HU000025666T2

(19) **HU**

(11) Lajstromszám: **E 025 666** (13) **T2**

MAGYARORSZÁG
Szellemi Tulajdon Nemzeti Hivatala

EURÓPAI SZABADALOM
SZÖVEGÉNEK FORDÍTÁSA

(21) Magyar ügyszám: **E 12 717287**
(22) A bejelentés napja: **2012. 04. 26.**

(51) Int. Cl.: ***C03B 3/02*** *(2006.01)*
C03B 52/35 *(2006.01)*

(96) Az európai bejelentés bejelentési száma:
EP 20120717287
(97) Az európai bejelentés közzétételi adatai:
EP 2705002 A1 **2012. 11. 08.**
(97) Az európai szabadalom megadásának meghirdetési adatai:
EP 2705002 B1 **2015. 07. 01.**

(86) A nemzetközi (PCT) bejelentési szám:
PCT/EP 12/057651
(87) A nemzetközi közzétételi szám:
WO 12150175

(30) Elsőbbségi adatok:
201100258 **2011. 05. 02.** **BE**

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(54) **Eljárás, kemencében felmelegített üveg olvasztására**

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmas az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.

Method of melting glass in a furnace

The present invention relates to processes for melting glass in furnaces in which the melting energy is produced essentially by burners fed with fuel and with oxygen or with gas very rich in oxygen. These furnaces are usually described as "oxy-combustion" furnaces.

For reasons of simplicity, in the continuation of the description, reference is made to oxy-combustion and to oxygen. The developments on that subject, unless otherwise indicated, include the use of oxy-combustion with an oxygen which may include a small proportion of air, or also a combination comprising a limited portion of air-combustion in combination with a predominant oxy-combustion.

The advantages of the use of the oxy-combustion techniques include mainly a reduced energy consumption and reduced emissions of undesirable flue gases.

Oxy-combustion makes possible a saving in energy at least for the reason that the energy of the combustion gases is not partially absorbed by the nitrogen of the air. In conventional furnaces, even if a portion of the energy entrained with the nitrogen is recovered in the regenerators, the flue gases finally discharged still entrain a significant part thereof. The presence of the nitrogen participates in this loss.

The reduction in the energy consumption per unit of production consequently exhibits in addition the advantage of limiting the emissions of carbon dioxide and thus of meeting the regulatory requirements in this field.

The presence of nitrogen is also a source of formation of oxides referred to as NOx, the emission of which is strictly regulated due to the damage related to the presence of these compounds in the atmosphere.

The use of oxygen makes it possible to obviate the problems related to the nitrogen of the air provided that the operation of the furnaces guarantees that, apart from the oxidant, air, and thus nitrogen, does not accidentally enter the chamber in which the combustion is carried out.

The publication WO 2009/118333 provides for the operation of high capacity glass furnaces in oxy-combustion. As indicated above, one of the conditions in order for these furnaces to exhibit as many advantages as possible with respect to the conventional furnaces using air as oxidant is that the combustion is carried out in an atmosphere devoid of nitrogen.

The economics of the melting of glass by oxy-combustion are inseparable from the cost related to the use of oxygen. In order for this technique to remain economically attractive, it is necessary to compensate for this additional cost by savings both with regard to the energy consumption necessary for the melting but also with regard to the techniques for recovering the heat which is not immediately used for the melting. The combustion gases exiting from the furnaces are at very high temperatures; a recovery of the energy discharged with these gases is essential. This energy in the abovementioned publication is used for bringing the consumed oxygen to temperature. This prior art document exhibits in detail methods of recovery of heat from the flue gases for the preheating of the oxygen.

The preheating of the oxygen, within the temperature limits permitted by the corrosion of the hot oxygen, does not exhaust the energy present in the flue gases. An additional recovery is thus desirable. In this sense, heating the starting materials is a possible solution to this question.

Various techniques have been provided for an operation of preheating the starting materials using the energy present in the flue gases. There are many constraints related to the recovery by preheating the starting materials.

