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(71) Applicant: **ABMG "Astra"**
62161 Alytus (LT)

(72) Inventor: **Kaluskevicius, Jonas**
LT-62161 Alytus (LT)

(74) Representative: **Zaboliene, Reda**
METIDA law firm of Reda Zaboliene
Business center VERTAS
Gyneju str. 16
01109 Vilnius (LT)

(54) **Flue with turbulence plates**

(57) The purpose of the invention is the design (construction) of the flue (1) of the solid fuel boiler system. The design which causes the effect of turbulence in the flue and at the same time is easy to disassemble and clean. It consists of the following: the inlet (2), the flue channel (3), the turbulence plates (4), the heat exchanger (5), the free passage (6), the outlet (7), and the inspection aperture (8). The main distinctive feature is the turbulence plates (4), which consist of the following structural elements: the bottom support (9), two upper supports (10), the body (11) and the notch (12). The said turbulence plates are called turbulence because they force gas (fumes) to stop itself in the flue, to rotate, and to flow around the obstacle. In boiler flue these plates are installed at a certain angle and stop the outgoing fumes; the latter spend a longer time in the heat exchanger and give a larger amount heat to it. In the design of the invention the aforementioned turbulence plates are not able to "burn" as they touch the small surface of the flue, also they are much easier to clean. The design of the invention is particularly well suited for solid fuel gas generation boilers, however it is also suitable for all equipment of the solid fuel boilers of the bottom and side combustion.

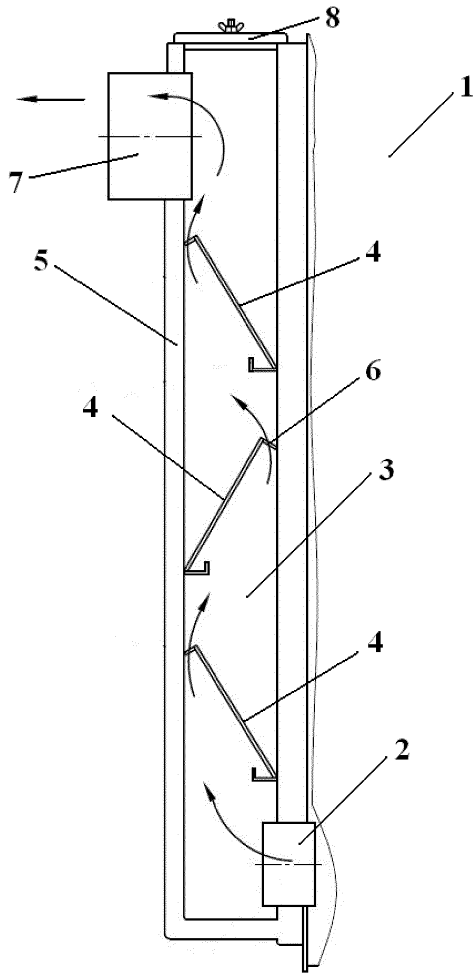

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to the solid fuel boilers of the bottom and side combustion, in particular with the solid fuel boilers. The invention addresses the problems of heat capture in the flue of the aforementioned types of boilers and presents a new design of a flue.

BACKGROUND OF THE INVENTION

[0002] Solid fuel gas generation boilers are designed for the heating of individual homes, small public, industrial or commercial facilities. They are fired with firewood, various dried and pressed briquettes of sawdust, wood shavings, peat. Solid fuel gas generational boilers operate under the principle of gas generation: the gas is emitted (generated) from the burning firewood at the upper chamber of the combustion boiler, then the gas is burned at the bottom chamber, from which it enters to the chimney flue and outwards / to the environment through it.

[0003] The Chinese patent No. CN201059574, published in 14 May, 2008, is known. Herein a bulky design of a flue is provided, where hot exhaust fumes are cooled using a water sprinkler system when passing between the plates. However, the construction described in this application is designed to address the issues of the climate change and is not intended for the heat capture from the emitted hot fumes in a chimney flue.

[0004] Also, the Dutch patent No. NL8301318, published in 1 October, 1984, is known. Herein a fireproof design of a flue is presented. The design consists of u-shaped structural elements within the flue. The design is intended to facilitate maintenance work of the chimney outlet; however it does not have the function of the heat capture from hot fumes.

[0005] Also the Canadian patent No.CA2101263, published in 6 April, 1994, is known. Herein the technological chain of the fuel combustion is described. The chain consists of a fuel feed conveyor, pyrolysis chamber and hot fumes exhaust system. One of the design elements of the system is a pipe with turbulence plates, through which supplied air is heated and directed to the combustion chamber. However, in this design the said plates are used as a heat exchanger, i.e., they are heated in order to warm the air which enters from the outside towards the pyrolysis chamber. The patent does not address the heat removal from the hot fumes coming out from the combustion chamber.

[0006] The German patent No.DE9216274, published in 24 June, 1993, is known. Herein the design of a flue, which uses the turbulence plates to cool the hot fumes, is examined. However, herein only the turbulence plates, which tightly interconnected at their ends form a single saw-teeth formation (construction), are addressed. In order to stabilize and position the aforementioned saw-teeth construction in the flue longitudinally, a bar goes through the centre of the plates. The design described herein is too complex (cumbersome) and impractical, i.e., in a practical sense, it is difficult to remove and clean it, in a commercial sense, it is not sold.

[0007] The closest in terms of the technical level is the application No. WO2011153992, published in 15 December, 2011. Herein the construction of the flue with the turbulence plates is described, where the plates are interconnected by levers, by means of swivel joins. Each of the plates is fixed in the middle of the boiler flue (not to the walls) on the axis, around which it can rotate. During the rotation of the turbulence plate its position is changed (i.e., angle / orientation) in respect to the emitted hot fumes. The change of the set angle affects the strength of the effect of turbulence (it may be strengthened or weakened). However, such a construction has a few negative aspects: it is difficult to remove and clean, due to high temperature and burns the moving parts often deteriorate and do not move, also during the rotation sound waves appear (especially when the construction is not new) which are usually not desirable.

