diagram of a control unit comprising the block of Fig. 3 and capable of controlling a process for treating an air flow through the hood of Fig. 1;

Fig. 5 shows a graph representing the isoafficiency curves of the hood of Fig. 1, determined in ideal conditions;

Fig. 6 is a block diagram of a system for measuring the efficiency of the hood of Fig. 1;

Fig. 7 shows a variant of the block diagram of the control system of Fig. 4, which also comprises the efficiency measurement system of Fig. 6.

With reference to Fig. 1, a hood 1 comprises a channel 10 with a pair of opposite side walls 11, a back wall 12 and a front wall 13; note that said front wall 13 is not shown in the annexed drawings, in order to show the internal architecture and components of the hood 1. The latter also comprises:

- an inlet section 20 for an air flow 60, containing fumes and/or substances coming from a process, preferably a food cooking process or the like;

- an outlet section 50 for the exit of the air flow 60;

- fan means 30 arranged between the inlet section 20 and the outlet section 50, wherein said fan means 30 may preferably comprise a motor fan (e.g. a model manufactured by EVEREL);

- filter means 40 to trap fumes and/or odours, interposed between the inlet section 20 and the outlet section 50, wherein said filter means 40 may be of a per se known
type, such as fibrous material cartridges, activated carbon layers, metal mesh layers, or combinations thereof;

- a control unit 70 connected to said fan means 30 and capable of controlling a process for treating the air flow 60, which will be further discussed hereafter.

The hood 1 according to the present invention can be alternatively positioned in front, behind or on one side of a cooking top (not shown in the drawing), so as to be able to collect most odours and fumes produced by the latter.

The fan means 30 comprise a variable-speed electric motor 31, preferably of the permanent-magnet synchronous three-phase brushless type, associated with an impeller 32 that provides circulation of the air flow 60.

When the fan means 30 are in operation, the hood 1 takes in the air 60 from the inlet section 20 and exhausts it through the outlet section 50.

When the hood 1 is in operation, the filter means 40 tend to get clogged by solid particles and liquid droplets present in the air flow 60, thus increasing the friction losses along the channel 10. As aforementioned in the introduction, in order to be able to keep constant the value of the flow rate of the air flow 60 it is necessary to estimate the flow rate by means of a suitable system. In the present invention, this estimation system comprises means for measuring at least one electric quantity associated with the operation of the fan means 30, e.g. current, and means for measuring or estimating at least one mechanical quantity of said fan means 30, e.g. the revolution speed thereof.

In fact, knowing the characteristics of the fan means 30, obtained from electromechanical curve measurements taken on an aero-technical test bench, it is possible to get an estimate, at a given instant, of the value of the flow rate of the air flow 60 by measuring a current drawn by the motor 31 of the fan means 30 and by measuring or estimating the revolution speed at the same instant.

Knowing the characteristics of the fan means 30 means herein knowing a model capable of providing, for each value of revolution speed and drawn electric current, the respective flow rate value.

This model depends on the specific fan means 30 in use (motor 31 and impeller 32), and can be experimentally obtained by using well-known regression statistical techniques, by starting from the data detected during a measurement campaign carried out on an aero-technical test bench exclusively on the fan means 30, i.e. with the latter not coupled to the
hood 1.

More specifically, the measurement campaign can be organized as follows: the current and/or power (dependent variable(s)) drawn by the motor 31 are measured with different flow rates of a test air flow (independent variable) flowing through the fan means 30, while keeping constant the revolution speed (control variable) of said fan means 30. The current and/or power measurements should preferably be repeated for each revolution speed at which the fan means 30 will operate in normal working conditions, i.e. when coupled to the hood 1.

With reference to Fig. 2, the dependency that binds the current drawn by the motor 31 to the flow rate of the test air flow flowing through the fan means 30 is typically a linearly increasing one (the greater the flow rate of the test air flow, the higher the current drawn by the motor 31), i.e. according to the following relation:

$$\text{FlowRate}_{rpm_x} = m_{rpm_x} \text{DrawnCurrent} + q_{rpm_x}$$

Where the parameters $m_{rpm_x}$ and $q_{rpm_x}$ are specific for a particular revolution speed $rpm_x$ of the fan means 30, and where $m_{rpm_x}$ is greater than zero.

With reference to Fig. 3, a flow rate model 71, created by means of a computer or electronic circuitry program, can output an estimated flow rate value by using, as inputs, the values of the revolution speed of and the current drawn by the fan means 30; said flow rate model 71 can be defined by a set containing $x$ pairs of parameters $m_{rpm_x}$ and $q_{rpm_x}$, where $x$ is the number of revolution speeds at which the fan means 30 can operate.