They are due first to the source of heat used, the combustion gases, their nature and in particular their temperatures. They also concern the nature of the materials treated, the pulverulent base products sand, sodium carbonate, calcium carbonate, magnesia, and the like, but also the recycled products (cullet) and the proportion of the latter in the combination.

The flue gases exiting from the furnaces are at high temperatures, even if they do not reach the temperatures of the furnaces operating in air-combustion. In the case of the oxy-combustion furnaces concerned, the heat exchange between the vitrifiable charge and the combustion gases is increased by a prolonged residence time of the combustion gases in the furnace. Specifically, the combustion gases are largely or completely recovered upstream of the furnace after they have swept the entire region of the supernatant starting materials on the molten bath.

In the case of an oxy-combustion furnace, the flue gases exiting from the furnace are generally at less than 1500°C whereas, in air-combustion, they can exceed 1600°C.

As in the abovementioned publication, the energy present in the flue gases is used to heat the oxygen feeding the burners of the furnace. This is carried out by heat exchange which is advantageously conducted in two steps, for the reasons which will be recalled below, and which are due to the need to carry out the heating of the oxygen close to the burners.

Hot oxygen is extremely corrosive for all alloys. Safety requires that the presence of any weld, any connection, any valve and even excessively exaggerated curves capable of increasing the corrosion mechanisms in the pipes transporting this hot oxygen be limited as much as possible. The circuit between the heating of the oxygen and its use in the burners of the furnace has to be as short as possible. High-capacity furnaces extend over lengths which do not make it possible to position just one exchanger for the heating of all the oxygen while retaining the proximity of the burners. For this reason, the heating is carried out in a plurality of exchangers of limited dimensions located in the immediate vicinity of the burners, and each of these exchangers for heating the oxygen feeds only a very small number of burners, indeed even just one.

In order to reconcile the treatment of the combined flue gases and the treatment of the oxygen located close to the burners, it is necessary to have recourse to a double heat exchange. On the one hand, in a first exchanger, the flue gases are used to reheat air constituting a heat-exchange fluid. This heated air feeds secondary exchangers used to heat the oxygen.

In the first exchanger, the flue gases can bring the air to temperatures of the order of 800°C or more. The air in question thus conveys a large part of the energy present in the flue gases.

According to the invention, the preheating of the oxygen is advantageously carried out in exchangers made of steels showing excellent resistance to hot oxygen. Exchangers and materials suitable for this use are described in the patent application EP A 2 145 151.

The hot oxygen supplied by the exchanger is brought to a temperature which at most can reach 650°C. This value depends on the resistance which can be obtained with metal alloys which exhibit the best characteristics. This limiting temperature makes it possible to guarantee a duration of use in keeping with the type of plant under consideration.

In practice, for better safety, it is preferable to maintain the temperature of the oxygen at less than 600°C.

In order for the preheating of the oxygen to be sufficient to significantly improve the energy balance, it is preferable to adjust the conditions of the exchange so that the temperature of the oxygen is not less than 350°C.

The temperature of the heat-exchange air at the outlet of the exchangers for heating the oxygen is thus reduced to at most 600°C and can fall down to approximately 350°C according to the respective flow rates of the gases involved in the heat exchange.

In all the configurations, the heating of the oxygen, even brought to the highest practicable temperatures as indicated above, cannot absorb all of the energy of the flue gases, nor even all of the energy present in the air acting as heat-exchange fluid between the primary and secondary exchangers. Under these conditions, the air which has heated the oxygen according to the invention is used to preheat the vitrifiable charge or a portion thereof.

As indicated above, the flue gases exit from the first exchanger still at high temperatures. At these temperatures, they still convey a considerable energy which it is necessary to recover for the economics of the system. Preferably, according to the invention, the preheating of the starting materials is obtained by combining the energy originating from the air which has heated the oxygen and from the flue gases exiting from the first exchanger used to heat the heat-exchange air.