[0008] On the basis of the patent and technology search results, also by observing and analysing the real situation in the world (from commercial point of view), in the field of solid fuel gas generation boilers, it can be concluded that in the world, in this field, there are many theoretically operating inventions patented, however, in reality they usually fail to be implemented simply because of their complexity and imperfection, also due to economic unprofitability. Currently the form of the boiler flue, consisting of a pipe system which is submerged in water, is widely used in the market. The flue usually has a shape of a cylinder. When passing through this pipe system, the fumes leave a certain amount of their heat to the pipes, or more precisely to the water, in which the pipes are submerged. Later, this thermal energy is transferred to the heating system. Also, turbulence spirals are usually installed in the pipes in order to stop the fumes, to make them rotate and stay in the pipes as long as possible: the longer the fumes remain in the pipe system, the more heat they transfer to the pipes and to the water (heat exchanger) respectively. The systems of this kind are very effective in terms of heat removal, but are not user friendly as the aforementioned turbulence spirals have to be regularly maintained, i.e., a the appropriate time they have to be stirred (moved) in the pipes. In case of a failure to do so, they "burn" so much that they clog the flue, the cleaning of which then requires assistance of a qualified person.

SUMMARY OF THE INVENTION

[0009] The essence of the invention is a more effective heat capture from the flue of the solid fuel boilers of hot gas (fumes).

[0010] The purpose of the invention is the flue installation design for the solid fuel boiler system, <u>which causes the turbulence of exhaust gas in the flue and which, at</u>

the same time, can be easily dissembled and cleaned. Such a design consists of the following: an inlet, a flue channel, turbulence plates, a heat exchanger, a gas flow passage clearance, an outlet and an inspection aperture. The main distinctive feature is the turbulence plates, which consist of the following structural elements: a bottom support, two upper supports, a body and a notch. Other distinctive feature of the flue is a flue channel having the greater passage area in a rectangular or other form.

[0011] The said turbulence plates are called turbulence because they force gas (fumes) to stop itself, to rotate, and to flow around the obstacle (Turbulence). In boiler flue these plates are installed at a certain angle and stop outgoing fumes; the latter spend a longer time in the heat exchanger and give more heat to it. In the design of the invention the aforementioned turbulence plates do not have a possibility to get "stuck" as they contact with the small surface areas of the flue, also they are much easier to clean.

[0012] Each turbulence plate rests on the heat exchanger of the boiler flue on three following supports: on the bottom support and two upper supports. There is only one bottom support as it is easier to insert the plate into its intended place (position), when putting it into the flue channel manually by using a hook. In this case, when putting the plate into the flue channel manually by using a hook, firstly, its bottom position is located, and further, by slightly releasing the hook, but still having not pulled it out, the plate, being affected by its own gravity, is allowed to lean to the opposite side of the heat exchanger as long as it does not touch the wall of the heat exchanger with its upper support. The turbulence plate (4), having been inserted into the operating position and occupying its position in the flue channel, closes a part of the passage and leaves a free passage only at its upper part. It should be noted that the top of the turbulence plate with a free passageway has to be necessarily near the flue wall, to which the heat exchanger is located.

[0013] The said turbulence plates causes the effect of turbulence during which the exhaust gas (fumes) is stopped and spends more time near to the heat exchanger, to which it transfers its thermal energy.

[0014] When the turbulence plates of the flue system were not used, the maximum temperature in the flue reached 360 deg C. When the design of this invention was used with the turbulence plates, the maximum temperature reached 175 deg C. This is the main reason why the design of the invention is very effective in practice and collects a double amount of thermal energy.

[0015] The design of the invention is particularly well suited for solid fuel gas generation boilers; however it is also suitable for all equipment of the solid fuel boilers of the bottom and side combustion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 The design of the flue with the turbulence plates, reflecting the essence of the invention (lateral section) is provided.

Fig. 2 One of the structural elements is provided: the bottom support of the turbulence plate (side view in different projections).

Fig. 3A more detailed design of the turbulence plate is provided (side view in different projections).

Fig. 4 The top view of the boiler flue is provided: when it does not have the turbulence plates (on the left), and when they are inserted into their places (on the right).

Fig. 5 The design of the hook intended for the removal and insertion of the turbulence plates is provided.

Fig. 6 The temperature graph of the exhaust gas combustion process is provided (delay time (s) on the horizontal axis, the temperature (deg C) of the exhaust gas on the vertical axis) when the process takes place without the turbulence plates (as additional visual material).

Fig. 7 The temperature graph of the exhaust gas combustion process is provided (delay time (s) on the horizontal axis, the temperature (deg C) of the exhaust gas on the vertical axis) when the process takes place with the turbulence plates (as additional visual material) under the same external conditions.

Fig. 8 The overall design of the solid fuel combustion boiler with the flue is provided in the section (as additional visual material).

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] As it is known, many solid fuel boiler systems have been designed in the world. At the technical level separate installations are known, the design of which consists of the plates directing the flow of hot fumes and exhaust gas from the firebox of the boiler towards other sections of the system. Such plates are usually known as the turbulence plates because they cause the effect of turbulence in the way of the said gas / fumes. The effect of turbulence of the exhaust gas is very useful as it does not allow the flow of air / gas / fumes (hereinafter referred to by the general term "gas") to move without any resistance through the flue (the definition of a flue can be expanded to any form of a pipe or tunnel), i.e., during the effect of turbulence, the moving gas flow is twisted and stopped in the flue: the longer the said fumes remains in the flue, the more heat they transfer to the objects in its vicinity, for example, to the pipe walls, to the same turbulence plates, etc. When the gas flow passes through the flue which does not have the turbulence plates (i.e., the effect of turbulence is absent), only the fringes of the hot flow are cooled (if there is a heat exchanger around the flue), however the middle of the flow of the hot fumes / gas (the middle part) remains hot and discharged to the atmosphere via the chimney.

