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(54) HOOD AND METHOD OF OPERATION THEREOF

HAUBE UND VERFAHREN ZUM BETRIEB DAVON
HOTTE ET PROCÉDÉ POUR SON EXPLOITATION

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Description

[0001] The present invention relates to an extraction hood and to a method of operation thereof.

[0002] 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.

[0003] 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.

[0004] 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.

[0005] 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.

[0006] In order to ensure the proper installation of a hood, it is therefore necessary to know the flow rate of the air flow.

[0007] 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.

[0008] 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.

[0009] 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.

[0010] 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.

[0011] 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.

[0012] 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.

[0013] 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.

[0014] 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.

[0015] 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.

[0016] 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.

[0017] 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. US 2005/0224069 A1 discloses a kitchen ventilation system including a sensor for detecting a chemical composition over an active zone of a cooktop. The system also includes an air moving device for displacing air including the chemical composition. A control circuitry is coupled to the sensor and to the air moving device for regulating operation of the air moving device.

[0018] WO 2010/120429 A2 discloses a ventilation system comprising a fan and a motor driving the fan, for providing a substantially constant airflow based on an electric current provided to the motor and a rotational speed of the motor. The present invention aims at solving these and others problems by providing a hood according to claim 1 and a method for controlling the treatment of an air flow according to claim 9. 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 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.

[0019] 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.

[0020] Further advantageous features of the present invention will be set out in the appended claims.

[0021] 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 isoefficiency 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 block diagram according to the present invention, which is a variant of the block diagram of the control system of Fig. 4, but which further comprises the efficiency measurement system of Fig. 6.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.
[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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:

$$FlowRate_{rpm_x} = m_{rpm_x} DrawnCurrent + q_{rpm_x}$$

[0032] 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.

[0033] 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.

[0034] 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 .

[0035] 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.

[0036] A method for controlling the process for treating the air flow 60 according to an example not part of 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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).

[0046] 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.

[0047] 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.

[0048] Both of the above-mentioned steps are preferably repeated cyclically when said hood 1 is in an operating condition.

[0049] 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.

[0050] 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).

[0051] Steps (b) and (c) of the method are preferably activated by the user or by an installer through the interface.

[0052] 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.

[0053] 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.

[0054] 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.

[0055] 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.

[0056] 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).

[0057] 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.

[0058] A further advantage offered by the use of the control unit 70 is the possibility of reducing the noise.

[0059] 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 an embodiment, 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 $\pm 2\%$ of the reference flow rate value, more preferably to $\pm 1\%$ of the reference flow rate value.

[0060] 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.

[0061] 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.

[0062] 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.

[0063] 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 isoefficiency 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.

[0064] 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.

[0065] Of course, the example described so far may be subject to many variations. A hood according to the invention, 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.

[0066] This hood according to the invention 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.

[0067] 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.

[0068] 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.

[0069] 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.

[0070] The method for controlling the process for treating the air flow 60 according to 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.

[0071] 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.

[0072] 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.

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 operating parameters thereof, wherein the control unit (70') is configured for estimating 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 operating parameters of said motor (31), and wherein the operating parameters comprise a current drawn by and a revolution speed of said motor (31),

characterized in that

said hood (1) comprises an inverter (73) for driving the motor (31) according to control signals inputted in said inverter (73), and 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), outputs a value of the flow rate of the air flow (60),
- an efficiency model (74) which, based on input values of said flow rate, a temperature of the air flow (60) and a value of the power drawn by said motor (31), outputs an efficiency value of said hood (1), and
- a controller (72') configured to generate the control signals for the inverter (73), and configured for selecting said control signals to keep a flow rate error value and an efficiency offset value as low as possible,

so that 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; whereby:

- said flow rate error value is obtained by subtracting said value of the flow rate of the air flow (60) from a reference flow rate value,
- said efficiency offset value is calculated as a difference between an unitary value and said efficiency value of said hood (1), and

wherein said flow rate error value and said efficiency offset value are inputted to said controller (72').

2. A hood (1) according to claim 1, wherein the variable-speed electric motor (31) is of the permanent-magnet synchronous three-phase brushless type.
3. A hood (1) according to claim 2, wherein the motor (31) is connected to and driven by the inverter (73).