It is obviously possible for the man skilled in the art to create flow rate models which are more complex than the one composed of a family of linear relations defined by the parameters $m_{rpm_x}$ and $q_{rpm_x}$, without however departing from the teachings of the present invention. For example, if the revolution speed of the motor 31 is continuously variable, it is possible, by interpolating the measured curves, to manage a virtually infinite number of revolution speeds $rpm_x$.

With reference to Fig. 4, there is shown the control system 70, comprising a feedback loop, in turn comprising the flow rate model 71, and a controller 72 adapted to generate control signals for the inverter 73, such as to eliminate the flow rate error; the control system 70 implements a flow rate control of said motor 31.

A method for controlling the process for treating the air flow 60 according to the invention comprises the following steps:
a. estimating the value of the flow rate of the air flow 60, by measuring electromechanical quantities associated with the operation of the motor 31 of the fan means 30;

b. generating, through the inverter 73, control signals for the motor 31, which are adapted to keep constant the value of the flow rate of the air flow 60;

wherein the electromechanical quantities comprise the revolution speed of the motor 31 and the current drawn by said motor 31. Furthermore, steps (a) and (b) of the above-defined method can be repeated cyclically by the control unit 70.

The flow rate model 71 advantageously allows to close the feedback loop by providing the estimated value of the flow rate of the air flow 60, without having to use specific flow rate sensors. The flow rate value thus estimated is then subtracted from a reference flow rate value (set point), thereby obtaining a flow rate error value which is inputted to the controller 72.

Based on control laws previously defined through techniques well known to those skilled in the art, the controller 72 generates, as its output, the control signals for the inverter. The latter are inputted to the inverter 73, which will then properly drive the windings comprised in the motor 31 so as to cause the estimated flow rate of the fan means 30 to become as quickly as possible equal to the reference flow rate set by the user or set automatically by the control system 70. In this manner, it is possible to control the flow rate without using specific flow rate sensors, by exploiting mechanical and electrical quantities which can be easily measured and/or estimated.

In addition, the controller 72 may be inputted the values of the revolution speed of and the current drawn by the fan means 30, so that the controller 72 can supervise the operation of said fan means 30 and control the motor 31 according to well-known algorithms and/or detect any problems that might arise, such as seizures, failures or the like.

The current drawn by the motor 31 may advantageously be measured by using techniques which are well known to those skilled in the art, such as, for example, shunts in the inverter 73 that drives the motor 31, without any moving parts being used. For measuring the revolution speed, instead, Hall-effect sensors may be used, which are usually already included in the stator of a permanent-magnet three-phase motor, and which can generate a signal when the permanent magnets on the rotor of the motor 31 pass in front of said Hall-effect sensors, thereby allowing to measure the revolution speed of said rotor. As an
alternative, the revolution speed may be measured by using sensors such as encoders, resolvers, tachometers. As a further alternative, said revolution speed may be estimated by using known sensorless control algorithms which, for example, measure the back electromotive force (back-EMF) by measuring the voltages and/or currents induced on the windings of the motor 31.

It is of course possible for the man skilled in the art to use techniques for measuring the current drawn by and/or the revolution speed of the motor 31 which are alternative to the above, without however departing from the teachings of the present invention. The operation of the control unit 70 allows to keep constant the flow rate of the air flow 60 flowing inside the hood 1 independently of the obstruction state of the filter means 40, in that the greater the obstruction of the latter, the greater the pressure drop value downstream of said filter means 40; assuming that the revolution speed of the motor 31 is kept constant, this will cause a flow rate reduction that will decrease the current drawn by the motor 31. This current reduction will lower the value outputted to the flow rate model 71, which will supply a greater flow rate error value to the controller 72, which in turn will modify the control signals inputted to the inverter 73 in such a way as to increase the current drawn by the motor 31 and, as a consequence, the flow rate of the air flow 60. More in general, the control signals inputted to the inverter 73 will be modified in such a way as to act in a combined manner on the current drawn by and the revolution speed of the motor 31, for the purpose of keeping constant the flow rate of the air flow 60. The reference flow rate value can be set by a user of the hood 1 through an interface (not shown in the annexed drawings), e.g. a keypad, by means of which the reference flow rate value can be set either directly or indirectly. The reference flow rate can be set directly by entering, through said interface, the numerical value of the desired flow rate of the air flow 60. As an alternative, the user can select a desired cooking type through said interface, which is operationally connected to a supervision unit. The supervision unit (not shown in the annexed drawings), which is comprised in the hood 1 and is operationally connected to the control unit 70, will then associate, based on a predetermined correspondence table stored in said supervision unit, the corresponding reference flow rate value to be set, which will be sent to the input of the control unit 70. To make the selection easier, the cooking type may be chosen from a set of predefined cooking programs.
The set of cooking programs comprises a “BOILED” program and a “FRIED” program, wherein the supervision unit associates with the “BOILED” program a reference flow rate value which is higher than the one associated with the “FRIED” program.