[0018] Thus the effect of turbulence is very useful if it occurs in the heat exchanger because only in this way the transfer of additional energy to the heating system is possible. However any turbulence equipment, installed in the boiler flue, located behind the firebox of the solid fuel boilers, or behind its economizer, or in the part of the chimney, is contaminated by unburned solid particles or tar which forms during the process of creosote formation. In such a way the inner surface of the flue and everything what is in the flue gets covered with a thin layer; due to the layer the passing area of the flue is reduced, the chimney draft gets worse. If it is not cleaned, any equipment in the flue of the solid fuel boiler loses its functionality. Moreover: due to high temperature and burns it may become impossible to disassemble the construction without special tools and intervention by a technician.

[0019] The aim of the invention is the design of the flue equipment, which would cause the turbulence of the exhaust gas and, at the same time, would be easy to disassemble and clean. Only in this case the said construction can be applied in the reality, in the sector of the solid fuel boilers.

[0020] Fig. 1 the design (1) of the invention of the flue with the turbulence plates is provided. It consists of the following structural elements: an inlet (2), a flue channel (3), turbulence plates (4), a heat exchanger (5), a free passage (6), an outlet (7) and an inspection aperture (8).

[0021] From the boiler combustion chamber (or other intermediate equipment) the flow of hot gas and fumes enters the flue (1) through the flue inlet (2). The flue inlet is usually installed at the side of the bottom of the flue and can be in any shape, for example, round, rectangular, etc. In such a way the said flow of hot gas enters the fuel channel (3), by which it moves towards the flue outlet (7), through which it is discharged by passing through the connecting part directly connected with the chimney. The flue outlet (7) is usually installed at the side of the upper part of the flue (1). The inspection aperture (8) is also installed next to the flue outlet (7), the aperture is set out at the very top of the construction of the flue (1) and is covered with a screwed cap with a gasket. The inspection aperture (8) is used for cleaning of the flue channel (corridor) and for the insertion / removal of the turbulence plates.

[0022] The construction of the flue (1) itself, as a longitudinal element, is usually positioned (installed) perpendicularly (at 90 degrees) in respect to gravity force, however the value of the angle is not necessarily 90 degrees: depending on the idea and specific scheme the angle can be different. When the said hot gas enters the flue channel (3), it starts to move upwards and gradually loses its thermal energy.

[0023] It is preferable that the shape of the flue corridor / channel (3) is rectangular, not cylindrical, because precisely such a shape of the flue corridor (3) is most efficient when implementing the invention. However the shape of the said channel (3) also can differ, for example, cylinder, half cylinder or irregular shape (the most important that it would be possible to insert the turbulence plates into the channel). The thermal energy of hot gas gets absorbed by the air in the said channel (3), the turbulence plates (4) and the heat exchanger (5). At the end, all energy (as much as possible) is transferred to the heat exchanger (5) because the said air heats up very fast and transfers its absorbed thermal energy to the plates (4) and the heat exchanger (5) by itself, while the plates (4), when they heat up, transfer their thermal energy to the heat exchanger (5) (although, in fact, the plates (4) can accumulate and transfer a relatively small amount of thermal energy to the heat exchanger themselves, because their weight usually is only 200-300 g). The heat exchanger (5) is essential and it is desirable that it should cover all four walls of the flue channel (3). Then even an additional heat removal by employing the essential structural elements of the invention, which are the turbulence plates (4), would be used the most effectively.

[0024] The main feature of the design (1) is the turbulence plates (4). The optimum amount of the turbulence plates should be 3 (three), however, depending on the length (height) of the flue, it can be more. Fig. 2 provides one of the structural elements of the turbulence plate (4): the bottom support (9) (from the side in different projections). Fig. 3 provides the design of the turbulence plate (4) (from the side in different projections). The turbulence plate (4) consists of the following structural elements: the bottom support (9), two upper supports (10), a body (11), and a notch (12).

[0025] The bottom support (9) is fixed to the middle of the wall of the heat exchanger (4) in respect to the angles of the heat exchanger. In fact the bottom support (9) is not a part of the turbulence plate (4) but a part of the flue channel (3), however in a structural sense it is much easier to analyse it together with the turbulence plate (4). The said bottom support (9) is produced from steel angle which does not require any labour intensity, i.e., it is standardized and cheap. Since the edge of the said bottom support (9) is folded vertically, it is easier to aim and locate the position of the turbulence plate (4) during its installation in the flue (1). The turbulence plates (4) take their position in the flue (1) affected only by their own force of gravity. The recommended length of the horizontal plane (up to the vertical fold) of the bottom support is 15-30 mm. It will be more difficult to position the turbulence plate, especially the lower one, in case of the shorter length. In case of the longer length, the support will protrude too much into the flue channel (3) and will cause problems during the cleaning of the channel (3). The area of the bottom supports (9) can vary: the more narrower it is, the easier is to clean the flue channel (3).

[0026] There are two upper supports (10), because in order to ensure the stability /better balance of the turbulence plate (4), its body (14) has to rest at least on three stable points. In comparison with the bottom support (9), which is permanently fixed to the surface (wall) of the flue (heat exchanger), the upper supports (10) are fixed to the body (11) of the turbulence plate (4). The turbulence plates (4) also have a notch (12) which, when hanged with a hook, is designed in order the turbulence plate (4) could be inserted into the flue channel and removed from the flue channel (3).

[0027] The said turbulence plates (4) are inserted and removed by using a simple tool, i.e., a hook made of bent wire (13) which is shown in Fig. 5. When the hook is manufactured in the factory it is bent at 80° angle (it is not appropriate to bend the hook in a more acute angle, because it will be more difficult to remove the plate from the hook (13) in the flue channel (3) when the plate is inserted into the required position) so that the plate would not slip when hanged on the hook. In order to hang the turbulence plate (4), the said notch (12) is drilled into its body (11).