4. A hood (1) according to any one of claims 1 to 3, wherein the control unit (70') is also configured for comparing the estimated flow rate of the air flow (60) with a reference flow rate value, in order to detect an obstructed condition of the filter means (40).
5. A hood (1) according to any one of claims 1 to 4, wherein the control unit (70') is also configured for comparing the estimated flow rate of the air flow (60) with a nominal flow rate value of said air flow (60), in order to detect an installation state of the hood (1).
6. A hood (1) according to any one of claims 1 to 5, wherein said control unit (70') is also configured for generating control signals for the motor (31) on the basis of the flow rate, in order to make a number of air changes, within a predefined time interval, in a room where said hood (1) has been installed.
7. A hood (1) according to any one of claims 1 to 6, wherein said control unit (70') is also configured for generating control signals for the motor (31) which are adapted to try to keep the estimated flow rate of the air flow (60) substantially equal to a reference flow rate value associated with a cooking type.
8. A hood (1) according to any one of claims 1 to 7, comprising acoustic measurement means (90) in signal communication with a noise control system comprised in the control unit (70'), and wherein said control unit (70') is also configured for generating control signals for the motor (31) which are adapted to try 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.
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),wherein the estimate of the flow rate of the air flow (60) is made by detecting electromechanical quantities associated with the operation of the fan means (30), wherein the electromechanical quantities comprise a revolution speed of and a current drawn by the fan means (30),
characterized in that
it also comprises the steps of
 - c. determining an efficiency value of the hood (1) by means of an efficiency model (74), wherein the estimate of the flow rate of the air flow (60) is made through a flow rate model (71) which take the values of the current drawn by and the revolution speed of said fan means (30) as input, wherein the efficiency model (74) takes the values of the flow rate, a temperature of the air flow (60) and the power drawn by said fan means (30) as input, and wherein the control signals are selected, during the step b., to keep a flow rate error value and an efficiency offset value as low as possible, so that 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;whereby:
 - said flow rate error value is obtained by subtracting said value of the flow rate of the air flow (60) from a reference flow rate value,
 - said efficiency offset value is calculated as a difference between an unitary value and said efficiency value of said hood (1).
10. A method according to claim 9, wherein the generation of the control signals for the fan means (30) occurs also on the basis of a reference flow rate value.

Patentansprüche

1. Haube (1) zur Behandlung eines Luftstroms (60), umfassend einen Einlassbereich (20) und einen Auslassbereich

(50), die entsprechend einen Eintritt und einen Austritt des Luftstroms (60) erlauben, Ventilatormittel (30) und Filtermittel (40), die zwischen dem Einlassbereich (20) und dem Auslassbereich (50) angeordnet sind, eine Steuereinheit (70'), die funktional mit den Ventilatormitteln (30) verbunden ist, um Betriebsparameter davon zu steuern, wobei die Steuereinheit (70') eingerichtet ist, die Strömungsrate des Luftstroms (60), folgend der Aktivierung eines elektrischen Motors (31), der mit den Ventilatormitteln (30) assoziiert ist, nach der Detektion der Betriebsparameter des Motors (31) zu schätzen und wobei die Betriebsparameter einen vom Motor (31) aufgenommenen Strom und eine Drehzahl des Motors (31) umfassen,

dadurch gekennzeichnet, dass

die Haube (1) einen Umrichter (72) zum Antreiben des Motors (31) in Abhängigkeit von Steuersignalen, die in den Umrichter (73) eingegeben werden, umfasst und wobei die Steuereinheit (70') umfasst

- ein Strömungsratenmodell (71), das auf Eingangswerten des vom Motor (31) aufgenommenen Stroms und der Drehzahl des Motors (31) und auf Ausgängen eines Werts der Strömungsrate des Luftstroms (60) basiert,
- ein Effizienzmodell (74), das, basierend auf Eingangswerten der Strömungsrate, einer Temperatur des Luftstroms (60) und einem Wert der vom Motor (31) aufgenommenen Energie, einen Effizienzwert der Haube (1) ausgibt und
- eine Steuerung (72'), die eingerichtet ist, Steuersignale für den Umrichter (73) zu generieren und eingerichtet ist, die Steuersignale auszuwählen, um einen Strömungsratenfehlerwert und einen Effizienzoffsetwert so gering wie möglich zu halten,

sodass es möglich ist, die Strömungsrate des Luftstroms (60), der in der Haube (1) strömt, unabhängig von den Luftdichteverhältnissen konstant zu halten, um dadurch den Verbrauch zu minimieren und die Effizienz zu maximieren;

wobei:

- der Strömungsratenfehlerwert durch Subtrahieren des Wertes der Strömungsrate des Luftstroms (60) von einem Referenzströmungsratenwert erhalten wird,
- der Effizienzoffsetwert als Differenz zwischen einem Einheitswert und dem Effizienzwert der Haube (1) berechnet wird, und

wobei der Strömungsratenfehlerwert und der Effizienzoffsetwert in die Steuerung (32') eingegeben werden.