In summary, a method for controlling the treatment of the air flow 60 based on the cooking type comprises the following steps:
   a. selecting a cooking type;
   b. associating a reference flow rate value on the basis of the cooking type selected at step (a);
   c. estimating the flow rate of the air flow 60;
   d. generating control signals for the motor 31, adapted to try to keep the estimate of the flow rate of the air flow 60, made at step (c), substantially equal to the reference flow rate value associated at step (b).

Furthermore, the interface may also be used for specifying the number of cubic meters of the room where the hood 1 has been installed, so that the supervision unit can calculate a reference flow rate value to be sent to the control unit 70 which can ensure a given number of air changes per time unit. In places like kitchens, in fact, there is a need to ensure a certain number of air changes per hour, and extractors are often installed to specifically fulfill this requirement. With the hood 1 according to the invention, such a requirement can be fulfilled by using said hood 1 alone. The number of air changes per hour may either be predetermined by the manufacturer in accordance with the standards of good practice or may be set by the user through said interface.

Therefore, a method for making a number of air changes within a predefined time interval in a room where the hood 1 has been installed comprises the following steps:
   a. measuring the flow rate of the air flow 60 flowing inside the hood 1;
   b. generating, based on the flow rate measured at step (a), control signals for the motor 31, so that the flow rate of the air flow 60 is kept constant.

Both of the above-mentioned steps are preferably repeated cyclically when said hood 1 is in an operating condition.

Another advantage offered by the use of the control unit 70 is the possibility of recognizing an unsatisfactory installation state of the hood 1, for example due to the adoption of an exhaust pipe that is smaller than required by the rules of good installation practice, excessively long or improperly positioned; such a situation, in fact, will
adversely affect the flow rate value, which will be lower than a nominal value predetermined on the basis of tests carried out by the manufacturer in nominal test conditions representing a properly installed hood.

Therefore, a method for detecting the installation state of the hood 1 comprises the following steps:

a. measuring the nominal flow rate value of the air flow 60 when the hood 1 is in an ideal installation condition;

b. estimating the value of the flow rate of the air flow 60 in preset operating conditions of the motor (31);

c. determining the installation state of the hood 1 by comparing the flow rate values obtained at steps (a) and (b).

Steps (b) and (c) of the method are preferably activated by the user or by an installer through the interface.

While measuring the flow rates at steps (a) and (b), the motor 31 is preferably run at a constant speed, more preferably at its highest speed. This will highlight any differences in the flow rate of the air flow 60 due to the installation conditions.

The installation state is determined on the basis of an algebraic ratio between the value of the flow rate of the air flow 60 determined at step (b) and the value of the nominal flow rate determined at step (a), and may take one of the following values:

- if the ratio is higher than a first threshold, preferably 0.75, then the installation state will be considered to be "OK", or good;

- if the ratio value is lower than or equal to said first threshold, then the installation state will be considered to be "NOK", or not good.

It is also conceivable to use a variant that includes a second threshold, lower than the first one and preferably equal to 0.5, to allow quantifying the insufficiency of the installation level. In this variant, when the ratio is lower than the first threshold, the installation state may take one of the following values:

- if the ratio is higher than the second threshold, then the installation state will be considered to be "NOK-improvable", i.e. it is acceptable on condition that flow rate levels close to the maximum ones are not required;

- if the ratio is lower than or equal to said second threshold, then the installation state will be considered to be "NOK-repeat installation", i.e. the hood 1 must be
installed again.
A further advantage offered by the use of the control unit 70 is the possibility of recognizing an obstructed condition of the filter means 40, so that such a situation can be signalled, through suitable signalling means such as a warning lamp and/or an audible alarm or the like, without having to use a differential pressure sensor upstream and downstream of said filter means 40; this situation is detected through periodic verifications carried out by a self-diagnosis procedure, which is preferably executed when the hood 1 is switched on. When installation is complete and the hood is switched on for the first time, an estimated flow rate value is stored at a predefined revolution speed, preferably the highest speed. Every time the hood is switched on again, the self-diagnosis procedure will estimate the flow rate at said predefined revolution speed. Any variation in the flow rate from the value stored at start-up will be indicative of the filter obstruction degree. When the estimated flow rate becomes lower than a minimum threshold value, it will be signalled that the filter needs to be replaced.

