



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 467 148 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
13.10.2004 Bulletin 2004/42

(51) Int Cl.7: **F23C 10/02**, F23C 10/04,
F23C 10/20, F23L 1/00

(21) Application number: **04100940.8**

(22) Date of filing: **09.03.2004**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**
Designated Extension States:
AL LT LV MK

(72) Inventor: **Ylitalo, Matti**
33720, Tampere (FI)

(74) Representative: **Rönkkö, Taina Mirjam**
Tampereen Patenttitoimisto Oy
Hermiankatu 12 B
33720 Tampere (FI)

(30) Priority: **10.04.2003 FI 20030542**

(71) Applicant: **Kvaerner Power Oy**
33101 Tampere (FI)

(54) Air system for a fluidized-bed boiler

(57) A method for supplying upper combustion air from an upper air supply level (10, 11) into a fluidized-bed boiler (1), which boiler is provided with at least a lower air supply (9) underneath the fluidized bed (4) and a fuel supply means (5) above the fluidized bed, as well as one or more upper air supply levels (10, 11) for supplying upper air into the furnace (2) of the boiler, which furnace is limited by a front wall (12), side walls (14, 15) and a rear wall (13) with the nose (6) of the boiler, the

air supply level (10, 11) underneath the nose comprising at least side air jets (17) placed in the side walls (14, 15) of the furnace (2). On the air supply level (10, 11), which also comprises at least one or more primary air jets (16) placed in the front wall (12) of the furnace (2), an air flow (18) is supplied from the primary air jet into the furnace, which air flow (18) is stronger than the air flow (19) supplied from the side jet (17) into the furnace. The invention also relates to an air arrangement and a fluidized-bed boiler (1) implementing the method.

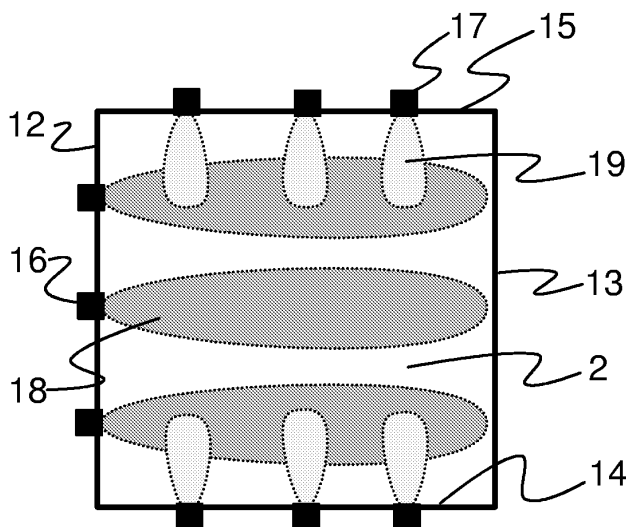


Fig.2

EP 1 467 148 A2

Description

[0001] The invention relates to a method for supplying upper air from upper air supply levels into a fluidized-bed boiler according to the preamble of the appended claim 1. Furthermore, the invention relates to an air system and a fluidized-bed boiler according to the preambles of the appended claims 4 and 7, respectively.

[0002] Air is supplied to the lower part of the furnace of a fluidized-bed boiler via a grate into a fluidized bed formed by fluidized bed material on the grate, to fluidize the material of the fluidized bed. A fuel, such as peat or bark, is supplied from a fuel channel onto the fluidized bed. About 40 to 70 % of the air needed for the combustion of the fuel is supplied as so-called primary air through the grate. For the combustion to be as complete as possible, with a minimum of emissions, upper air is typically supplied from two upper air levels into the furnace of the boiler. In a typical fluidized-bed boiler, air jets of the secondary air level are provided above the fuel channel, and air jets of the tertiary air level are provided above these. Furthermore, the boiler typically comprises various burners which are used as start-up and auxiliary burners.