[0028] Each plate rests on the heat exchanger (5) of the boiler flue on three supports: by the bottom support (9) and two upper supports (10). There is one bottom support so that it would be easier to locate the intended place (position) of the plate when it is inserted into the flue channel (3) manually by using the hook (13). Although the construction described is provided with one bottom support (9), in order to improve plate stability two bottom supports (9) can be installed, however, that type of installation requires greater flue cleaning efforts. Depending on the system and external parameters / conditions and requirements, the quantity of the bottom supports (9) is determined separately (individually): it may depend on the type / configuration of the heat exchanger, its diameter, length, the load of the flue channel, and so on.

[0029] When inserting the turbulence plate (4) into the flue channel by using the hook (13), at first, the bottom position intended for the plate is located and then, after slightly slacking the hook (13) but without pulling it, the plate, affected by gravity, is allowed to lean in the opposite direction of the heat exchanger (5) as long as it does not touch the wall of the heat exchanger (5) with its upper supports (10). Then the hook can be pulled, also the same operation of the insertion of the other turbulence plates (4) into the flue channel (3) can be carried out in a similar manner.

[0030] Fig. 4 the view from the top of the boiler flue (1) when there are no the turbulence plates (4) (on the left) yet and when they are inserted in their places /positions (on the right). The turbulence plate (4), having been inserted into the operating position and occupying its position in the flue channel, closes a part of the passage and leaves a free passage only at its upper part. The bottom edge of the turbulence plate (4) closely fits to the heat exchanger (5), therefore the whole flow of the exhaust gas, directed along the body of the plate (11) towards the flue outlet (7), can move only through the said free passage (6) consisting of the following openings: a free passage at the top of the plate over its entire length, a narrow free passage of 2-4mm at both sides of the plate (4) and a notch to hang a hook (12). The upper supports (10) are positioned from the edge at the distance of approximately 2-4 mm in respect to the body (11) of the plate so that a limited freedom of movement for the plate (4) would be guaranteed and it would be easier to insert / remove it. The area of the free movement (6) has to be approximately equal to the area of the flue inlet (2) so that the turbulence plates (4) would not have an adverse effect on the chimney draft. It should be noted that the top of the turbulence plate (4) with the opening for the free passage (6) should be near the wall of the flue (1), where the heat exchanger is located (5). The said turbulence plates causes the effect of turbulence during which the exhaust gas is stopped and spends more time near to the heat exchanger, to which it transfers the larger part of its thermal energy.

[0031] In order to prove the efficiency of the turbulence plates (4) several graphs have been included in the description (as additional visual material). Fig. 6 provies the temperature graph of the exhaust gas combustion process (delay time (s) on the horizontal axis, the temperature of the exhaust gas (deg C) on the vertical axis) when the process takes place without the turbulence plates (as additional visual material). Fig. 7 provides the temperature graph of the exhaust gas combustion process (delay time (s) on the horizontal axis, the temperature of the exhaust gas (deg C) on the vertical axis) when the process takes place with the turbulence plates (as additional visual material) under the same external conditions. The boiler of 20 kW was used for these experiments. When the turbulence plates (4) were not used, the value of the maximum temperature reached 360 deg C in the flue. While, when the turbulence plates (4) are used, the maximum temperature reaches only 175deg C. As we see, the effectiveness of the turbulence plates is strongly felt, also a double amount of thermal energy is collected.

<u>The inclination angle of the turbulence plates (4) and their quantity.</u>

[0032] The most optimal inclination angle of the turbulence plates from the horizontal plane of the bottom support (9) is 40-60°. The angle smaller than 40° degrees is not recommended because the more the notch (12) is horizontal in the plane of the plate (4), the harder is to attach the hook (13). The number of the plates in the flue can be from 1 to 5: each additional plate increases additional removal of the heat from the exhaust gas and, in case of 2-3 plates, the effect can be felt rather strongly. In case of a larger number (more than 5) of the turbulence plates (4) and increased length of the hook (13), the insertion of the said plates (4) through the inspection aperture (8) becomes very cumbersome as it is difficult to detect (not visible) their position in a dark flue. Meanwhile the upper plates are much easier to insert because they are positioned near the inspection aperture (8) where there is light enough.

<u>Control of the plates and the flue</u>

[0033] When implementing the design solution of this invention, the removal of the turbulence plates (4) is not difficult: they do not burn because only with one complete edge, which is a corner (edge), they come into contact with the flue. Also, they are very light (200-300 g.) and not interconnected into bulky constructions, i.e., they do not have connecting structures, and are positioned only by their own gravity, which is very important. After the removal of the turbulence plates (4), it is very easy to clean the flue channel (3) with a simple scraper designed for the boiler cleaning which is supplied together with the solid fuel boiler equipment. Due to their small size the bottom supports (9) in the flue channel (3) do not cause any problems during the control of the flue (1), which is carried out via the inspection aperture (8). There are two ways to clean the removed turbulence plates (4): 1) by scraping burned residue (burns) with the scraper of the same boiler or 2) by putting the plates (4) in the boiler firebox and completing one boiler combustion cycle during which all dirt burns away. After the cleaning procedure of the plates (4), they are inserted into their operating positions in the flue by using the hook again.

[0034] In order to illustrate and describe the invention, the most appropriate implementation options are described above. This is not a complete or limiting invention aiming to determine an exact form or implementation option. The aforementioned description should be perceived as an illustration and not as a limitation. It is evident that for professionals of the field there may be obvious many modifications and variations. Implementation options are selected and described in order the specialists of the field to provide the best explanation of the construction of the invention and its best practical application for different implementation options with different modifications suitable for a particular usage or application of implementation because, in case of a specific system of the solid combustion boiler, quantitative parameters of the design of the invention may differ. The scope of the invention is specified in its claims and its equivalents where all said terms have meaning at the widest limits unless it is specified otherwise. It must be recognized that in relation to the implementation options, described by professionals of the relevant field, modifications may be made without deviating from the scope of the invention.

