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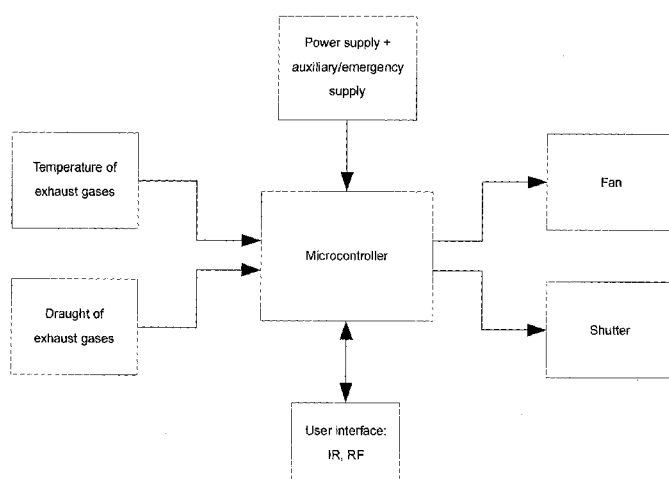
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upon receipt of that report (Rule 48.2(g))(54) Title: METHOD AND DEVICE FOR AUTOMATIC REGULATION OF OPTIMAL CONDITIONS OF BIOMASS COM-
BUSTION

Fig. 1

(57) Abstract: The technical problem solved by the
present invention is regulation of a flow of exhaust
gases with the purpose of increasing the efficiency of
a biomass powered stove and ensuring optimal
combustion conditions. The object of the invention
is a method for an automatic regulation of optimal
conditions of biomass combustion that following an
internal algorithm adequately evaluates data from a
temperature sensor of exhaust gases and a draught
sensor, and by means of a processor and a user inter-
face sends commands to control electronics for a fan
and to control electronic of a mechanical actuator
for movement of a shutter. This creates conditions
for a rapid cool startup under consideration of vari-
ous influential burning factors, it allows mainten-
ance of operating temperature by reducing the rate
of exhaust gases and an autonomous way of supply
of the regulation and control system. The construc-
tional solution of the device of the invention is de-
signed in modules, wherein the device has a fume
shutter of a typical shape, an electronic control cir-
cuit, a control electronic regulator, sensors of ex-
haust gas status, mechatronic actuators and a power
unit with a safety function of shutter opening in the
case of electricity failure and is controlled by a com-
puter designed intelligent system.

Method and device for automatic regulation of optimal conditions of biomass combustion

5 Field of the Invention

The object of the invention belongs to the field of methods and devices for an intelligent control and automatic regulation of a stream of exhaust gases in order to provide optimal combustion conditions and belongs to the field of combustion
10 regulation and/or control.

Technical Problem

15 The technical problem solved by the present invention is a method and a constructional design of a device that would allow measuring of exhaust gas status and regulation of a flow of exhaust gases with the purpose of increasing the efficiency of a biomass powered stove and ensuring optimal combustion conditions. Heating an oven or a wood burner with biomass is done in three
20 phases. A startup phase, in which the natural pressure in a combustion chamber is low due to a cooled fume system and an engine ventilation system is needed for a rapid startup without exhaust gases escaping back into the room (power-assisted systems). A burning phase when the fume system is heated and the created natural draught accelerates burning up to a level, at which exhaust gases can
25 reach temperatures over 600°C and can damage the oven and the fume system. Further, much energy is consumed in this phase and this energy cannot get transferred so rapidly to the heating system, through the exhaust system to the environment, and has a certain influence on atmosphere heating and on a poorer efficiency of the heating system itself. The reburning phase, when glowing fuel
30 needs a minimal quantity of air to successfully maintain the heat in the oven and the fuel system must be almost closed if the reburning step is to be prolonged as long as possible and if the escape of hot air from a room through the fume system to the ambient is to be prevented.

The goal of the invention is to provide a regulation and control system that will be intelligent and able to provide for an efficient and safe process of biomass combustion in a heating system via embedded sensors by means of integrated algorithms. A further task is also a constructional design of the device according to this method that will allow for a continuous regulation of a stream of exhaust gases and withdrawal of air, wherein it will be efficient and will allow a relatively quiet operation.