To the constraints related to the flue gases and to the oxygen set out above are added those relating to the heating of the vitrifiable charges. This heating is also carried out in a heat exchanger. In order to avoid any risk of entrainment of dust from the pulverulent charge, the heated solid products circulate in the exchanger without coming into contact with the gases, air and flue gases, acting as heat-exchange gases. Both circulate in separate spaces and the heating of the starting materials is carried out essentially by conduction in contact with the walls of the exchanger which are heated by the gases.

One of the difficulties in the heating of the starting materials is to ensure that they are transported without agglomerates being formed which are liable to block the equipment. The presence of moisture in the pulverulent charge increases this risk. A certain water content is conventional in order to avoid the flight of dust during the introduction of the charge into the furnace. The separation of the starting materials and heating gases removes the risks of increase in this water content.

In order to avoid an excessively high water content in the portion of the exchanger receiving the starting materials, the temperature at any point in this exchanger is preferably greater than 100°C and preferably is not less than 150°C.

Of course, it is advantageous to bring the starting materials to the highest possible temperatures which are compatible with the nature of these materials. It is thus necessary not to exceed a temperature which would render some compounds of this vitrifiable charge "sticky". In practice, the temperature of the vitrifiable charge in the exchanger should not exceed 550°C and preferably should not be greater than 500°C.

In the same way, it is necessary to avoid the difficulties specific to the gases in the portion of the exchanger in which they circulate. When the gas used to heat the starting materials is a mixture of flue gases and air, the temperature of these gases at the outlet of the exchanger has to be precisely regulated in order to make possible a desulfurization treatment on electrostatic filters according to the forms conventional for these operations. This temperature has to be between 300 and 400°C and preferably between 300 and 350°C.

In order to arrive at a suitable exchange, the temperature of the mixture of air originating from the heating of the oxygen and of the flue gases resulting from the first exchangers has to be relatively high. However, in particular in order to take into account the resistance of the alloys, the temperature of the gases entering the exchanger preferably does not exceed 650°C and is advantageously equal to or less than 600°C.

Optionally, if the temperature of the mixture of gases entering the exchanger for heating the starting materials is too high, an adjustment can be undertaken by diluting with a limited contribution of ambient air.

The invention is defined by the process of claim 1 and is described in detailed fashion subsequently with reference to the plates of drawings, in which:

- figure 1 is a general diagram illustrating the mode of operation in oxy-combustion of a high-capacity glass melting furnace;
- figure 2 illustrates in more detail the treatment of the flue gases of figure 1;
- figure 3 gives a general illustration of the operation of the furnace comprising a mode of preheating the starting materials;
- figure 4 exhibits an alternative form of the preheating of figure 3;
- figure 5 is analogous to figure 4 and furthermore comprises the heating of the fuel in parallel with that of the oxygen.

The furnace represented diagrammatically in figure 1 is of the type of those used for high-capacity production, such as those used to feed the production of flat glass by float-glass techniques. Furnaces of this type continuously produce amounts of glass which can range up to 1000 tonnes/day. In order to achieve this performance, the furnaces have to exhibit a power which reaches 60 MW. For this type of furnace, production is not less than 300 tonnes/day. The mode of operation of the furnace and in particular everything which concerns the questions of optimization of energy consumption as specified subsequently depends at least in part on its capacity.

The furnace comprises a melt and refining end 1 into which the materials M forming the vitrifiable charge are filled at one end and from which the molten glass V is extracted at the other end to follow its treatment in the conditioning zone and then up to the formation of the sheet on the float bath.

On the furnace, and particularly in the upstream part of the latter, oxy-combustion burners are distributed on either side of the melt end. The location of these burners, which are not represented, is given material form in the diagram by the dot-and-dash lines.

The combustion or flue gases F are essentially or even completely discharged in the upstream part of the furnace in the vicinity of the filling of the starting materials. If appropriate, a modest fraction of these gases F' can be directed towards the downstream end of the furnace with the aim of preventing the penetration into the chamber of the furnace of air originating from the conditioning zone located downstream.