[0003] In fluidized-bed boilers, upper air is typically introduced into the upper part of the furnace of the boiler on the secondary and tertiary air levels in such a way that 50 to 70 % of the upper air is supplied from the secondary air level, and the rest, *i.e.* 30 to 50 %, is supplied from the tertiary air level. Placing said secondary and tertiary air levels as far from each other as possible has an advantageous effect on the NO_x contents of the flue gases from the boiler. For this reason, the aim is to place the tertiary air level as far up as possible.

[0004] In known upper air systems of fluidized-bed boilers, air is introduced, on the tertiary air level, from opposite sides or one side of the boiler. In practice, it has been found that the best way to introduce the upper air is to place the air jets in both the front wall and the rear wall. Thus, the flow of the flue gases can be easily adjusted as desired, wherein the temperatures and the flow rates in the furnace of the boiler are optimal.

[0005] When the structure of the boiler or the power plant is such that it is not possible to provide air jets and channels in the wall on the side of the boiler nose, *i.e.* on the rear wall, the air is typically introduced from both of the side walls of the furnace and, in some cases, from the front wall only.

[0006] When upper air is only introduced from air jets which are opposed or interlaced in the side walls from the boiler, the flow gases flowing upwards in the furnace typically incline towards one of the side walls. This means that the oxygen content of the flue gases varies in the lateral direction of the boiler, and the combustion process becomes poor.

[0007] When the fuel is introduced from the front wall of the boiler, the combustion is weighted on the side of the front wall. Thus, the content of carbon monoxide

gases increases in the vicinity of the front wall of the boiler, whereas the oxygen content is higher in the vicinity of the rear wall. To introduce a sufficient quantity of air from the front wall to the rear part of the furnace, very strong air jets must be used, which results in the development of harmful turbulence in the area of the furnace. Such turbulence underneath the nose of the boiler reduces the efficiency of the boiler.

[0008] The primary aim of the present invention is to present an air system which produces an even temperature distribution in such a fluidized-bed boiler in which the rear wall cannot be provided with air jets.

[0009] To attain this purpose, the method according to the invention is primarily characterized in what will be presented in the characterizing part of the independent claim 1. The air arrangement according to the invention, in turn, is primarily characterized in what will be presented in the characterizing part of the independent claim 4. The fluidized-bed boiler according to the invention, in turn, is primarily characterized in what will be presented in the characterizing part of the independent claim 7.

[0010] The other, dependent claims will present some preferred embodiments of the invention.

[0011] The basic idea of the invention is to supply the fluidized-bed boiler with air from one or more upper air levels above the primary air level, from three directions. According to the invention, the primary air flows are provided from primary air nozzles placed in the wall opposite to the nose of the boiler, *i.e.* the front wall. Auxiliary air flows are provided from the side walls in such a way that the air flows supplied from auxiliary air nozzles in opposite walls are opposed to each other. The primary air flows and the auxiliary air flows are supplied substantially form the same level in such a way that said primary and auxiliary air flows are either on the same level or on slightly different levels.

[0012] By the air system according to the invention, air can be evenly supplied onto the whole air supply level, to intensify the oxidation of the gases in the vicinity of the front wall. Furthermore, the air flow shifts the combustion process also to the area close to the rear wall underneath the nose, which improves the utilization of the volume of the boiler.

[0013] Furthermore, in a boiler equipped with the air system according to the invention, it is possible to use a smaller upper air coefficient than in conventional boilers, in which the upper air is supplied from the side walls or from the front wall only.

[0014] The air system according to the invention reduces the turbulence of gases flowing inside the boiler when compared with a boiler in which the upper air is supplied from the front wall only, because in the system of the invention, it is possible to use lower strengths of the primary air jets. In an advantageous embodiment, 40 to 80 % of the total quantity of air is supplied by the primary air jets from the front wall, and 20 to 60 % of the total quantity of air is supplied by the auxiliary air jets from the side walls.

[0015] Providing, in addition to the air jets in the front wall of the boiler, air jets in the side walls, opposite to each other, will prevent the inclination of upward-flowing flue gases towards either side. In conventional arrangements, in which air is only introduced from opposed or interlaced air jets in the side walls of the boiler, the flue gases typically incline towards one of the side walls, wherein the oxygen content of the flue gases varies in the lateral direction of the boiler, resulting in a poor combustion process.