2. Haube (1) nach Anspruch 1, wobei der elektrische Motor (31) mit einer variablen Geschwindigkeit vom bürstenlosen, Permanentmagneten-Synchronen-Dreiphasen- Typs ist.
3. Haube (1) nach Anspruch 2, wobei der Motor (31) verbunden mit und angetrieben durch den Umrichter (73) ist.
4. Haube (1) nach einem der Ansprüche 1 bis 3, wobei die Steuereinheit (70') außerdem eingerichtet ist, die geschätzte Strömungsrate des Luftstroms (60) mit einem Referenzströmungsratenwert zu vergleichen, um eine Behinderung der Filtermittel (40) zu detektieren.
5. Haube (1) nach einem der Ansprüche 1 bis 4, wobei die Steuereinheit (70') außerdem eingerichtet ist, die geschätzte Strömungsrate des Luftstroms (60) mit einem nominalen Strömungsratenwert des Luftstroms (60) zu vergleichen, um einen Einbauzustand der Haube (1) zu detektieren.
6. Haube (1) nach einem der Ansprüche 1 bis 5, wobei die Steuereinheit (70') außerdem eingerichtet ist, Steuersignale für den Motor (31) auf der Basis der Flussrate zu generieren, um eine Anzahl von Luftwechseln innerhalb eines vordefinierten Zeitintervalls in einem Raum, in dem die Haube (1) installiert wurde, zu machen.
7. Haube (1) nach einem der Ansprüche 1 bis 6, wobei die Steuereinheit (70') außerdem eingerichtet ist, Steuersignale für den Motor (31) zu generieren, die angepasst sind, um zu versuchen, die erwartete Strömungsrate des Luftstroms (60) im Wesentlichen gleich eines Referenzströmungsratenwerts, der mit einem Kochtyp assoziiert ist, zu halten.
8. Haube (1) nach einem der Ansprüche 1 bis 7, umfassend akustische Messmittel (90) in Signalverbindung mit einem in der Steuereinheit (70') enthaltenen Geräuschkontrollsystem, und wobei die Steuereinheit (70') außerdem eingerichtet ist, um Steuersignale für den Motor (31) zu generieren, die angepasst sind, um zu versuchen, die geschätzte Strömungsrate des Luftstroms (60) nahe einem Referenzströmungsratenwert und Geräuschpegel, die durch die akustischen Messmittel (90) gemessen werden, unterhalb einem Schwellenwert zu halten.

9. Verfahren zum Steuern der Behandlung eines Luftstroms (60), der in einer Haube (1) nach einem der Ansprüche 1 bis 8 strömt, umfassend die Schritte:

- a. Schätzen der Strömungsrate des Luftstroms (60),
- b. Generieren, auf der Basis der geschätzten Strömungsrate im Schritt a., von Steuersignalen für Ventilatormittel (30), die eingerichtet sind, den Wert der Strömungsrate des Luftstroms (60) konstant zu halten,

wobei das Schätzen der Strömungsrate des Luftstroms (60) durch Detektion elektromechanischer Größen, die mit dem Betrieb der Ventilatormittel (30) assoziiert sind, ausgeführt wird, wobei die elektromechanischen Größen eine Drehzahl und einen von dem Motor (30) aufgenommenen Strom umfassen,

dadurch gekennzeichnet, dass
es außerdem die Schritte umfasst:

- c. Bestimmen eines Effizienzwerts der Haube (1) mittels eines Effizienzmodells (74), wobei die Schätzung der Strömungsrate der Luftströmung (60) durch ein Strömungsratenmodell (71) ausgeführt wird, das die Werte des von den Ventilatormitteln (30) aufgenommenen Stroms und der Drehzahl der Ventilatormittel (30) als Eingang nimmt, wobei das Effizienzmodell (74) die Werte der Strömungsrate, eine Temperatur der Luftströmung (60) und der Energie, die durch die Ventilatormittel (30) aufgenommen werden, als Eingang nimmt, und wobei die Steuersignale während dem Schritt b. ausgewählt werden, um einen Strömungsratenfehlerwert und einen Effizienzoffsetwert so gering wie möglich zu halten, sodass es möglich ist, eine konstante Strömungsrate der Luftströmung (60), die innerhalb der Haube (1) strömt, unabhängig von den Luftdichteverhältnissen konstant zu halten, um dadurch den Verbrauch zu minimieren und die Effizienz zu maximieren;

wobei:

- der Strömungsratenfehlerwert durch Subtrahieren des Wertes der Strömungsrate des Luftstroms (60) von einem Referenzströmungsratenwert erhalten wird,
- der Effizienzoffsetwert als Differenz zwischen einem Einheitswert und dem Effizienzwert der Haube (1) berechnet wird.

10. Verfahren nach Anspruch 9, wobei das Generieren von Steuersignalen für die Ventilatormittel (30) außerdem auf der Basis eines Referenzströmungsratenwerts erfolgt.

Revendications

1. Hotte (1) pour traiter un flux d'air (60), comprenant une section d'admission (20) et une section de refoulement (50) permettant respectivement l'entrée et la sortie dudit flux d'air (60), un moyen de ventilateur (30) et un moyen de filtre (40) agencé entre ladite section d'admission (20) et ladite section de refoulement (50), une unité de commande (70') raccordée fonctionnellement audit moyen de ventilateur (30) pour commander des paramètres de fonctionnement de celui-ci, dans laquelle l'unité de commande (70') est configurée pour estimer le débit du flux d'air (60) suite à l'activation d'un moteur électrique (31) associé audit moyen de ventilateur (30), après la détection desdits paramètres de fonctionnement dudit moteur (31), et dans laquelle les paramètres de fonctionnement comprennent un courant tiré par ledit moteur (31) et une vitesse de révolution de celui-ci,

caractérisée en ce que

ladite hotte (1) comprend un onduleur (73) pour entraîner le moteur (31) selon des signaux de commande entrés dans ledit onduleur (73), et dans laquelle l'unité de commande (70') comprend