Claims

1. The design of the solid fuel gas generation boiler, consisting of the inlet, the flue channel, the heat exchanger, the outlet, and the inspection aperture, is **characterized in that,** in addition, it has the turbulence plates (4), which consist of the following structural elements:

   bottom support / support (9),
   two upper supports (10),
   the body (11) and
   the notch (12);

   where:

   the turbulence plates (4) create the effect of turbulence in the flue (1) during which the exhaust gas is stopped and spend more time near the heat exchanger (5) to which it transfers a larger part of its thermal energy;
   the turbulence plate (4), inserted into operating position and taking its place in the flue channel (3), covers a part of the flue channel (3) and leaves only a free passage (6) near its upper part (the bottom edge of the turbulence plate (4) fits closely to the heat exchanger (5),
   therefore all flow of the exhaust gas, directed along the body (11) of the plate upwards to the flue outlet (7), can move only through the free passage (6));
   the turbulence plates (4) take their position in the flue (1) affected by their own gravity, they are removed and inserted by using a simple tool - a hook made from bent wire (13);
   each of the turbulence plates rests on the heat exchanger of the boiler flue on three supports: by one bottom support (9) and two upper supports (10):

      the bottom support is only one in order so that it would be easier to insert the plate into its intended place (position) when inserting it into the flue manually by using the hook;
      the upper supports (10) are two so that in order to guarantee the stability / better balance of the turbulence plate (4), its body (4) has to rest on at least three stable points;

   the bottom support (9) is permanently fixed to the surface (wall) of the flue heat exchanger (5);
   the upper supports (10) are fixed to the body of the turbulence plate (11);
   the notch (12) is drilled in the body (11) of the turbulence plate (4) and
   intended for the insertion and removal of the turbulence plate (4) into/from the flue channel (3) by using the hook (13).

2. The design of the flue of the solid fuel gas generation boiler according to the claim 1, **characterized in that** the most optimal inclination angle of the turbulence plates (4) from the horizontal plane of the bottom support (9) is 40-60°.

3. The design of the flue of the solid fuel gas generation boiler according to the claims 1 and 2, **characterized in that** the optimal length of the horizontal plane (up to the vertical fold) of the bottom support is 15-30 mm.