A further goal of this invention is a design of a regulation and control system that will be modular and will allow manufacturing of independent modules. The modules will allow various combinations and will be adaptable to various systems of combustion chambers, which will provide a simple and a price efficient solution to installation into existing heating systems. A further goal of the invention is a design of a regulation and control system that can be built in already existing fume systems as an upgrade.

An additional goal of the present invention is also to provide a regulation and control system that will be autonomous and will not need a supplementary energy source for its operation.

Prior Art

Systems intended to accelerate draught are known on the market. These systems are mostly arranged on the top of a flue pipe outside a building, which makes installation and maintenance difficult. Systems intended to reduce the rate of exhaust gases in the form of flaps arranged on a gas duct are also known on the market. These flaps reduce the cross-section of a flue pipe. If such rate reduction is uncontrolled, it can cause soot formation due to too low temperatures in the heating chamber and deposition of same at the narrowed section of the gas duct. This can endanger fire safety of the system.

Systems intended to accelerate draught are known on the market. These systems are mostly arranged on the top of a flue pipe outside a building as disclosed for

instance in US patent 6450874, which makes installation and maintenance difficult. They can also be arranged in the fume system within a building, such as disclosed in patents US 4750433 and US 7290981.

- 5 There are also known systems for reducing the rate of exhaust gases in the form of shutters on a gas duct, such as disclosed in patent US 4449512 that uses a split shape of the shutter, or in patent US 4039123 which discloses a butterfly-shaped shutter that makes the cross-section of the flue pipe narrower. If such reduction in speed is uncontrolled, it can cause soot formation due to too low temperatures in
10 the heating chamber and deposition of same at the narrowed section of the gas duct. This can endanger fire safety of the system.

Patent US 2007/0221205 discloses autonomous systems that use the heat of the heating device to generate the needed electricity for the operation of regulation.

- 15 Patent US 6053163 discloses an autonomous system that uses the heat of the flue pipe to generate electricity needed for the system of hot air circulation in a room.

- European patent No. 2 439 453 discloses a constructional solution to a solid-fuel
20 oven provided with means for controlling the temperature in the cooking cavity via a thermostate. Regulation is done in a way that, when a certain temperature is reached, the air flow for air cooling is increased through the disclosed secondary system. Damping of a flow of exhaust gases is done by a regulation of a hatch open/closed during combustion of solid fuel.

25

None of the mentioned inventions solves a problem of an automatic regulation of optimal combustion conditions as the present invention does.

30 Solution to the Technical Problem

The object of the invention is a method for automatic regulation of optimal conditions of biomass combustion that following an internal algorithm adequately evaluates data from a temperature sensor of exhaust gases and a draught sensor,

and by means of a processor and a user interface sends commands to control electronics for a fan and to control electronic of a mechanical actuator for movement of a shutter. This creates conditions for a rapid cool startup under consideration of various influential burning factors, it allows maintenance of operating temperature by reducing the rate of exhaust gases and an autonomous way of supply of the regulation and control system. The constructional solution of the device of the invention is designed in modules, wherein the device has a fume shutter of a typical shape in a housing, an electronic control circuit, a control electronic regulator, sensors of exhaust gas status, mechatronic actuators and a supply unit with a safety function of shutter opening in the case of electricity failure and is controlled by a computer designed intelligent system.

The method and the device for the automatic control of optimal conditions of biomass combustion of the invention will be described in more detail in the continuation by way of drawings, representing in:

Figure 1 – block diagram of a controller for the device of the invention

Figure 2 – block diagram of a device for an automatic control of a stream of exhaust gases to provide optimal conditions of biomass combustion of the invention

Figure 3 – an embodiment of the device of the invention

Figure 4 – an embodiment of the device of the invention

Figure 5 – a shutter of the device of the invention.

As shown in Figure 1, data from a temperature sensor of exhaust gases and a rate sensor of air created by a flow of exhaust gases are led to a first and a second input of a microprocessor MCU that is connected to a power supply and a supply for a safe closing of a shutter. The first output from the processor MCU is connected to the input for fan control, and the second output is connected to the input for shutter movement. A user interface for setting the temperature is bidirectionally connected to the processor MCU. The block diagram of the controller for the device allows manufacturing of a printed circuit board that contains a microprocessor with an integrated algorithm according to the described method. The complete device with the controller is installed in a fume pipe and

provided with a user module on the device or with an independent remote controller.