- un modèle de débit (71) qui, d'après des valeurs d'entrée du courant tiré par ledit moteur (31) et la vitesse de révolution de celui-ci, fournit en sortie une valeur du débit du flux d'air (60),
- un modèle de rendement (74) qui, d'après des valeurs d'entrée dudit débit, une température du flux d'air (60) et une valeur de la puissance tirée par ledit moteur (31), fournit en sortie une valeur de rendement de ladite hotte (1), et
- un dispositif de commande (72') configuré pour générer les signaux de commande pour l'inverseur (73), et configuré pour sélectionner lesdits signaux de commande pour garder une valeur d'erreur de débit et une valeur de décalage de rendement aussi faibles que possible,

de sorte qu'il soit possible de garder constant le débit du flux d'air (60) circulant à l'intérieur de la hotte (1) indépen-

damment des conditions de masse volumique d'air, minimisant ainsi la consommation et maximisant le rendement ; moyennant quoi :

- 5 - ladite valeur d'erreur de débit est obtenue en soustrayant ladite valeur du débit du flux d'air (60) d'une valeur de débit de référence,
 - ladite valeur de décalage de rendement est calculée en tant que différence entre une valeur unitaire et ladite valeur de rendement de ladite hotte (1), et dans laquelle ladite valeur d'erreur de débit et ladite valeur de décalage de rendement sont entrées dans ledit dispositif de commande (72').
- 10 2. Hotte (1) selon la revendication 1, dans laquelle le moteur électrique à vitesse variable (31) est du type sans balai triphasé, synchrone à aimant permanent.
3. Hotte (1) selon la revendication 2, dans laquelle le moteur (31) est raccordé à et entraîné par l'onduleur (73).
- 15 4. Hotte (1) selon l'une quelconque des revendications 1 à 3, dans laquelle l'unité de commande (70') est également configurée pour comparer le débit estimé du flux d'air (60) avec une valeur de débit de référence, afin de détecter une condition obstruée du moyen de filtre (40).
- 20 5. Hotte (1) selon l'une quelconque des revendications 1 à 4, dans laquelle l'unité de commande (70') est également configurée pour comparer le débit estimé du flux d'air (60) avec une valeur de débit nominale dudit flux d'air (60), afin de détecter un état d'installation de la hotte (1).
- 25 6. Hotte (1) selon l'une quelconque des revendications 1 à 5, dans laquelle ladite unité de commande (70') est également configurée pour générer des signaux de commande pour le moteur (31) sur la base du débit, afin de réaliser un certain nombre de changements d'air, dans un intervalle de temps prédéfini, dans une pièce où ladite hotte (1) a été installée.
- 30 7. Hotte (1) selon l'une quelconque des revendications 1 à 6, dans laquelle ladite unité de commande (70') est également configurée pour générer des signaux de commande pour le moteur (31) qui sont adaptés pour tenter de garder le débit estimé du flux d'air (60) sensiblement égal à une valeur de débit de référence associée à un type de cuisson.
- 35 8. Hotte (1) selon l'une quelconque des revendications 1 à 7, comprenant un moyen de mesure acoustique (90) en communication de signal avec un système de commande de bruit faisant partie de l'unité de commande (70'), et dans laquelle ladite unité de commande (70') est également configurée pour générer des signaux de commande pour le moteur (31) qui sont adaptés pour tenter de garder le débit estimé du flux d'air (60) proche d'une valeur de débit de référence et un niveau de bruit mesuré par le moyen de mesure acoustique (90) en dessous d'une valeur seuil.
- 40 9. Procédé de commande du traitement d'un flux d'air (60) circulant à travers une hotte (1) selon l'une quelconque des revendications 1 à 8, comprenant les étapes de :
 - a. estimation d'un débit du flux d'air (60),
 - b. génération, sur la base du débit estimé à l'étape a., de signaux de commande pour un moyen de ventilateur (30) adaptés pour garder constante la valeur du débit du flux d'air (60),
- 45 dans lequel l'estimation du débit du flux d'air (60) se fait en détectant des quantités électromécaniques associées au fonctionnement du moyen de ventilateur (30), dans lequel les quantités électromécaniques comprennent une vitesse de révolution du moyen de ventilateur (30) et un courant tiré par celui-ci,
 caractérisé en ce que
50 il comprend également les étapes de
 - c. détermination d'une valeur de rendement de la hotte (1) au moyen d'un modèle de rendement (74), dans lequel l'estimation du débit du flux d'air (60) se fait par un modèle de débit (71) qui adopte les valeurs du courant tiré par ledit moyen de ventilateur (30) et la vitesse de révolution de celui-ci en entrée, dans lequel le modèle de rendement (74) adopte les valeurs du débit, une température du flux d'air (60) et la puissance tirée par ledit moyen de ventilateur (30) en entrée, et dans lequel les signaux de commande sont sélectionnés, pendant l'étape b., pour garder une valeur d'erreur de débit et une valeur de décalage de rendement aussi faibles que possible, de sorte qu'il soit possible de garder constant le débit du flux d'air (60) circulant à l'intérieur de la hotte
- 55