The movement of the combustion gases countercurrent wise to the general direction of flow of the glass makes it possible to maximize the transfer of heat in the chamber. Nevertheless, the temperature of the combustion gases exiting grouped together from the furnace remains very high. They are usually at temperatures of the order of 1200 to 1400°C.

The passage through a first heat exchanger 2 makes it possible to lower the temperature of these gases and in particular to recover a portion of the heat which they convey.

Two exchangers 2 are presented in the diagram of figure 1, one on each side of the furnace, in order to facilitate the treatment. Optionally, the presence of two exchangers makes it possible to interrupt the operation of one of them in order to carry out maintenance, the second for a short while treating all of the combustion gases. In this event, which is not represented, the heat-exchange gas, air A, exchanging with the flue gases also has to feed both symmetrical pipes 3.

The gas which recovers the heat in the exchanger 2 has to be used to heat the oxygen Q used in the burners. For the reason in particular that the heating of the oxygen has to occur to the nearest point of the location of its use, the heating is carried out systematically in exchangers 4 close to the burners 5, as presented in figure 2. The exchangers 4 receive, on the one hand, the heat-exchange gas, typically air A, preheated by the flue gases in the exchanger 2, and, on the other hand, the oxygen. In contrast to the hot oxygen, the hot air A can be transported without damage over a certain distance.

In the exchangers 4, the oxygen changes from ambient temperature to a temperature which can reach at the highest 550-600°C.

In figure 2, each burner 5 is fed with hot oxygen Q via an exchanger 4. If appropriate, an exchanger 4 can feed several burners. However, generally, each exchanger does not feed more than two burners simultaneously.

In the abovementioned application WO 2009/118333, the heat-exchange gas carries out a double exchange. On the one hand, it is heated by the flue gases and, on the other hand, it heats the oxygen. The circulation of the heat-exchange gas between the exchangers is carried out in a closed circuit. The circuit of this gas, which is reproduced in figure 2, causes the gas to return to the exchanger 2 after it has heated the oxygen. In this way, the energy still present in this heat-exchange gas is conserved.

The temperature of this gas, after having heated the oxygen in the exchangers 4, is still relatively high. It can reach 500°C or more. The use of the energy stored in this gas thus remains important. A subject matter of the invention is the use of the energy from this heat-exchange gas A to heat the starting materials.

In contrast to what is represented in figure 2, corresponding to the cited prior art, according to the invention, represented in figures 3, 4 and 5, the heat-exchange air A is not returned to the exchanger 2 after the heating of the oxygen Q. This air, originating from the different exchangers 4, is combined and sent to an exchanger 6 in order to heat the vitrifiable charge M before the filling of the latter.

The energy conveyed by the air A after the heating of the oxygen makes possible the at least partial heating of the starting materials M. Nevertheless, it is preferable to add an additional source in order to achieve more significant heating. One means consists, as represented in figures 4 and 5, in using the flue gases F exiting from the exchanger 2.

After the exchanger 2, the flue gases are still at high temperature. It is generally not less than 700°C, short of using oversized exchangers.

Of course, these flue gases might be discharged. However, even in this sequence, which is not very advantageous energetically, they would have to be subjected to decontamination in order to remove sulfur oxides in particular from them. This removal is carried out, for example, in electrostatic filters and, in order to avoid damage to these filters, it is necessary to further lower the temperature down to approximately 300-400°C. The use of these flue gases F, added to the use of the air A originating from the heating of the oxygen Q, makes possible both increased heating of the starting materials M and a lowering of the temperatures, which guarantees the protection of the exchanger.

The mixing of the flue gases exiting from the exchanger 2 and of the air originating from the exchangers 4 AF must not result in temperatures greater than those which can be employed in the exchanger 6 for heating the starting materials. The temperature which the vitrifiable charge must not exceed depends on its composition. The cullet does not present a particular problem as its softening point is greater than that acceptable for some of the other starting materials used, in particular the carbonates, which can become "sticky" at temperatures far

below the softening point of the cullet.

As a general rule, for typical vitrifiable compositions, the temperature should not exceed 600°C.