[0016] Furthermore, another advantage of a preferred embodiment of the invention is a reduction in the corrosion and soiling of the superheaters, because the temperatures of the flue gases entering the superheater region are reduced.

[0017] In the following, the invention will be described in more detail with reference to the appended principle drawings, in which

Fig. 1 shows an embodiment of the air system according to the invention in a side view,

Fig. 2 shows an embodiment of the air system according to the invention from above,

Fig. 3 shows another embodiment of the air system according to the invention from above,

Fig. 4 shows the temperature distribution in a boiler equipped with the air supply system according to the invention, and

Fig. 5 shows the temperature distribution in a boiler equipped with a conventional air supply system.

[0018] For the sake of clarity, the figures only show the details needed for understanding the invention. The structures and details which are not needed for understanding the invention and which are obvious for anyone skilled in the art have been omitted from the figures in order to emphasize the characteristics of the invention.

[0019] Figure 1 shows schematically a fluidized-bed boiler 1 with a furnace 2. From an air box 9 in the lower part of the fluidized-bed boiler 1, primary air is supplied through a grate to a fluidized bed 4 formed by fluidized bed material on the grate. In this way, the fluidized bed material is fluidized. Fuel is supplied from a fuel channel 5 onto the fluidized bed 4. Above the fuel channel 5, there is a secondary air level 10, whose single air jets are not shown in the figure. Above the secondary air level 10, there is a tertiary air level 11, whose single air jets are not shown in Fig. 1 either. Furthermore, the fluidized-bed boiler 1 typically comprises various burners which are used as start-up and auxiliary burners. Said burners are not illustrated in the figure.

[0020] In the upper part of the furnace 2 of the fluidized-bed boiler 1, there is a nose 6 which is a structure

protruding from the rear wall 13 towards the front wall 12 of the furnace. The nose 6 guides the flow of flue gases into superheaters 7 and further into the flue gas duct 8. Furthermore, the nose 6 is preferably used as a shield for the superheaters, separating the superheaters from a direct contact with the flame.

[0021] From Fig. 1, it can be seen that if, for example, the flue gas duct 8 is arranged to extend close to the rear wall 13 of the fluidized-bed boiler 1 and as far down as possible, the rear wall 13 of the boiler cannot be equipped with the structures of the upper air level 10, 11 at a height which would be advantageous for the combustion process. For this reason, the air systems of the upper air levels 10, 11 are preferably placed as shown in the invention, wherein the air jets 16, 17 and air channels are placed in three walls 12, 14, 15 of the furnace, and the rear wall 13 remains intact, as shown in Fig. 2.

[0022] Figure 2 shows the air system according to the invention, seen from above. This air system is suitable for use as secondary and tertiary air levels 10, 11 of the fluidized-bed boiler 1 of Fig. 1, but a similar air supply arrangement can also be used on other levels, such as, for example, a quaternary air level, by maintaining the basic idea of this invention.

[0023] Figure 2 shows that the primary air flows 18 to be supplied from the primary air nozzles 16 placed in the front wall 12 are so strong that their flow preferably extends up to the rear wall 13. Thus, the primary air flows 18 carry a part of the combustible particles of the flue gases, or of the combustion gases, to the rear part of the furnace 2, which results in an efficient utilization of the volume of the furnace. The rate of the primary air flow 18 is advantageously 40 to 90 m/s and preferably 50 to 60 m/s in a fluidized-bed boiler 1 with a bottom whose one side has a length of about 10 metres and comprises 3 to 5 primary jets.