(1) indépendamment des conditions de masse volumique d'air, minimisant ainsi la consommation et maximisant le rendement ;

moyennant quoi :

- 5
- ladite valeur d'erreur de débit est obtenue en soustrayant ladite valeur du débit du flux d'air (60) d'une valeur de débit de référence,
 - ladite valeur de décalage de rendement est calculée en tant que différence entre une valeur unitaire et ladite valeur de rendement de ladite hotte (1).
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10. Procédé selon la revendication 9, dans lequel la génération des signaux de commande pour le moyen de ventilateur (30) se produit également sur la base d'une valeur de débit de référence.

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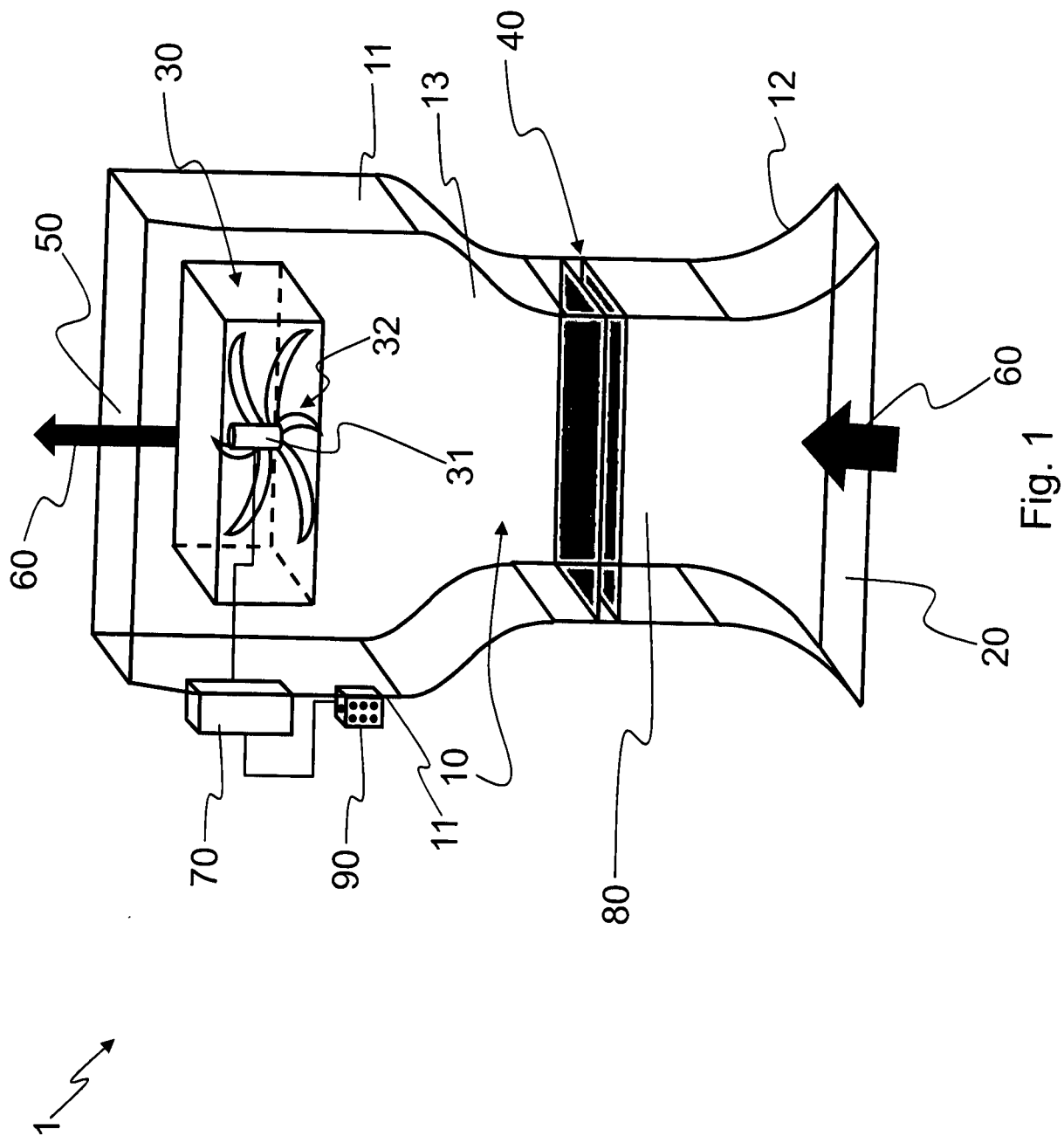
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Relation among Flow Rate, Drawn Current, and Actual Revolution Speed