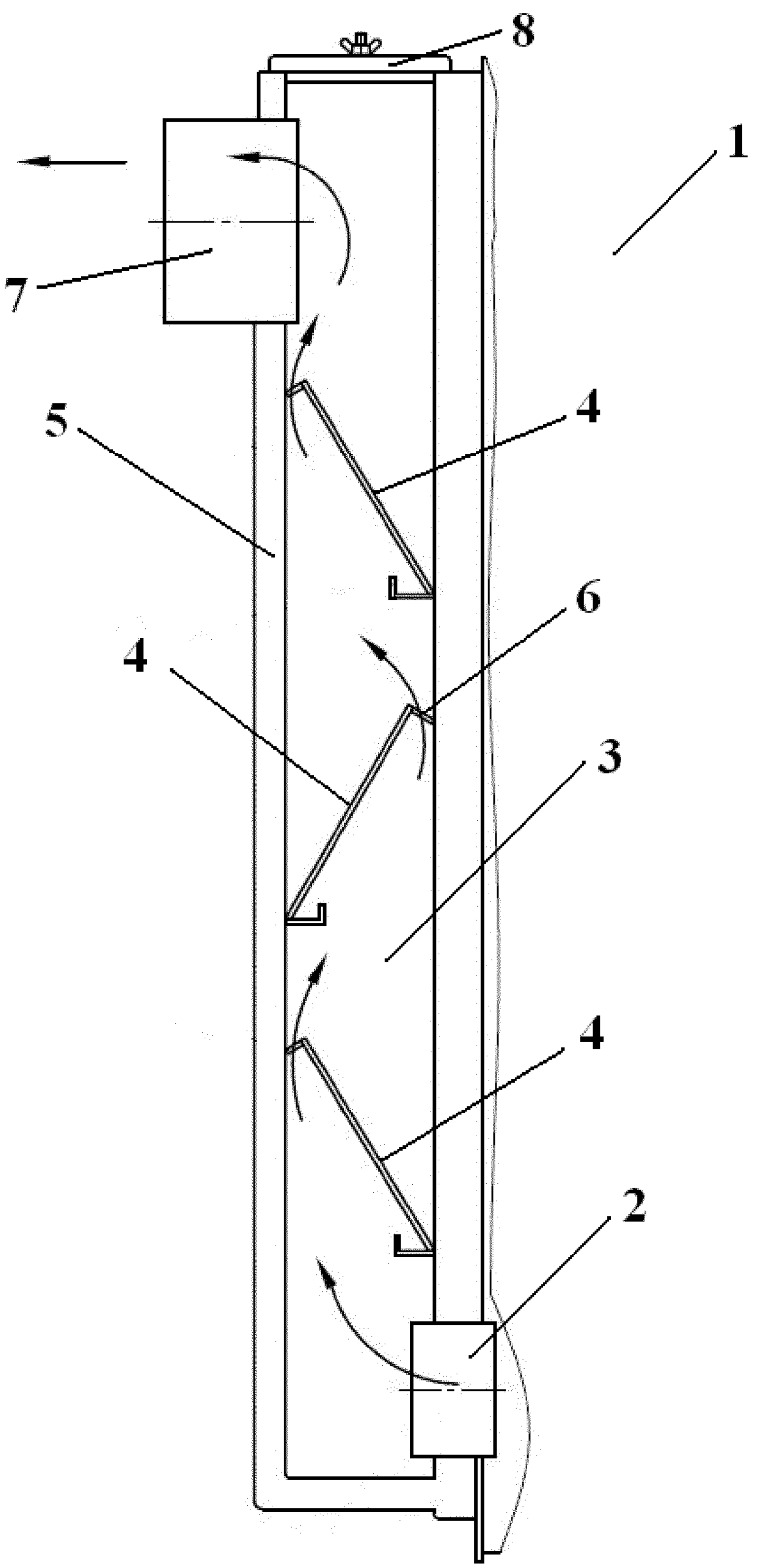

Fig. 1

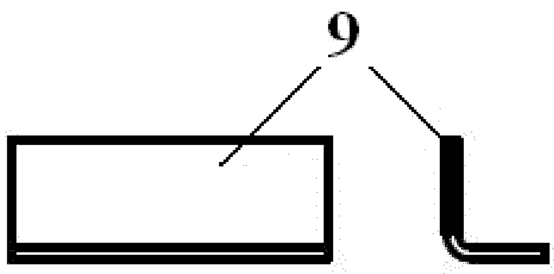

Fig. 2

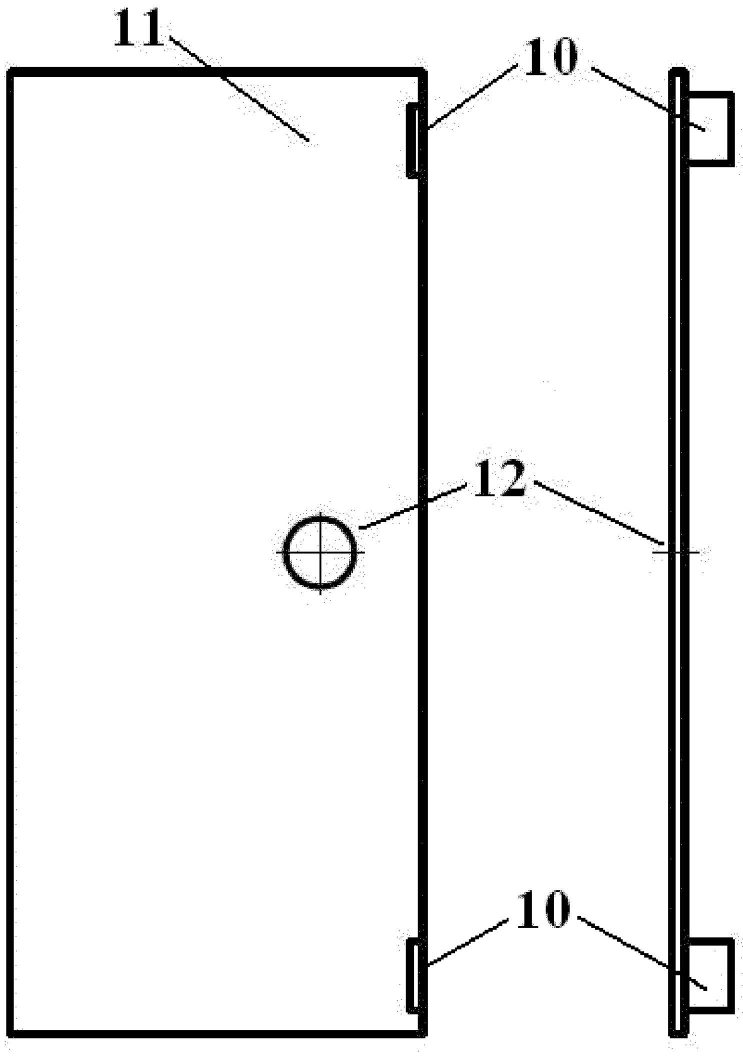

Fig. 3

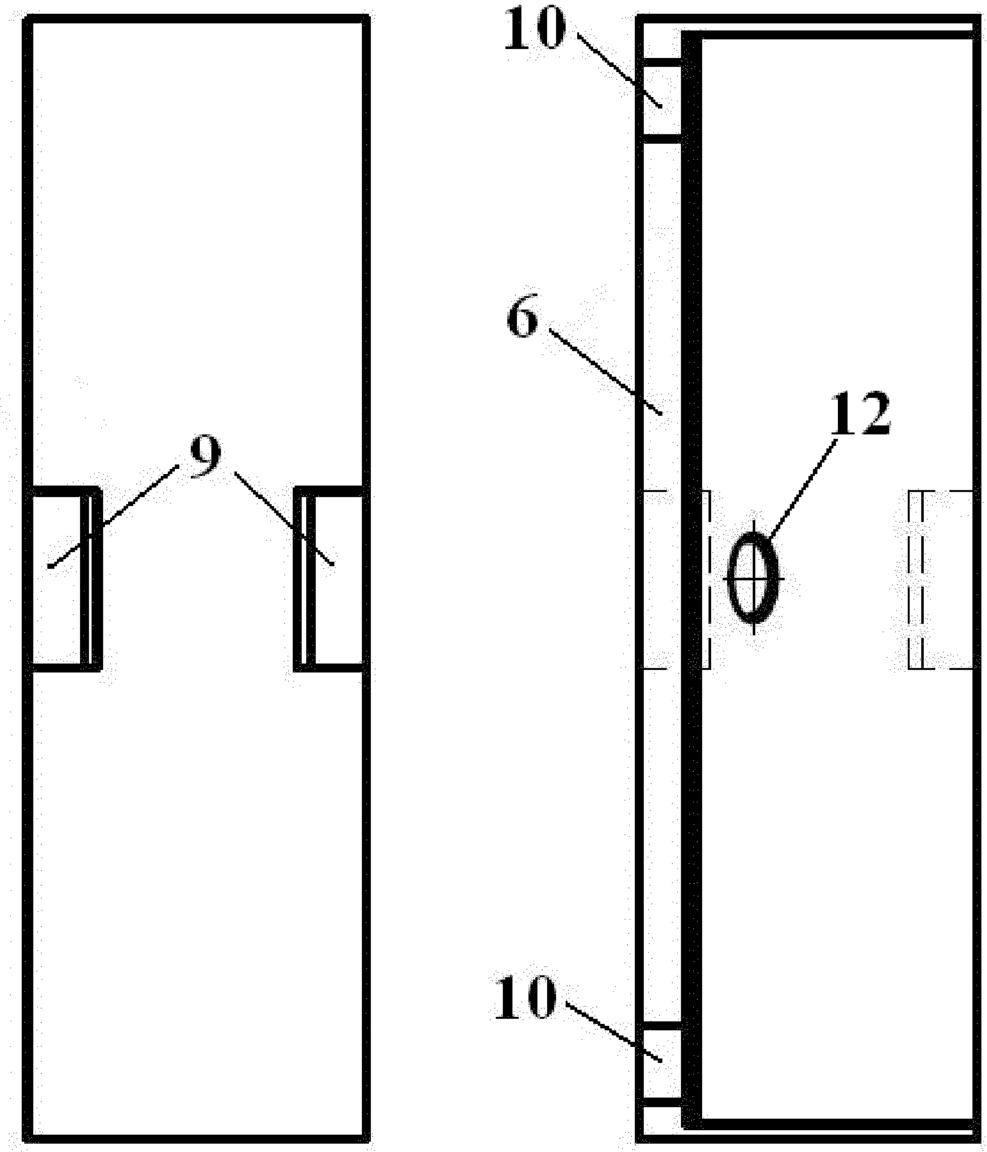