In summary, a method for detecting the obstructed condition of the filter means 40 comprises the following steps:

a. estimating the flow rate of the air flow 60 when the filter means 40 are in an unobstructed condition (e.g. when they are new or have just been cleaned);
b. determining the onset of the obstructed condition on the basis of a second estimate of the air flow 60 and of the estimate made at step (a).

More specifically, the onset of the obstructed condition is determined when the ratio between the estimate of the flow rate of the air flow 60 made at step (a) and the second estimate made at step (b) is above a threshold value, preferably equal to 2.

A further advantage offered by the use of the control unit 70 is the possibility of reducing the noise.

Based on experimental tests, the Applicant has observed that the noise generated by the hood, which generally increases with the flow rate, typically has a non-monotonic trend through the operating range. Due to selective phenomena, such as, for example, resonances, it may happen that within a certain range of flow rate values there are one or more relative minimum points of generated noise, where the hood could advantageously operate to reduce the generated noise without any significant flow rate variation. The generated noise can be measured through acoustic measurement means 90 comprised in
the hood 1 and comprising a microphone; said acoustic measurement means 90 are adapted to generate a signal corresponding to the noise generated by the hood. Said measurement means 90 are in signal communication with a noise control system (not shown in the annexed drawings) and supply thereto the information corresponding to the generated noise, said noise control system being possibly comprised in the control unit 70. According to the invention, therefore, the noise silencing procedure makes a fine adjustment of the flow rate within a predetermined range of the reference flow rate value defined by the control system 70, in search for an operating point of minimum noise. Said predetermined range is preferably equal to +/- 2% of the reference flow rate value, more preferably to +/- 1% of the reference flow rate value.

In substance, the method for reducing the noise emitted by the hood 1 comprises the following steps:

a. measuring a noise level through the acoustic measurement means 90;

b. estimating a flow rate of the air flow 60;

c. generating control signals for the motor 31, adapted to try to keep the estimate of the flow rate of the air flow 60, made at step (b), substantially equal to a reference flow rate value and the noise level measured at step (a) below a threshold.

Further benefits deriving from the use of the present invention concern the energetic efficiency of the hood 1. In fact, by measuring not only the current, but also the power (or the voltage) drawn by the motor 31, it is possible to (indirectly) measure the efficiency value of the hood 1. By so doing, one can try to operate the fan means 30 in such a way as to obtain the highest efficiency.

In this regard, Figure 5 shows a family of characteristic curves (solid lines) of the fan means 30, each one representing the flow rate-prevalence relation at a certain revolution speed of said fan means 30. These curves can be easily determined experimentally, but they are usually included by the manufacturer in the nominal data of the fan means 30.

By conducting a measurement campaign as already described, and by calculating the efficiency values as ratios between the values of the flow rate of the air flow 60 flowing through the fan means 30 and the respective values of the power drawn by the motor 31 of said fan means 30 (normalized within the range [0,1]), it is possible to experimentally determine iso-efficiency curves (dashed lines) intersecting the characteristic curves at the working points of the fan means 30, thus allowing to know, at said points, the value of the
efficiency of the fan means 30.
The isoefficiency curves are closed curves arranged concentrically to a maximum isoefficiency curve \( \eta_{\max} \), which associates with each flow rate value of the air flow 60 the respective optimal prevalence value generated by the fan means 30.

Of course, the example described so far may be subject to many variations.

A first variant, which can benefit from the efficiency measurement, is shown in Figs. 6 and 7; for brevity, the following description will only highlight those parts which make this and the next variants different from the above-described main embodiment; for the same reason, wherever possible the same reference numerals, with the addition of one or more apostrophes, will be used for indicating structurally and/or functionally equivalent elements.

This variant comprises a control circuit 70' similar to the control circuit 70 of the preceding example, but also comprising a controller 72' with two inputs (instead of one) and an efficiency model 74.

The efficiency model 74 can also be created through a computer and/or electronic circuitry program, and can output an efficiency value, being inputted a set of variables comprising the following variables:

- value of the flow rate of the air flow 60, determined through the flow rate model 71;

- value of the power drawn by the motor 31 of the fan means 30.