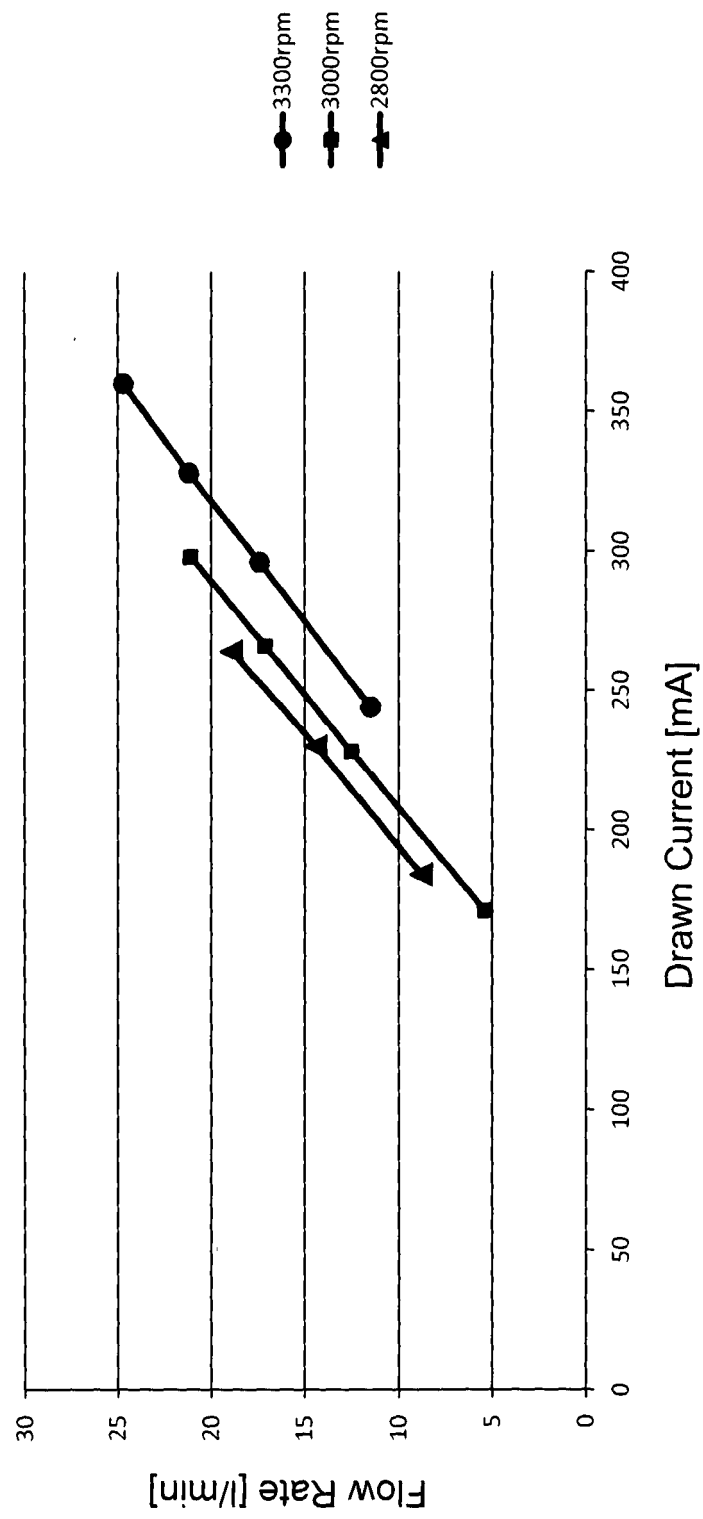


Fig. 2

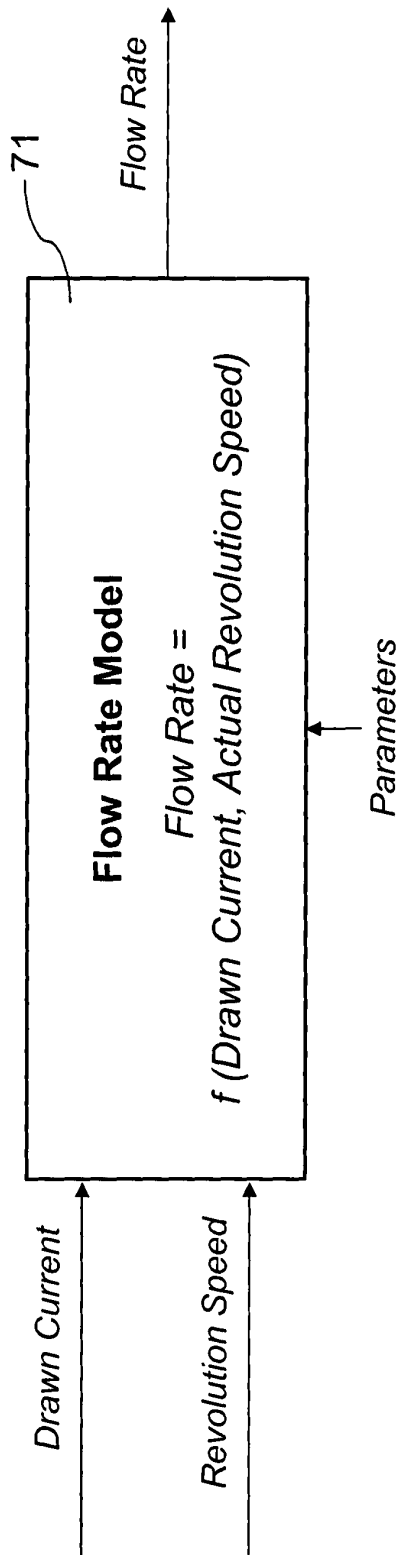


Fig. 3

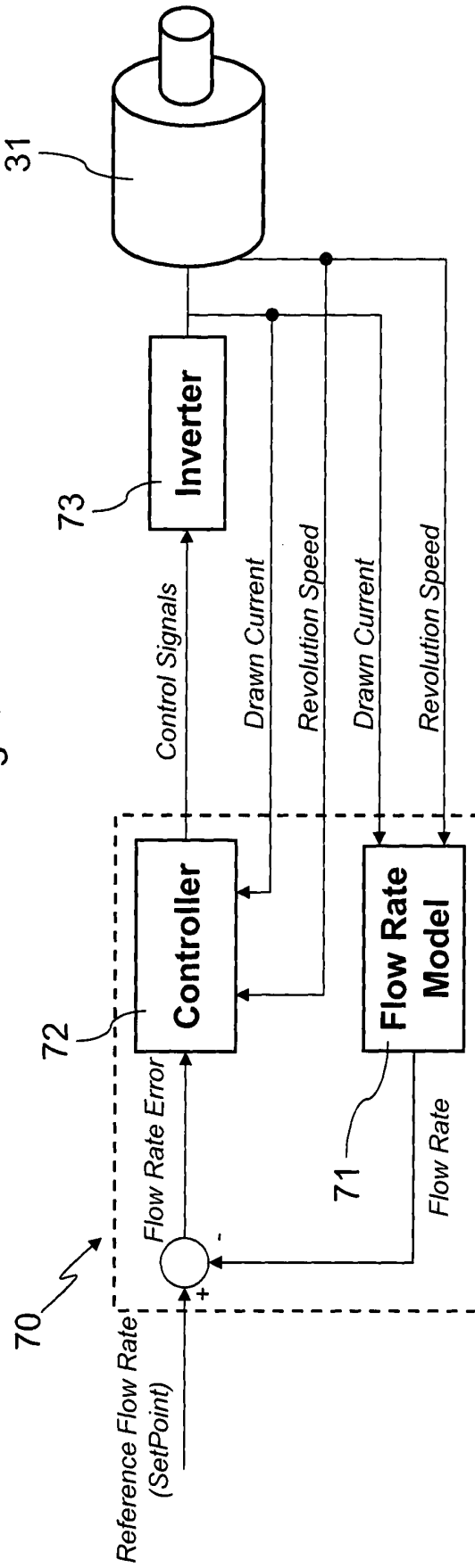