[0024] From the auxiliary air nozzles 17, i.e. side air nozzles, placed on the side walls 14, 15, the auxiliary air flows 19, i.e. side air flows, are directed, which are significantly smaller than the primary air flows 18 in their strength. The auxiliary air flows 19 are directed from the opposite side walls 14, 15 in such a way that the auxiliary air flows are opposite to each other. The auxiliary air flow 19 supplied from the side wall 14, 15 is equal in strength with the auxiliary air flow supplied in the opposite direction from the opposite wall. In other words, the auxiliary air jets 17 on the opposite side walls 14, 15 are mirror images to each other. In an advantageous embodiment of the invention, shown in Fig. 3, the auxiliary air flows 19 are supplied in such a way that their strength varies from the front wall 12 to the rear wall 13 of the fluidized-bed boiler 1.

[0025] In an advantageous embodiment of the invention, in the normal situation of running the fluidized-bed boiler 1, 40 to 80 % of the total quantity of air to be supplied is introduced from the front wall 12, wherein 10 to 13 % of the total quantity of air to be supplied is arranged

to be introduced from one side wall 14, 15. For the use, it is advantageous to arrange the primary air flows 18 and the auxiliary air flows 19 to be separately controlled. Thus, if necessary, it is possible, for example, to first reduce the air quantity of the auxiliary air flows 18 and then the quantity of the primary air flows 19.

[0026] The primary air flows 18 and the auxiliary air flows 19 are placed on substantially the same level in the height direction of the boiler 1. In some cases, it may be advantageous to place the air jets 16, 17 in such a way that the primary air flows 18 and the auxiliary air flows 19 are placed at slightly different heights, wherein the air flows do not impact on each other. In another embodiment of the invention, the primary and/or auxiliary air flows 18, 19 are arranged to proceed in a slightly oblique direction in the furnace 2. Thus, in some embodiments, the air flows 18, 19 are provided with a better capacity of penetrating into the flue gases than air flows supplied in the transverse direction.

[0027] Figure 4 shows the temperature distribution in the fluidized-bed boiler 1 of Fig. 1 when the tertiary air supply level 11 of the boiler is implemented according to the invention. Figure 5, in turn, shows the temperature distribution for a boiler with a conventional arrangement, in which, on the tertiary air supply level, air is only supplied from air jets in the side walls. When these results are compared, it can be stated that the whole furnace 2 of the boiler 1 can be better utilized with the air supply system according to the invention. Furthermore, it is seen that the temperature in the furnace 2 under the superheater 7 is lower with the arrangement of the invention than with the conventional arrangement. For the sake of clarity, Figs. 4 and 5 do not show the structures of the fluidized-bed boiler 1 which are illustrated in Fig. 1.

[0028] By combining, in various ways, the modes and structures presented in connection with the different embodiments of the invention presented above, it is possible to produce various embodiments of the invention in accordance with the spirit of the invention. Therefore, the above-presented examples must not be interpreted as restrictive to the invention, but the embodiments of the invention can be freely varied within the scope of the inventive features presented in the claims hereinbelow.

Claims

1. A method for supplying upper air from an upper air supply level (10, 11) into a fluidized-bed boiler (1) which comprises at least

- a furnace (2) limited by a front wall (12), side walls (14, 15) and a rear wall (13),
- a nose (6) provided in the rear wall (13) of the furnace (12),
- a fluidized bed (4) in the furnace (2),
- a lower air supply level (9) arranged under-

neath the fluidized bed (4),

- a fuel supply means (5) arranged above the fluidized bed (4),
- one or more upper air supply levels (10, 11) placed above the fuel supply means (5) and underneath the nose (6), and
- at least one air supply level (10, 11) comprises at least side air jets (17) placed in the side walls (14, 15) of the furnace (2),

characterized in that on one or more air supply levels (10, 11), which comprise at least one or more primary air jets (16) placed in the front wall (12) of the furnace (2), an air flow (18) is supplied from the primary air jet into the furnace, which air flow (18) is stronger than the air flow (19) supplied from the side jet (17) into the furnace.

2. The method according to claim 1, **characterized in that** 40 to 80 % of the air quantity to be supplied from the upper air supply level (10, 11) is supplied from one or more primary air jets (16) placed in the front wall (12) of the furnace (2).

3. The method according to claim 1 or 2, **characterized in that** aligned air flows (19) in opposite directions are supplied from opposite side walls (14, 15), and equal quantities of air are supplied from the opposite side walls.