If the temperature of the mixture AF is greater than 600°C, it can be lowered, for example, by addition of supplementary air at ambient temperature.

A diagram analogous to that of figures 3 and 4 is reproduced in figure 5. For this diagram, the air heated by the flue gases in the exchanger 2 is used, on the one hand, as above, to heat the oxygen in the exchangers 4 and, on the other hand, to heat the fuel used by the burners in the exchanger 7.

The respective flow conditions in the exchangers 2 and 7 are regulated as a function of the temperatures appropriate to the different products heated. The fuels cannot be brought to very high temperatures; in particular, liquid fuels only withstand, without decomposition, temperatures not exceeding 180°C and preferably not exceeding 150°C. Natural gases can be brought to higher temperatures. These temperatures can reach 500°C without risk of cracking capable of fouling the burners.

The air exiting from the exchanger 7 is either discharged or it is also used for the heating of the starting materials together with that originating from the heating of the oxygen (as dotted line in figure 5).

The exchangers 6 used for the heating of the starting materials have to exhibit two separate circuits, one for the hot gases and the other for the solid pulverulent starting materials. Exchangers of this type are known from the prior art. In particular, the preferred exchangers for this operation according to the invention arrange the progression of the starting materials by simple gravity, these materials being introduced at the top of the exchanger and flowing from the top downward. In this advance, the starting materials advance in contact with the walls of the exchanger which are heated by the gases.

The walls of the exchanger 6 can comprise deflectors which divert the advance of the charge. These deflectors also participate in a contact which promotes the conduction of the heat. They also make it possible to prevent this charge from becoming excessively packed down by seeing to it that the mass of this charge does not result in a compression corresponding to the complete height of the exchanger. In a way, these deflectors form intermediate stationary levels, the pressure at each of these stationary levels being limited to the mass positioned between two successive stationary levels. To this end, the deflectors are advantageously positioned quincuncially on the walls.

In the type of exchanger, separating the charge of starting materials and the heating gases, used and at the temperatures recommended according to the invention, the proportion of cullet present is not important. Optionally, all of the charge can be composed of base starting materials.

By way of example, the technique according to the invention is carried out on a glass furnace producing 750 tonnes per day of glass, operating in oxy-combustion. The operating diagram is that illustrated in figure 4. The forms become established as follows:

in the furnace

- gas consumption 3900 Sm^3/h
- oxygen consumption 8000 Sm^3/h
- flow rate of the flue gases at the outlet of the furnace 18 700 Sm^3/h
- temperature of the flue gases at the outlet of the furnace 1400°C

2 exchangers (2)

- outlet temperature of the flue gases 800°C

- air entering at ambient temperature heated at the outlet to 800°C
- air flow rate 15 300 Sm^3/h

10 burners and exchangers (4) for heating the oxygen

- temperature of the oxygen at the outlet of the exchangers (4) 550°C
- temperature of the air at the outlet of the exchangers (4) 350°C

mixing of flue gases at 800°C and air at 350°C, resulting in a temperature of 600°C for a flow rate of 34 000 Sm^3/h at the inlet into the single exchanger (6)

starting materials fed at 50°C, residing on average for 8 hours in the exchanger, and brought to 420°C

The benefit of the use of the heating of the starting materials in terms of energy saving is greater than that originating from the heating of the oxygen. The preheating of the starting materials results approximately in an energy gain of the order of 18%, i.e. approximately 1 GJ/tonne of glass, to which is added the corresponding saving with regard to the oxygen consumption. The heating of the starting materials thus significantly contributes to the overall economics of the furnaces operating in oxy-combustion. This saving allows these techniques to be used despite the necessary additional capital cost. The balance becomes increasingly positive as the furnaces under consideration increase in capacity.