The method for automatic regulation of the flow of exhaust gases with the purpose of providing optimal conditions of biomass combustion of the invention, shown in Figure 2, is carried out as follows: a status detector A simultaneously reads data from the temperature sensor of exhaust gases in the fume pipe during burning method in module B, data in module C, data in module D and data in module E and obtains feedback via common data from modules B, C, D and E, which data make it possible to send commands to the fan control electronics and to the control electronics of the mechanical actuator for the movement of the shutter for a continuous regulation of a stream of exhaust gases. Module B is composed of a user module b1 for desired power selection, a module b2 for startup time compensation, a module b3 for temperature regulation of exhaust gases, and a module b4 for draught regulation. Module C for a quick startup or loading of woods allows activation of the fan and opening of the shutter. Module D allows preservation of embers and regulates draught. Module E allows a selection of the shutter status (open/closed) in the case of no burning. The escape of hot air from a room through the fume system to the ambient is herewith opened/closed.

Figure 2 shows a method for an automatic regulation of a stream of exhaust gases in order to offer optimal conditions of biomass combustion of the invention in a way that automatic operation is provided based on selected desired power of burning and measured value from sensors.

The method of the invention has the following characteristic steps of regulation:

A': Detection of status on the basis of data from sensors and user's interface;

B': Burning steps:

b1': Selection of power, wherein the power is changed by the user with a remote controller, with a key or is changed automatically on the basis of a room's temperature sensor;

b2': Compensation of startup time in the case of poorer fuel and/or lower ambient temperatures in order to provide for a more intense combustion;

b3': Regulation of temperature of exhaust gases by opening and closing the shutter;

b4': Regulation of draught of exhaust gases by opening and closing the shutter;

C': Switching-on of the fan and opening of the shutter for a rapid startup or loading of fuel;

D': Preservation of embers; when a drop in temperature is detected, a stream of exhaust gases is slowed down by closing the shutter, wherewith the smouldering of embers is preserved for a longer period of time; that the shutter is set ajar for so much that minimal draught is preserved;

E': Selection of the shutter status in the status of no burning.

According to the embodiment, the device for the automatic regulation of a stream of exhaust gases in order to provide for optimal conditions of biomass combustion is designed in a way that a housing 1 is provided at one side with a tube attachment 2 and at the other side with a tube attachment 3 and serves simultaneously for the flow of exhaust gases and as a support part for the remaining subassemblies of the device. The attachments 2 and 3 have a diameter somewhat smaller than that of the fume pipe, which makes it possible that the device of the invention can be installed in the gas duct. Diameters of the attachments 2 and 3 are standard ones and can be Ø120 mm, Ø130 mm, Ø150 mm, Ø160 mm, Ø180 mm. There may be angles between the attachments 2 and 3 and can be: 90°, 135° and 180°. Within the housing 1 a shutter 4 is pivotably mounted and regulates the flow of exhaust gases in dependence on the position. The shutter 4 is rotatable by control electronics 5 of a mechanical actuator 6 that moves the shutter 4 in a way to allow a continuous regulation of the stream of exhaust gases. The mechanical actuator 6 consists of a mechanical transmission reduction gear and an electric motor. The housing 1 further houses sensors for sensing the temperature of exhaust gases. The assembly fume pipe-shutter 4 must provide enough resistance to enable slowing down of the rate of exhaust

gases when the shutter is closed and it must simultaneously allow a flow of gases as unobstructed as possible when fully opened.

5 The construction of the shutter 4 provides a good fitting into the attachments 2 and 3 and makes blocking of rotation of the shutter 4 during operation impossible. The shutter 4 is fastened on a shaft mounted in the housing 1 and connected with the reduction box via a clutch. The shutter 4 can be rotated by means of a special lever 7 that also serves as an external indicator of the shutter position. The construction allows the shutter to be moved to the opened or closed position for
10 cleaning purposes.

The device of the invention is provided with an electric motor that is usually a brushless motor or a stepping motor with a high yield for the movement of the reduction box, with which the specially shaped shutter 4 is moved, said shutter 4
15 regulating the flow of exhaust gases through the fume pipe by closing or opening.