4. An air arrangement for supplying upper air from an upper air supply level (10, 11) into a fluidized-bed boiler (1) which comprises at least

- a furnace (2) limited by a front wall (12), side walls (14, 15) and a rear wall (13),
- a nose (6) provided in the rear wall (13) of the furnace (12),
- a fluidized bed (4) in the furnace (2),
- a lower air supply level (9) arranged underneath the fluidized bed (4),
- a fuel supply means (5) arranged above the fluidized bed (4),
- one or more upper air supply levels (10, 11) placed above the fuel supply means (5) and underneath the nose (6), and
- at least one air supply level (10, 11) comprises at least side air jets (17) placed in the side walls (14, 15) of the furnace (2),

characterized in that the air arrangement also comprises at least one or more primary air jets (16) placed in the front wall (12) of the furnace (2).

5. The air arrangement according to claim 4, **characterized in that** opposite to the side air jet (17) placed in the first side wall (14, 15), another side air jet is placed on the second side wall (14, 15), and

said side air jets are placed at the same height and the same distance from the front wall (12).

6. The air arrangement according to claim 4 or 5, **characterized in that** the primary air jets (16) are provided with a separate control system for the air flow (18), and the side air jets (17) are provided with a separate control system for the air flow (19). 5

7. A fluidized-bed boiler (1) comprising at least 10
 - a furnace (2) limited by a front wall (12), side walls (14, 15) and a rear wall (13),
 - a nose (6) provided in the rear wall (13) of the furnace (12), 15
 - a fluidized bed (4) in the furnace (2),
 - a lower air supply level (9) arranged underneath the fluidized bed (4),
 - a fuel supply means (5) arranged above the fluidized bed (4), 20
 - one or more upper air supply levels (10, 11) placed above the fuel supply means (5) and underneath the nose (6), and
 - at least one air supply level (10, 11) comprises at least side air jets (17) placed in the side walls (14, 15) of the furnace (2), 25

characterized in that the air arrangement for the upper air supply level (10, 11) also comprises one or more primary air jets (16) placed in at least the front wall (12) of the furnace (2), an air flow (18) being supplied from the primary air jet into the furnace, which air flow (18) is stronger than the air flow (19) supplied from the side jet (17) into the furnace. 30

8. The fluidized-bed boiler according to claim 7, **characterized in that** said air arrangement of the upper air supply level (10, 11) is placed on the secondary air supply level or on the tertiary air supply level. 35

9. The fluidized-bed boiler according to claim 7 or 8, **characterized in that** the primary air jets (16) are placed in the same wall (12) as the fuel supply means (5). 40

10. The fluidized-bed boiler according to any of the preceding claims 7 to 9, **characterized in that** a flue (8) is provided in the location of said upper air supply level (10, 11), behind the rear wall (13). 45