Fig. 4

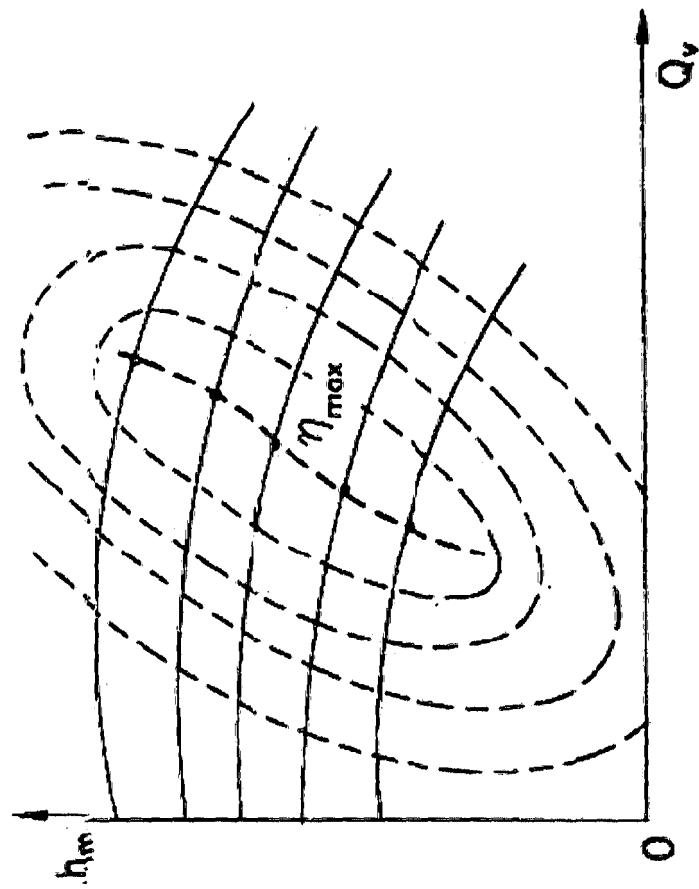


Fig. 5

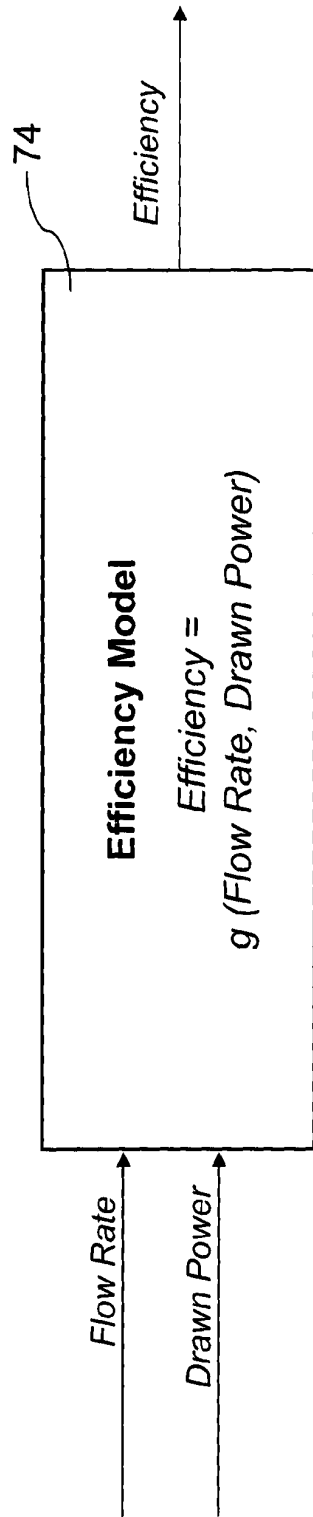


Fig. 6