The device is designed as a modular device and allows various functional modules to be added. The basic module can be upgraded by a module with an integrated fan with an electric motor that allows acceleration of the rate of exhaust gases.
20 This is especially suitable for a gas duct and/or fuel of poorer quality, when startups take more time and return smoking into the room is experienced.

If there is no possibility of connection to grid voltage or if such a connection impacts the aesthetic appearance of the heating system, the basic module can be
25 upgraded by a supply module with a thermo-electric generator that converts the heat energy of exhaust gases into electric energy needed for the normal operation of the system. The thermo-electric generator generates electricity from the waste heat of the fume pipe and stores it in a suitable storage unit. The module is fastened to the fume pipe which provides a sufficient transfer of heat energy for an
30 efficient operation of the thermo-electric generator.

As a blocking system a shutter with a special aperture shown in Figure 5 is used. The aperture is shaped in a way not to considerably slow down the natural flow at low exhaust gas rates if the shutter is in the closed position; at higher rates, it

allows an efficient slowing down of the flow of exhaust gases. A second embodiment of the blocking system uses a shape of the shutter that allows an integration of a fan and considerably improves spatial usefulness of the entire device. As the rotational axle is fastened outside the shutter, a continuous
5 regulation of the flow of exhaust gases is achieved.

The method for automatic regulation of a flow of exhaust gases for providing optimal conditions of biomass combustion of the invention is conceived in a way to control individual units of the basic module consisting of a slow-down shutter, a
10 control electronic regulator, sensors of status of exhaust gases, mechatronic actuators and a supply unit with a safety function of shutter opening in case of electricity failure. The device according to this method represents an independent, efficient and price efficient system. The basic module with its developed algorithms can efficiently maintain optimal temperature of biomass combustion in the
15 combustion chamber and strongly prolongs the time of burning at the same fuel unit. Therewith the yield of the heating system is increased and the heating of the atmosphere is reduced.

Claims

1. A method for automatic regulation of a flow of exhaust gases with the purpose of providing optimal conditions of biomass combustion, characterized in that it is carried out as follows: a status detector (A) simultaneously reads data from a temperature sensor of exhaust gases in the fume pipe during burning method in module (B), data in module (C), data in module (D) and data in module (E) and obtains feedback via common data from modules (B, C, D and E), which data make it possible to send commands to fan control electronics and to control electronics of the mechanical actuator for the movement of a shutter for a continuous regulation of a stream of exhaust gases; that module (B) is composed of a user module (b1) for desired power selection, a module (b2) for startup time compensation, a module (b3) for temperature regulation of exhaust gases, and a module (b4) for draught regulation; that module (C) for a quick startup or loading of woods allows activation of the fan and opening of the shutter; that module (D) allows preservation of embers and regulates draught of exhaust gases; module (E) allows a selection of the shutter status (open/closed) in the case of no burning, which shutter opens/closes the escape of hot air from a room through the fume system to the ambient.

2. Method of claim 1 characterized by the following steps:

A': Detection of status on the basis of data from sensors and user's interface;

B': Burning steps:

b1': Selection of power, wherein the power is changed by the user with a remote controller, with a key or is changed automatically on the basis of a room's temperature sensor;

b2': Compensation of startup time in the case of poorer fuel and/or lower ambient temperatures in order to provide for a more intense combustion;

b3': Regulation of temperature of exhaust gases by opening and closing the shutter;

b4': Regulation of draught of exhaust gases by opening and closing the shutter;

C': Switching-on of the fan and opening of the shutter for a rapid startup or loading of fuel;

D': Preservation of embers; when a drop in temperature is detected, a stream of exhaust gases is slowed down by closing the shutter, wherewith the smouldering of embers is preserved for a longer period of time; that the shutter is set ajar for so much that minimal draught is preserved;

E': Selection of the shutter status in the status of no burning.

3. A device for automatic regulation of optimal conditions of biomass combustion with an electronic controller characterized in that data from a temperature sensor of exhaust gases and a rate sensor of air created by a flow of exhaust gases are led to a first and a second input of a microprocessor (MCU) that is connected to a power supply and a supply for a safe closing of a shutter; that the first output from the processor (MCU) is connected to the input for fan control, and the second output is connected to the input for shutter movement; that a user interface for setting the temperature is bidirectionally connected to the processor (MCU).