Fig. 4

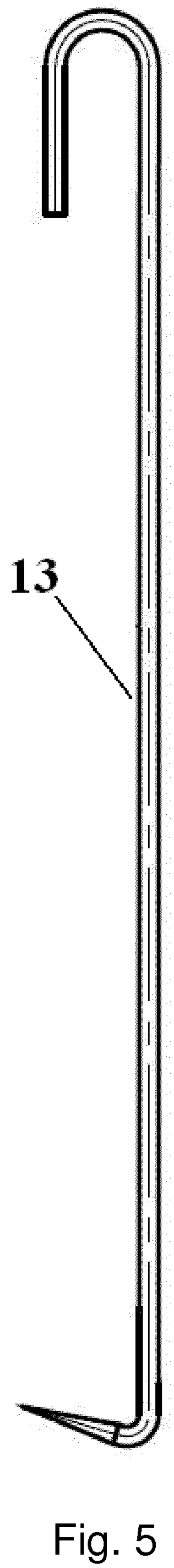

Fig. 5

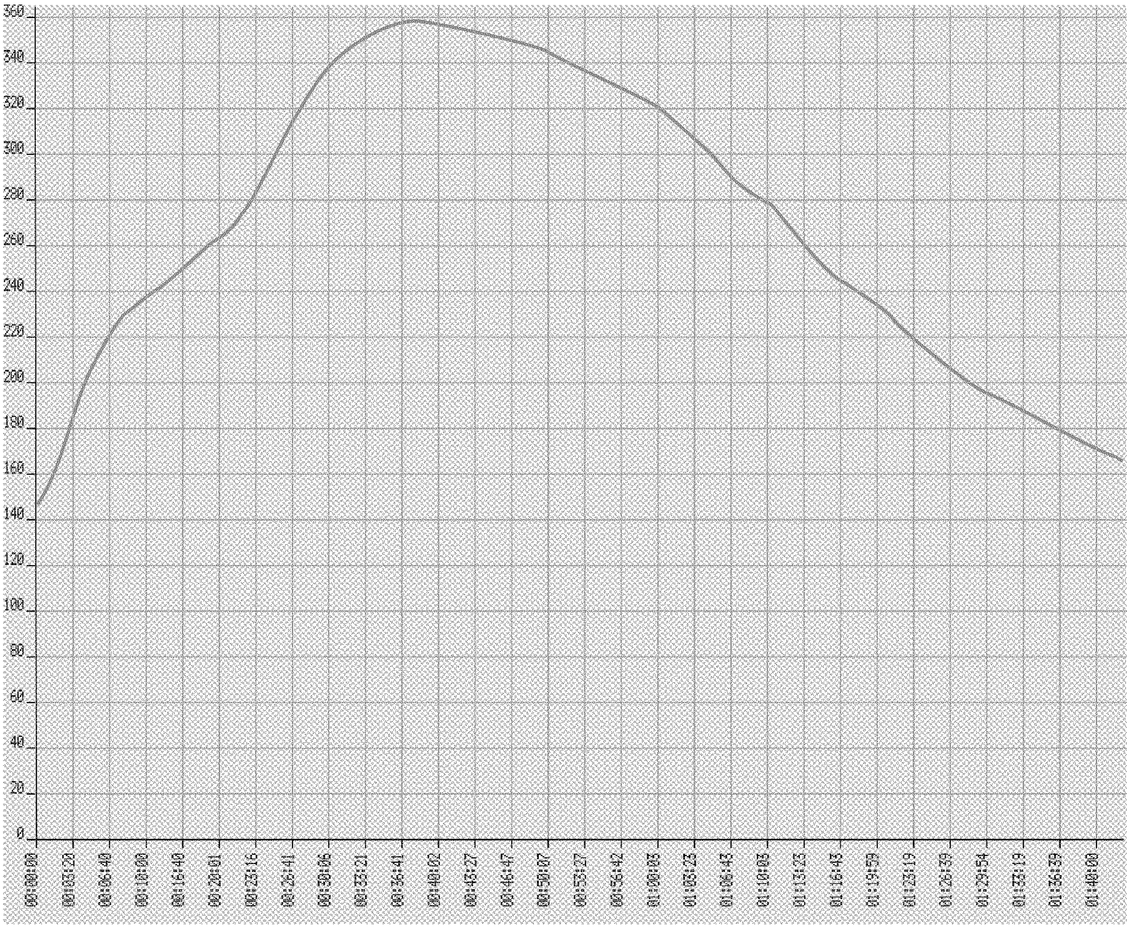
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Fig. 6