The simplest way to create the efficiency model 74 is to use a computer and/or electronic circuitry program capable of calculating the ratio between the value of the flow rate of the air flow 60 and the value of the power drawn by the motor 31, and then of multiplying the result by a normalization factor, in order to normalize the efficiency value outputted by the model 74 to a value comprised between 0 and 1. The normalization factor is calculated by dividing the value of the power drawn by the fan means 30 when operating in the maximum efficiency condition by the value of the flow rate obtained from said fan means 30.

It is of course possible for a man skilled in the art to create a more complex efficiency model 74, i.e. one using more sophisticated regression models that can use a larger number of input variables, such as, for example, the temperature of the air flow 60, pressure or the like.
The method for controlling the process for treating the air flow 60 according to this variant of the invention comprises the following steps:

a. measuring the value of the flow rate of the air flow 60 and determining an efficiency value of the hood 1 by measuring electromechanical quantities associated with the operation of the motor 31;

b. selecting a revolution speed value at which the motor 31 of the fan means 30 will be kept, on the basis of the flow rate and efficiency values measured at step (a); wherein the electromechanical quantities comprise the revolution speed of the motor 31, the current and the power drawn by said motor 31.

The efficiency value outputted by the efficiency model 74 allows, within the control circuit 70', to calculate an efficiency offset value by simply calculating a difference between a unitary value and the efficiency value. This efficiency offset value is then inputted to the controller 72', which, by using suitable control laws, will select appropriate control signals for the inverter to advantageously keep both the flow rate error value and the efficiency offset value as low as possible.

By using the control unit 70', just like the control unit 70 used in the preceding example, it is possible to keep constant the flow rate of the air flow 60 flowing inside the hood 1 independently of the air density conditions, thereby minimizing consumption and maximizing efficiency.

Of course, the example described herein may be subject to further variations, which will nonetheless still fall within the scope of the following claims.
CLAIMS

1. A hood (1) for treating an air flow (60), comprising an inlet section (20) and an outlet section (50) respectively allowing the entry and exit of said air flow (60), fan means (30) and filter means (40) arranged between said inlet section (20) and said outlet section (50), a control unit (70) operationally connected to said fan means (30) for controlling at least one operating parameter thereof,

characterized in that

the control unit (70) estimates the flow rate of the air flow (60) following the activation of an electric motor (31) associated with said fan means (30), after the detection of said at least one operating parameter of said motor (31).

2. A hood (1) according to claim 1, wherein the operating parameter comprises a current drawn by and/or a revolution speed of said motor (31).

3. A hood (1) according to claim 2, wherein the control unit (70) comprises a flow rate model (71) which, based on input values of the current drawn by and the revolution speed of said motor (31), can output a value of the flow rate of the air flow (60).

4. A hood (1) according to any one of claims 1 to 3, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type.

5. A hood (1) according to claim 4, wherein the motor (31) is connected to and driven by an inverter (73).

6. A hood (1) according to any one of claims 2 to 5, wherein the current drawn by said motor (31) is measured by means of at least one shunt coupled to a supply phase of the motor (31).

7. A hood (1) according to any one of claims 2 to 6, wherein the revolution speed of said motor (31) is measured by means of Hall-effect sensors comprised in the motor (31).

8. A hood (1) according to any one of claims 1 to 7, comprising an interface through which it is possible to set a reference flow rate value.

9. A method for controlling the treatment of an air flow (60) flowing through a hood (1) according to any one of claims 1 to 8, comprising the steps of:

a. estimating a flow rate of the air flow (60),

b. generating, on the basis of the flow rate estimated at step (a), control signals for fan means (30) adapted to keep constant the value of the flow rate of the air flow (60),