4. Device of claim 3 characterized in that a housing (1) is provided at one side with a tube attachment (2) and at the other side with a tube attachment (3) and serves simultaneously for the flow of exhaust gases and as a support part for the remaining subassemblies of the device; that the attachments (2 and 3) have a diameter somewhat smaller than that of the fume pipe, which makes it possible that the device of the invention can be installed in the gas duct; that within the housing (1) the shutter (4) is pivotably mounted and regulates the flow of exhaust gases in dependence on the position; that the shutter (4) is rotatable by control electronics (5) of a mechanical actuator (6) that moves the shutter (4) in a way to allow a continuous regulation of the stream of exhaust gases; that the mechanical actuator (6) consists of a mechanical transmission reduction gear and an electric motor; that the housing (1) further houses sensors for sensing the temperature of exhaust gases; that the assembly fume pipe-shutter (4) must provide enough resistance to enable slowing down of the rate of exhaust gases when the shutter (4) is closed and it must simultaneously allow a flow of gases as unobstructed as possible when fully opened.

5. The device for automatic regulation of the flow of exhaust gases for providing optimal conditions of biomass combustion of claim 4 characterized in that it is designed as a modular device and allows various functional modules to be added.

6. The device of claim 5 characterized in that it is provided with an electric motor that is usually a brushless motor or a stepping motor with a high yield for the movement of a tooth of the reduction box, with which the specially shaped shutter (4) is moved, said shutter (4) regulating the flow of exhaust gases through the fume pipe by closing or opening.

7. Device of claim 5 characterized in that the basic module can be upgraded by a function of a system for accelerating exhaust gases by means of a suitable fan and an electric motor.

8. The device of claim 5 characterized in that it is provided with a supply module with a thermo-electric generator that converts the heat energy of exhaust gases into electric energy needed for the normal operation of the system.

9. Device of claim 5 characterized in that it uses a control electronic regulator for regulating the flow of exhaust gases, said regulator obtaining the data on temperature and draught of exhaust gases from one or several temperature sensors and from one or several sensors of draught of exhaust gases.

10. The device of any of claims 4 to 9 characterized in that a shape of a shutter is used as a blocking system, said shutter allowing an integration of a fan and considerably improves spatial usefulness of the entire device; that as the rotational axle is fastened outside the shutter, a continuous regulation of the flow of exhaust gases is achieved.