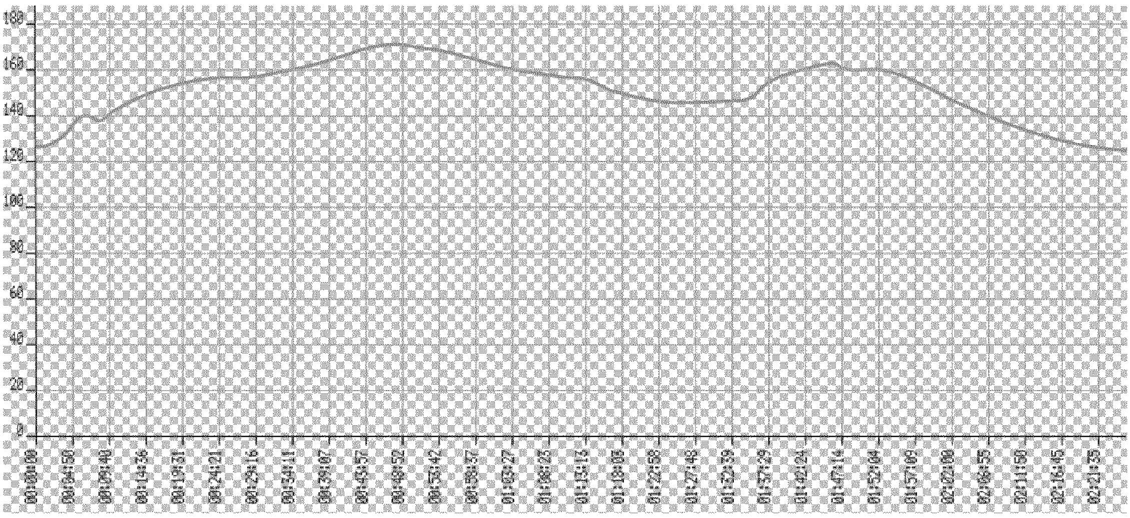
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Fig. 7

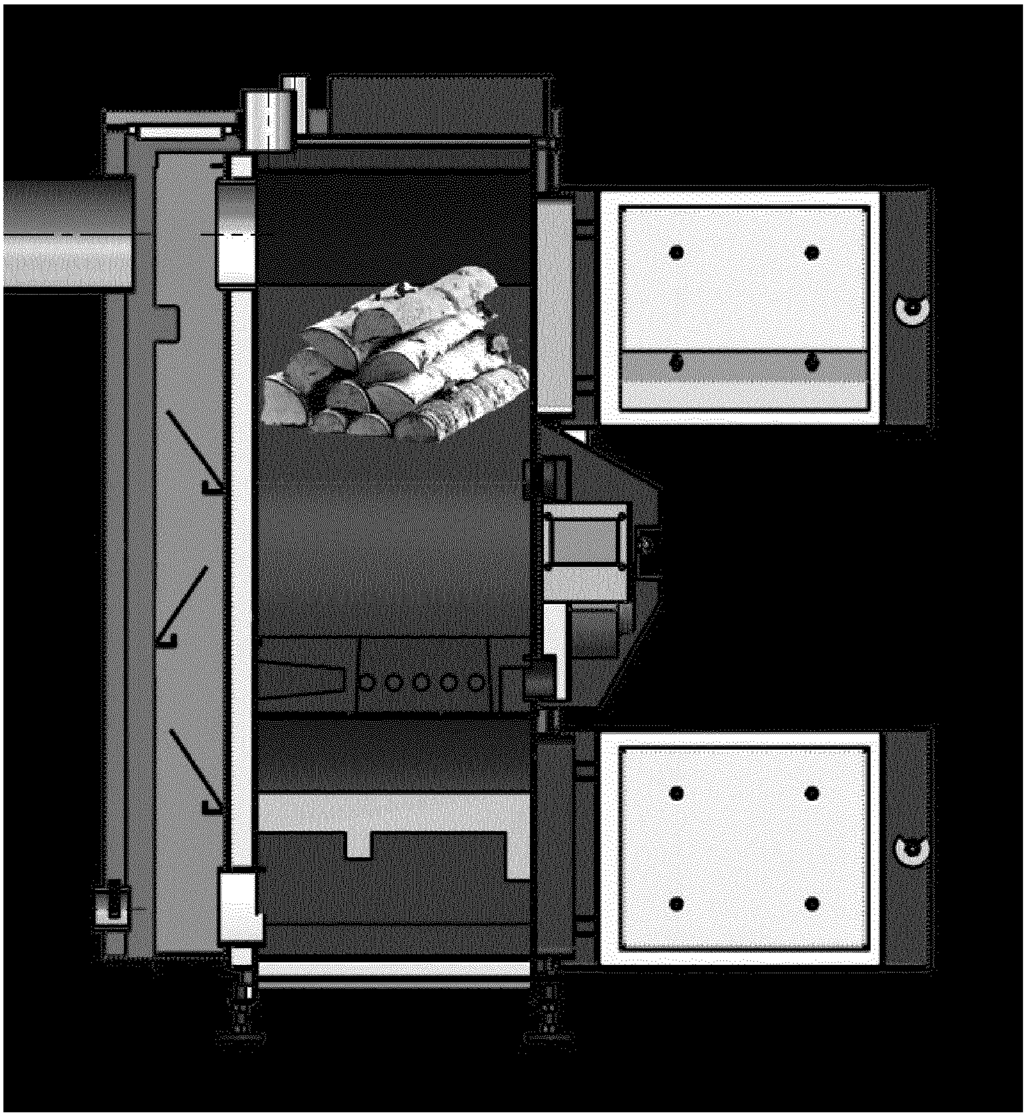

Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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