Eljárás, kemencében felmelegített üveg olvasztására

SZABADALMI IGÉNYPONTOK

1. Eljárás, kemencében égők segítségével felmelegített üveg olvasztására, ahol az égési energia legalább 65%-a, előnyösen legalább 80%-a oxigén elégetése útján keletkezik, ahol a kemence kijáratánál az égési gázokat bevezetjük egy cirkuláló levegőt tartalmazó első hőcserélőbe (2), ahol a levegő és az égési gázok különböző, és egymástól elválasztott körfolyamatokban találhatók, ahol ebben az első cserélőben (2) felmelegedett levegőt legalább egy második cserélőbe (4) vezetjük be, ami arra szolgál, hogy az égést tápláló anyagot az oxigén bázisán előmelegítse, ahol az égést tápláló anyag és a levegő különböző, és egymástól elválasztott körfolyamatokban cirkulálnak, azzal jellemezve, hogy ebből a második cserélőből (4) kilépő levegőt egy szárító egységbe (S) vezetjük, ahol ez az üveget alkotó nyersanyaggal kerül érintkezésbe, amit előzőleg granulátumokká vagy préselt agglomerátumokká alakítottunk.

2. Az 1. igénypont szerinti eljárás, amelynek napi termelési kapacitása legalább 300 tonna.

3. Az 1. igénypont szerinti eljárás, ahol az első cserélőben (2) felmelegített levegőt részben a második cserélőbe vagy cserélőkbe (4) juttatjuk el az égést tápláló anyag felmelegítésére, és részben ebből a második cserélőből vagy ezekből a második cserélőkből (4) kilépő levegővel keverjük össze a granulátumok vagy préselt agglomerátumok szárításához.

4. Az 1. igénypont szerinti eljárás, ahol az első cserélőből (2) kilépő égési gázok egy cserélőbe (7) jutnak, ahol felmelegítik a levegőt, amit azután a granulátumok vagy préselt agglomerátumok szárításához azokkal keverünk össze, amik a második cserélőből vagy cserélőkből (4) kilépnek.

5. Az előző igénypontok bármelyike szerinti eljárás, ahol a szárazlevegő áram és a granulátumoktól vagy préselt agglomerátumoktól érkező áram együttes hőmérséklete maximálisan 550 °C, előnyösen maximum

500°C.

6. Az előző igénypontok bármelyike szerinti eljárás, ahol a szárító egységbe belépő levegő hőmérséklete maximum 600 °C.

7. Az 1. igénypont szerinti eljárás, ahol granulátumok vagy préselt agglomerátumok szárítás előtti víztartalma nagyobb, mint 4%.

8. Az előző igénypontok bármelyike szerinti eljárás, ahol az első cserélőből (2) kilépő égési gázok legalább egy részét bevezetjük egy cserélőbe (6), ahol ezekkel a gázokkal a korábban megszárított granulátumokat vagy préselt agglomerátumokat érintkeztetés nélkül melegítjük fel.

9. A 8. igénypont szerinti eljárás, ahol granulátumok vagy préselt agglomerátumok bevezetése a nehézségi erő által történik, az égési gázok cirkulációja ellenáramban történik az üveget képező anyaghoz képest, és azzal való érintkezés nélkül.