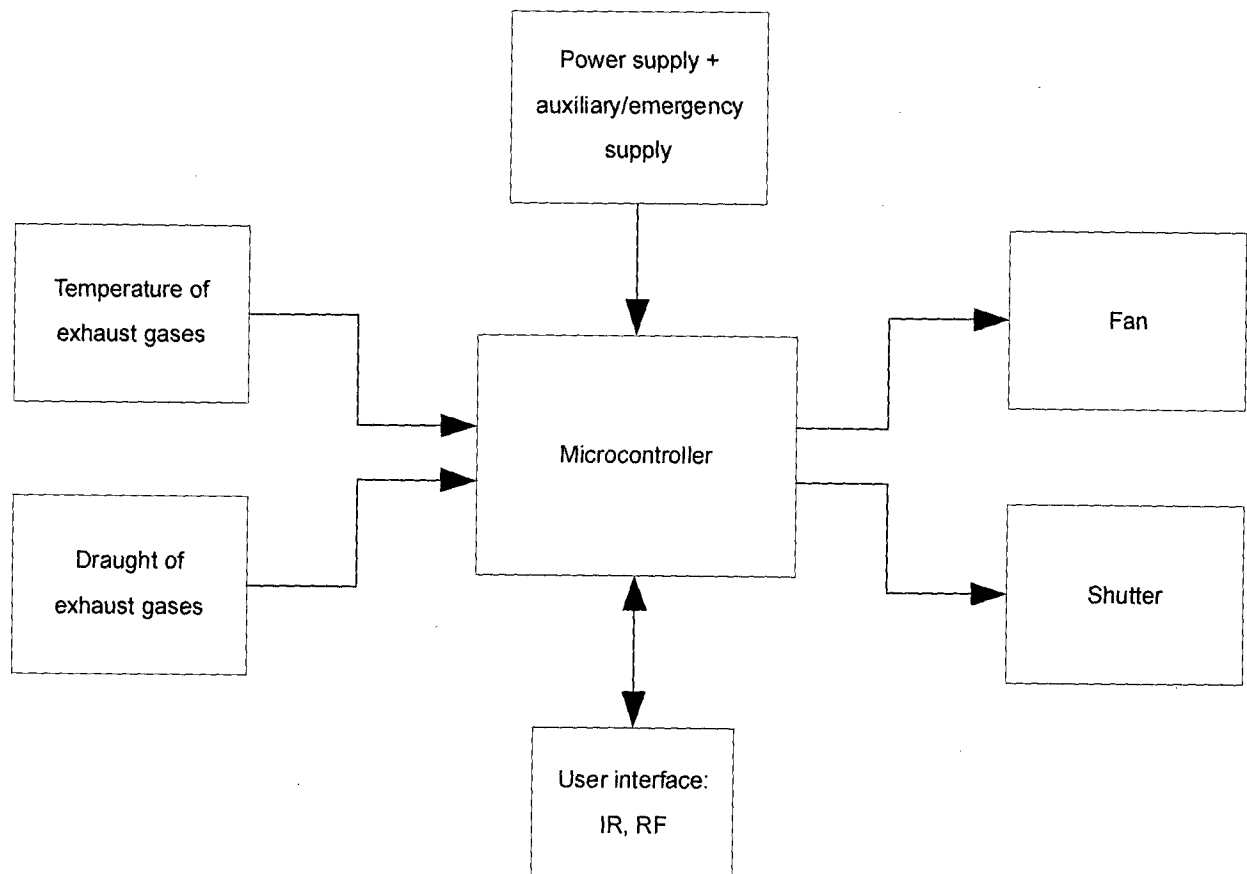


Fig. 1

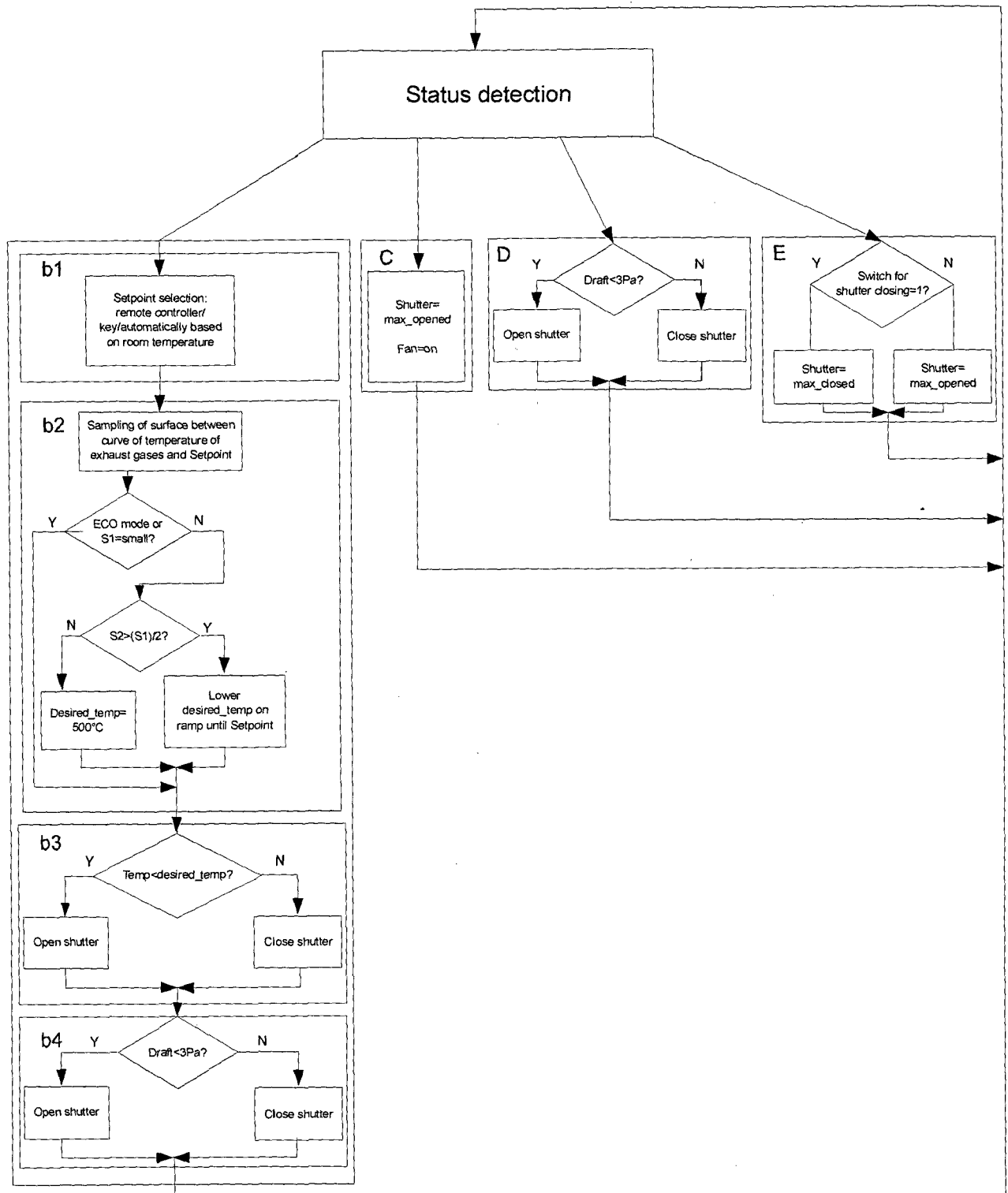


Fig. 2

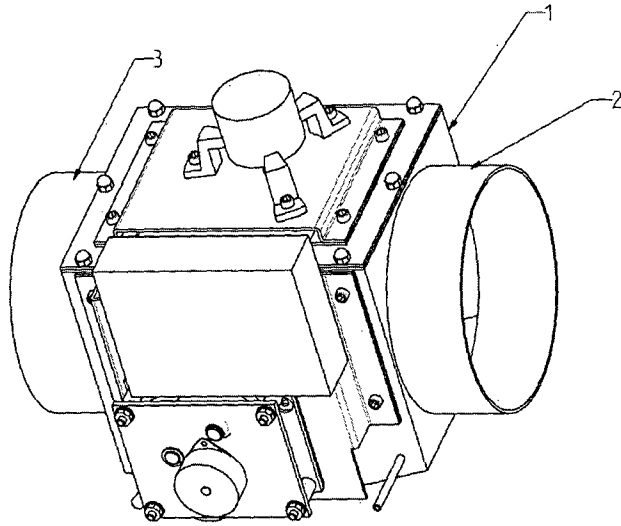