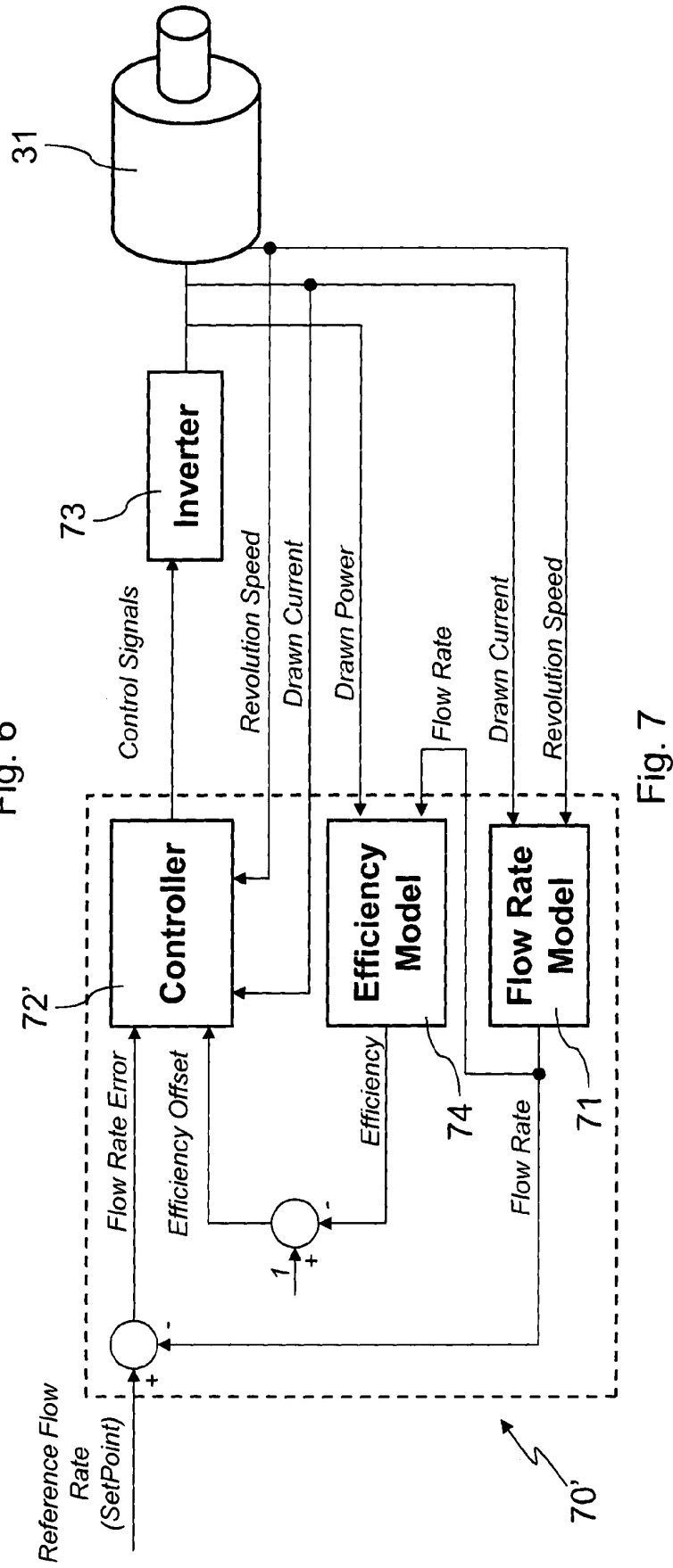


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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