characterized in that
the estimate of the flow rate of the air flow (60) is made by detecting at least one
electromechanical quantity associated with the operation of the fan means (30).
10. A method according to claim 9, wherein steps (a) and (b) are repeated cyclically.
11. A method according to claim 9 or 10, wherein the electromechanical quantity
comprises a revolution speed of and/or a current drawn by the fan means (30).
12. A method according to any one of claims 9 to 11, wherein the generation of the
control signals for the fan means (30) occurs also on the basis of a reference flow rate
value.
13. A method according to claim 12, wherein the reference flow rate value is set
through an interface comprised in said hood (1).
14. A method according to claim 13, wherein the interface allows the reference flow
rate value to be set directly.
15. A method according to claim 13, wherein the interface allows the reference flow
rate value to be set indirectly by associating a specific reference flow rate value with a
cooking type.
16. A hood (1) for treating an air flow (60), comprising an inlet section (20) and an
outlet section (50) respectively allowing the entry and exit of said air flow (60), fan
means (30) and filter means arranged between said inlet section (20) and said outlet
section (50), a control unit (70) operationally connected to said fan means (30) for
controlling the flow rate of the air flow (60),
characterized in that
the control unit (70) estimates the flow rate of the air flow (60) following the activation of
an electric motor (31) associated with said fan means (30) and on the basis of the
detection of at least one operating parameter, so as to detect an obstructed condition of the
filter means (40) by comparing the estimated flow rate of the air flow (60) with a
reference flow rate value.
17. A hood (1) according to claim 16, wherein the reference flow rate value is
detected when the filter means (40) are in an unobstructed condition.
18. A hood (1) according to claim 16 or 17, wherein the operating parameter
comprises a current drawn by and/or a revolution speed of said motor (31).
19. A hood (1) according to claim 18, wherein the control unit (70) comprises a flow
rate model (71) which, based on input values of the current drawn by and the revolution
speed of said motor (31), can output a value of the flow rate of the air flow (60).
20. A hood (1) according to any one of claims 16 to 19, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type.
21. A hood (1) according to claim 20, wherein the motor (31) is connected to and driven by an inverter (73).
22. A hood (1) according to any one of claims 18 to 21, wherein the current drawn by said motor (31) is measured by means of at least one shunt coupled to a supply phase of the motor (31).
23. A hood (1) according to any one of claims 18 to 22, wherein the revolution speed of said motor (31) is measured by means of Hall-effect sensors comprised in the motor (31).
24. A hood (1) according to any one of claims 16 to 23, comprising signalling means for signalling the onset of the obstructed condition of the filter means (40).
25. A method for detecting an obstructed condition of filter means (40) comprised in a hood (1) according to any one of claims 16 to 24, wherein an air flow (60) generated by fan means (3) flows through said filter means (40), said method comprising the steps of:
a. estimating a flow rate of the air flow (60) when the filter means (40) are in an unobstructed condition,
b. determining the onset of the obstructed condition of the filter means (40) on the basis of a second estimate of the air flow (60) and of the estimate made at step (a),
characterized in that
the flow rate of the air flow (60) is estimated by detecting at least one electromechanical quantity associated with the operation of an electric motor (31) coupled with the fan means (30).
26. A method according to claim 25, wherein step (b) is repeated every time the hood (1) is switched on.
27. A method according to claim 25 or 26, wherein the electromechanical quantity comprises a revolution speed of the fan means (30) and/or a current drawn by said fan means (30).
28. A method according to any one of claims 25 to 27, wherein, during the execution of steps (a) and (b), the revolution speed of the motor (31) is highest.
29. A method according to any one of claims 25 to 28, wherein the onset of the
obstructed condition is determined when the ratio between the estimate of the flow rate of the air flow (60) made at step (a) and the second estimate made at step (b) is above a threshold value.

30. A method according to claim 29, wherein the threshold value is 2.

31. A hood (1) comprising an inlet section (20) and an outlet section (50) respectively allowing the entry and exit of an air flow (60), fan means (30) arranged between said inlet section (20) and said outlet section (50), and a control unit (70) operationally connected to said fan means (30),

**characterized in that**

the control unit (70) estimates the flow rate of the air flow (60) following the activation of a motor (31) associated with said fan means (30) and on the basis of the detection of at least one operating parameter, so as to detect an installation state of the hood (1) by comparing the estimated flow rate of the air flow (60) with a nominal flow rate value of said air flow (60).

32. A hood (1) according to claim 31, wherein the nominal flow rate value is determined when said hood (1) is in an ideal installation condition.

33. A hood (1) according to claim 31 or 32, wherein the operating parameter comprises a current drawn by and/or a revolution speed of said motor (31).

34. A hood (1) according to claim 33, wherein the control unit (70) comprises a flow rate model (71) which, based on input values of the current drawn by and the revolution speed of said motor (31), can output a value of the flow rate of the air flow (60).

35. A hood (1) according to any one of claims 31 to 34, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type.

36. A hood (1) according to claim 35, wherein the motor (31) is connected to and driven by an inverter (73).

37. A hood (1) according to any one of claims 33 to 36, wherein the current drawn by said motor (31) is measured by means of at least one shunt coupled to a supply phase of the motor (31).

38. A hood (1) according to any one of claims 33 to 37, wherein the actual revolution speed of said motor (31) is measured by means of Hall-effect sensors comprised in the motor (31).

39. A hood (1) according to any one of claims 31 to 38, comprising signalling means
for signalling the installation state of said hood (1).