50

55

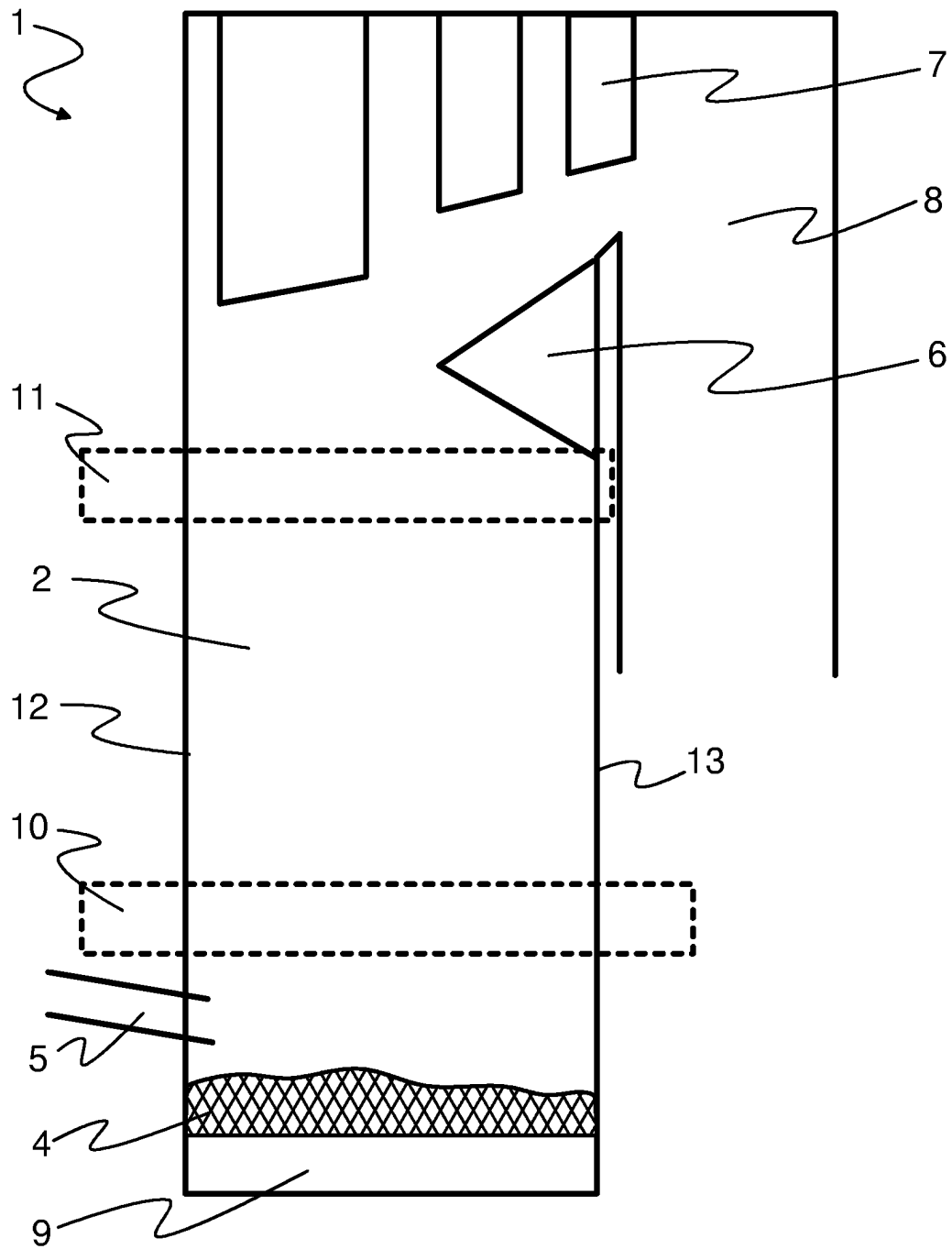


Fig. 1

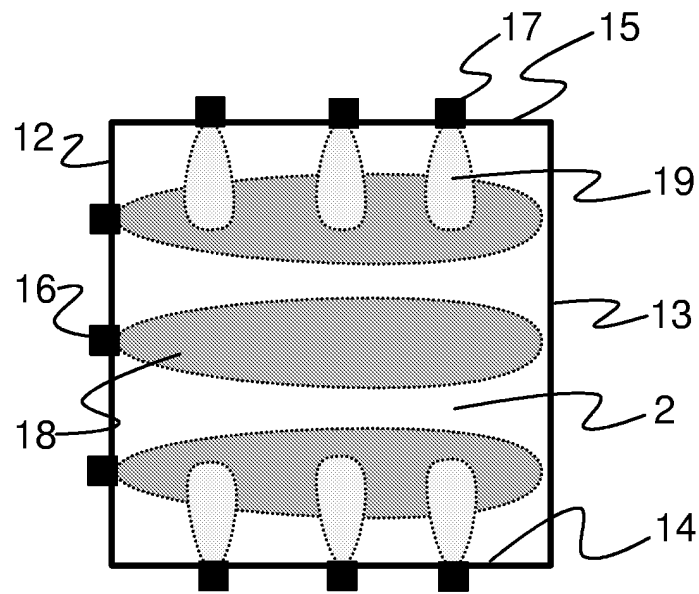


Fig.2

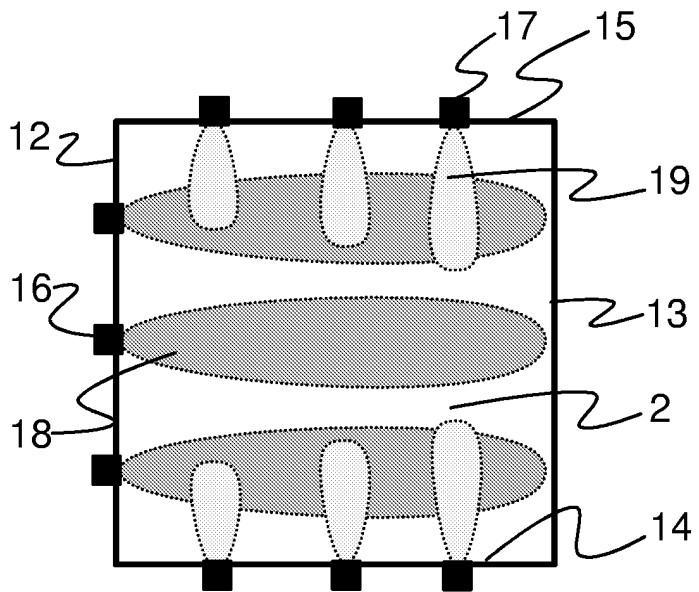


Fig.3