Fig. 3

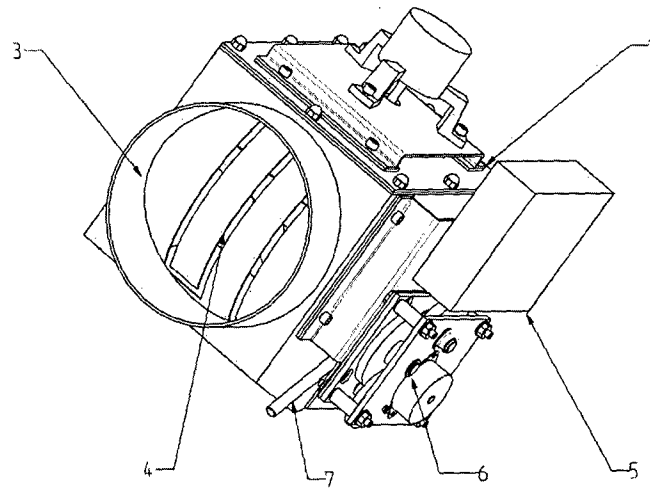


Fig. 4

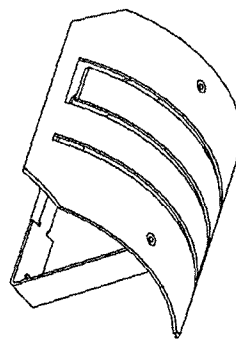


Fig. 5