40. A method for detecting an installation state of a hood (1) according to any one of claims 31 to 39, comprising the steps of:
   a. measuring a nominal flow rate value of an air flow (60) when the hood (1) is in an ideal installation condition,
   b. estimating a value of a flow rate of the air flow (60) in preset operating conditions of a motor (31) associated with a motorized fan (30) comprised in said hood (1),
   c. determining the installation state of the hood (1) by comparing the flow rate values obtained at steps (a) and (b),

wherein the estimate of the flow rate of the air flow (60) is made by detecting at least one electromechanical quantity associated with the operation of the electric motor (31).

41. A method according to claim 40, wherein steps (b) and (c) can be activated through an interface comprised in the hood (1).

42. A method according to claim 40 or 41, wherein the electromechanical quantity comprises a revolution speed of the fan means (30) and/or a current drawn by said fan means (30).

43. A method according to any one of claims 40 to 42, wherein, during the execution of steps (a) and (b), the revolution speed of the motor (31) is highest.

44. A method according to claim 43, wherein, based on a ratio between the value of the flow rate of the air flow (60) determined at step (b) and the value of the nominal flow rate determined at step (a), the installation state of the hood (1) may be either "OK", if the ratio is higher than a first threshold, or "NOK", if the ratio is lower than or equal to said first threshold.

45. A method according to claim 44, wherein, if the ratio is lower than the first threshold, then the installation state of the hood (1) may be "NOK-improvable", if the ratio is higher than a second threshold that is lower than the first threshold, or "NOK-repeat-installation", if the ratio is lower than or equal to said second threshold.

46. An extraction hood (1) comprising an inlet section (20) and an outlet section (50) respectively allowing the entry and exit of an air flow (60), fan means (30) arranged between said inlet section (20) and outlet section (50), a control unit (70) operationally connected to the fan means (30) for controlling the flow rate of the air flow (60) in the hood (1),
characterized in that
the control unit (70) estimates the flow rate following the activation of an electric motor (31) associated with the fan means (30), after the detection of at least one operating parameter of said motor (31), in order to allow making a number of air changes, within a predefined time interval, in a room where said hood (1) has been installed.

47. A hood (1) according to claim 46, comprising an interface through which it is possible to set a room volume value.
48. A hood (1) according to claim 47, wherein the interface allows setting said number of air changes to be made within the predefined time interval.
49. A hood (1) according to any one of claims 46 to 48, wherein said supervision unit determines the flow rate which is suitable for ensuring the execution of said number of air changes within the predefined time interval, on the basis of said room volume value.
50. A hood (1) according to any one of claims 46 to 49, wherein the operating parameter comprises a current drawn by and/or a revolution speed of said motor (31).
51. A hood (1) according to claim 50, wherein the control unit (70) comprises a flow rate model (71) which, based on input values of the current drawn by and the revolution speed of said motor (31), can output a value of the flow rate of the air flow (60).
52. A hood (1) according to any one of claims 46 to 51, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type, and is connected to and driven by an inverter (73).
53. A hood (1) according to any one of claims 49 to 52, wherein the current drawn by said motor (31) is measured by means of at least one shunt coupled to a supply phase of the motor (31).
54. A hood (1) according to any one of claims 49 to 53, wherein the revolution speed of said motor (31) is measured by means of Hall-effect sensors comprised in the motor (31).
55. A method for making a number of air changes within a predefined time interval in a room where a hood (1) according to any one of claims 46 to 54 has been installed, comprising the steps of:

a. estimating a flow rate of an air flow (60) flowing inside the hood (1),
b. generating, based on the flow rate estimated at step (a), control signals for a variable-speed motor (31) comprised in fan means (30), so that the flow rate of the air
65. A hood (1) according to claim 64, wherein the set of cooking programs comprises a "BOILED" program and a "FRIED" program, wherein the supervision unit associates with the "BOILED" program a reference flow rate value which is higher than the one associated with the "FRIED" program.

66. A hood (1) according to any one of claims 61 to 65, wherein the operating parameter comprises a current drawn by and/or a revolution speed of said motor (31).

67. A hood (1) according to claim 66, wherein the control unit (70) comprises a flow rate model (71) which, based on input values of the current drawn by and the revolution speed of said motor (31), can output a value of the flow rate of the air flow (60).