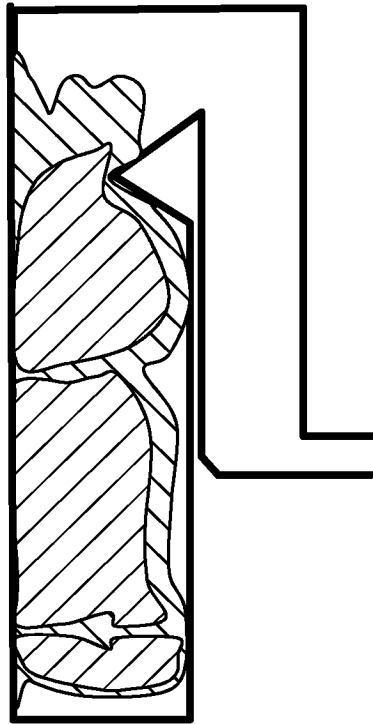
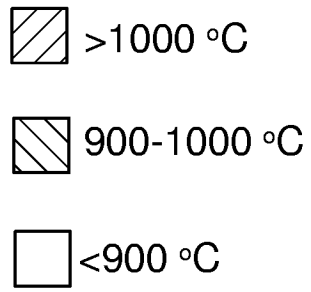


Fig. 4

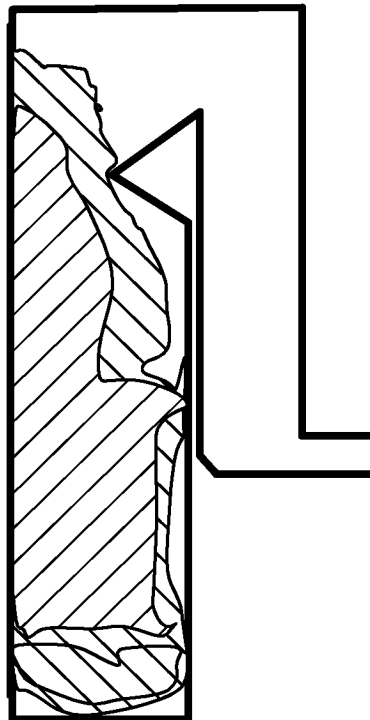
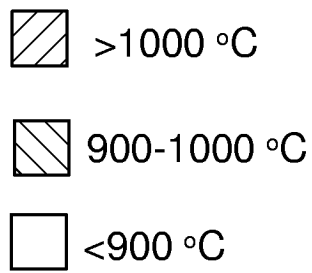


Fig. 5