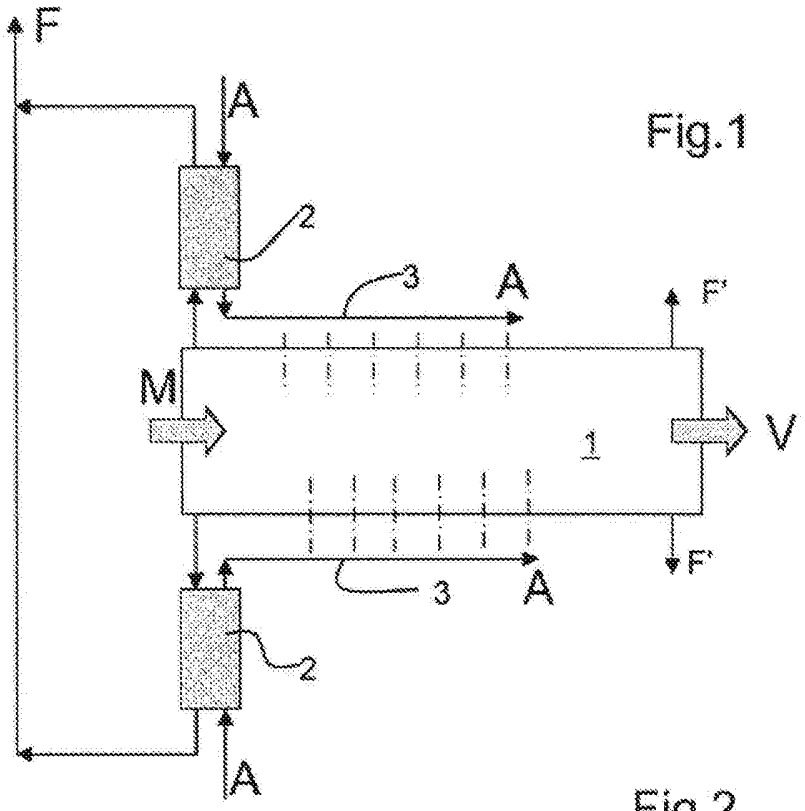


Fig.1

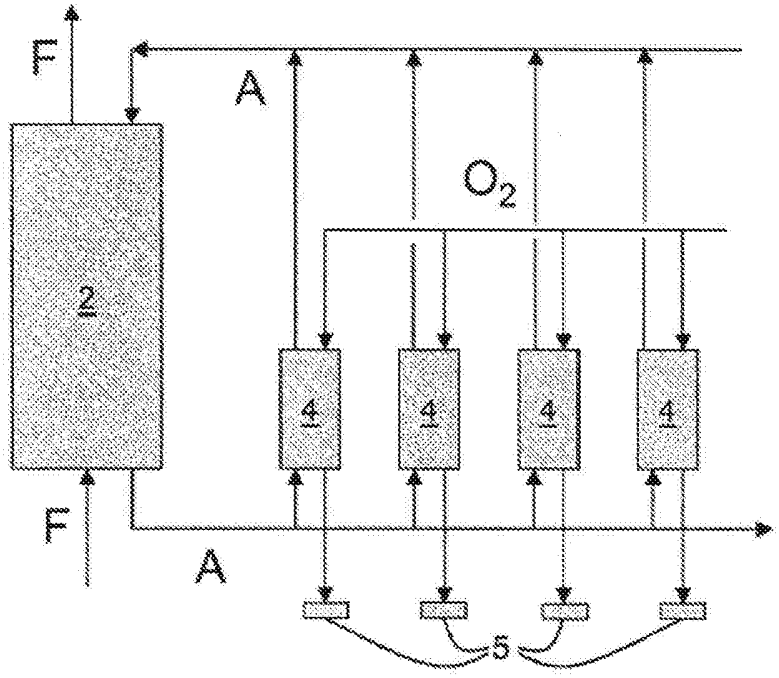


Fig.2