68. A hood (1) according to any one of claims 61 to 67, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type.

69. A method for controlling the treatment of an air flow (60) on the basis of a cooking type, wherein said air flow (60) flows through a hood (1) according to any one of claims 61 to 68, comprising the steps of:

a. selecting a cooking type,

b. associating a reference flow rate value on the basis of the cooking type selected at step (a),

c. estimating a flow rate of the air flow (60),

d. generating control signals for a variable-speed motor (31) associated with fan means (30) adapted to try to keep the estimate of the flow rate of the air flow (60), made at step (c), substantially equal to the reference flow rate value associated at step (b), wherein at step (c) the estimate of the flow rate of the air flow (60) is made by detecting at least one electromechanical quantity associated with the operation of the fan means (30).

70. A method according to claim 69, wherein steps (c) and (d) are repeated cyclically.

71. A method according to claim 69 or 70, wherein the electromechanical quantity comprises a revolution speed of and/or a current drawn by the fan means (30).

72. A method according to any one of claims 69 to 71, wherein the step (a) of selecting a cooking type is carried out through an interface comprised in the hood (1).

73. A method according to any one of claims 69 to 72, wherein step (b) is carried out by a supervision unit, which is comprised in the hood (1), on the basis of a correspondence table stored in said supervision unit.
74. A hood (1) for treating an air flow (60), comprising an inlet section (20) and an outlet section (50) respectively allowing the entry and exit of said air flow (60), fan means (30) and filter means (40) arranged between said inlet section (20) and said outlet section (50), a control unit (70) operationally connected to said fan means (30) for controlling at least one operating parameter thereof, acoustic measurement means (90) in signal communication with a noise control system comprised in the control unit (70), characterized in that

the control unit (70) estimates the flow rate of the air flow (60) following the activation of a variable-speed electric motor (31) associated with said fan means (30), after the detection of said at least one operating parameter of said motor (31), and wherein said control unit (70) generates control signals for the motor (31), for the purpose of trying to keep the estimated flow rate of the air flow (60) near a reference flow rate value and a noise level measured by the acoustic measurement means (90) below a threshold value.

75. A hood (1) according to claim 74, wherein the threshold is equal to the noise level measured when the estimated air flow (60) is equal to the reference flow rate value.

76. A hood (1) according to claim 74 or 75, wherein the noise control system varies the reference flow rate value within a range of +/- 2% of the same.

77. A hood (1) according to claim 76, wherein the range is equal to +/- 1% of the reference flow rate value.

78. A hood (1) according to any one of claims 74 to 77, wherein the operating parameter comprises a current drawn by and/or a revolution speed of said motor (31).

79. A hood (1) according to claim 78, wherein the control unit (70) comprises a flow rate model (71) which, based on input values of the current drawn by and the revolution speed of said motor (31), can output a value of the flow rate of the air flow (60).

80. A hood (1) according to any one of claims 74 to 79, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type.

81. A method for reducing the noise emitted by a hood (1) according to any one of claims 74 to 80, wherein said hood (1) is run through by an air flow (60), comprising the steps of:

a. measuring a noise level through acoustic measurement means (90),
b. estimating a flow rate of the air flow (60),
c. generating control signals for a variable-speed motor (31) associated with fan
means (30) adapted to try to keep the estimate of the flow rate of the air flow (60), made at step (b), substantially equal to a reference flow rate value and the noise level measured at step (a) below a threshold,

wherein at step (b) the estimate of the flow rate of the air flow (60) is made by detecting at least one electromechanical quantity associated with the operation of the fan means (30).

82. A method according to claim 81, wherein the electromechanical quantity comprises a revolution speed of and/or a current drawn by the fan means (30).

83. A method according to any one of claims 81 to 82, wherein at step (c) the reference flow rate value is varied within a range of +/- 2% of the same.

84. A method according to claim 83, wherein at step (c) the reference flow rate value is varied within a range of +/- 1% of the same.
Relation among Flow Rate, Drawn Current, and Actual Revolution Speed

Fig. 2
Flow Rate Model

\[ \text{Flow Rate} = f(\text{Drawn Current, Actual Revolution Speed}) \]

Fig. 3

Drawn Current
Revolution Speed
Parameters

Fig. 4

Controller
Flow Rate Model
Flow Rate Error
Reference Flow Rate (Set Point)
Control Signals
Drawn Current
Revolution Speed
Drawn Current
Revolution Speed
Flow Rate
Efficiency Model

\[ \text{Efficiency} = g(\text{Flow Rate, Drawn Power}) \]

Fig. 6

Controller

Efficiency Model

Flow Rate Model

Inverter

Control Signals

Revolution Speed

Drawn Current

Drawn Power

Flow Rate

Efficiency Offset

Flow Rate Error

Reference Flow Rate (SetPoint)

\[ 1^+ \]

\[ 1^- \]