Fig.3

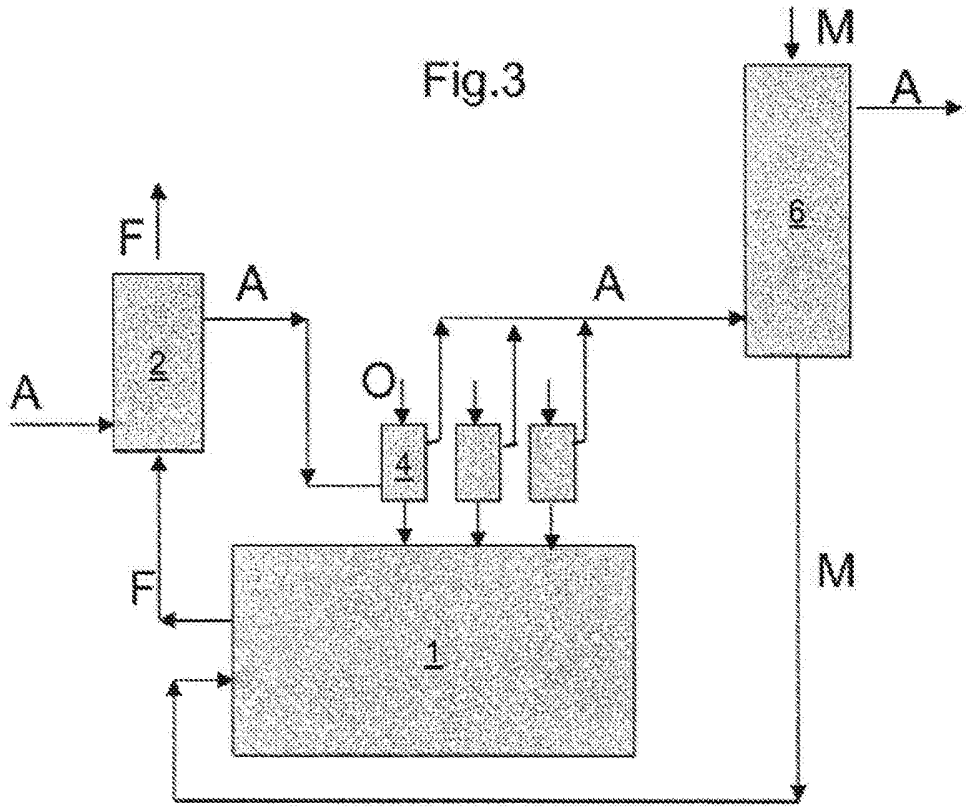


Fig.4

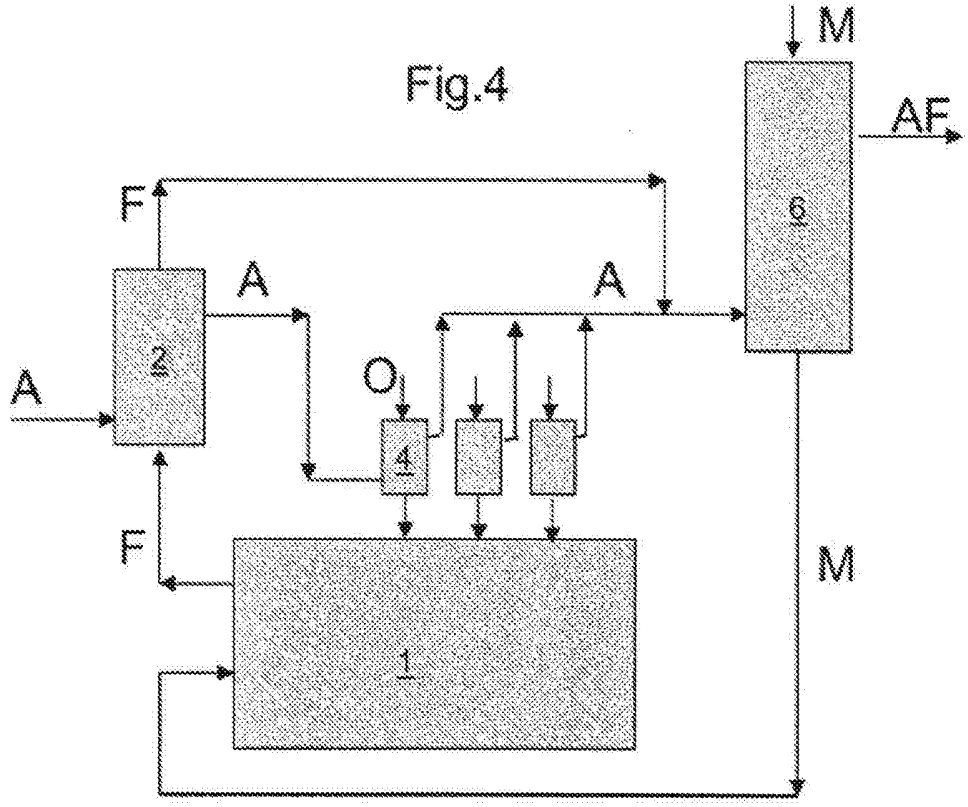


Fig.5

