

## A METHOD OF CLEANING HEAT EXCHANGE SURFACES OF FURNACES IN OPERATION

The invention relates to a method of cleaning  
surfaces of furnaces in operation, in particular metal  
5 heat-exchange surfaces on the flue-gas side of industrial  
furnaces, such as petrochemical and oil refinery stills,  
and industrial boilers.

Such furnaces often burn heavy fuel oil for economic  
reasons. However, since the combustion of heavy fuel oil  
10 is incomplete, deposits form on the heat-exchange  
surfaces. These deposits are constituted in particular  
by heavy fractions of hydrocarbons, silica, heavy metals,  
and stable components that retain a solid state inside  
the furnace, even at high temperature. Similar problems  
15 can also be observed with other liquid or gaseous fuels.

These deposits reduce heat exchange between the  
combustion gas and the fluid to be heated to a  
considerable extent, thereby leading to a loss of furnace  
efficiency.

20 Various techniques are already known that enable the  
heat-exchange surfaces of a furnace to be cleaned, while  
keeping the furnace in operation. In particular,  
EP-A-0 410 867 discloses performing the following steps:

- generating a jet of gas that is directed towards  
25 the surfaces for cleaning;
- integrating solid-state particles in the fluid  
jet, and projecting the particles at a speed such that  
the particles disintegrate on coming into contact with  
said surfaces to be cleaned; and
- 30 • moving the jet of fluid and particles along the  
surfaces to be cleaned.

The particles eliminate the deposit by an oxidizing  
chemical effect and by a mechanical effect due to the  
speed of the particles which sublime only after coming  
35 into contact with the surfaces to be cleaned.

However, that method raises severe safety problems  
in supplying the oxidizing agent insofar as the most

satisfactory agent is constituted by ammonium nitrate, which in association with other substances can constitute a powerful explosive.

Consequently, the invention seeks to propose a  
5 solution that solves those problems while being inexpensive and while retaining good effectiveness in eliminating the deposit.

To do this, in accordance with the invention, particles are used having a formulation that is  
10 constituted for the most part (more than 50% by weight) by carbamide.

Carbamide (urea) is inexpensive and is obtained without major difficulty in the form of solid beads. In addition, although carbamide is not an oxidizer, it has  
15 been found to be more effective in eliminating deposits than the substances used in the past, and to be less polluting overall. Finally, the presence of carbamide as the major ingredient of the formulation makes it possible to obtain a melting temperature for the formulation that  
20 is high enough to ensure that the particles do not sublime before coming into contact with the surfaces for cleaning, while also being low enough to neutralize the acidic components of the deposit, to weaken the physical structure of the deposit by chemical action, and then to  
25 sublime or vaporize completely under the heat of the combustion gas.

Given the advantages obtained by using carbamide in accordance with the invention, at least 95% (by weight) of carbamide is introduced in the formulation of the  
30 particles.

Only a few additives are added in small quantities for targeted actions.

In particular, in accordance with the invention, a magnesium salt is added to the formulation of the  
35 particles, advantageously magnesium carbonate or magnesium silicate.

Since carbamide is hygroscopic, the magnesium salt makes it possible to sequester moisture and avoid particles agglomerating and clogging the device that generates the gas jet. In addition, the magnesium  
5 captures vanadium that is often present in the deposit and that leads to heat-exchange surfaces corroding. In addition, it makes it possible to raise the melting temperature of the particles a little, thus further improving the effectiveness of the cleaning.

10 Advantageously, 0.5% to 5% of magnesium salt is added to the weight of the particle formulation.

This quantity makes it possible to obtain satisfactory effectiveness while generating only a minimum amount of solid residues. A portion of the  
15 magnesium salt is not vaporized and it drops onto the hearth of the furnace together with a portion of the deposit detached from the cleaned surfaces.

According to another advantageous characteristic of the invention, in order to obtain good effectiveness for  
20 the formulation, the furnace is adjusted so that the temperature of said surfaces for cleaning is higher than 250°C.

Thus, the formulation, and in particular the carbamide, changes state on coming into contact with the  
25 surfaces to be cleaned, thus obtaining much higher performance in terms of reacting with the components of the deposit.

In addition, the particles are advantageously projected into contact with the surfaces for cleaning at  
30 a speed of at least 50 meters per second ( $\text{m.s}^{-1}$ ).

This achieves satisfactory disintegration of the solid particles of the formulation, thereby further improving its effectiveness and ensuring even better chemical and mechanical effect cleaning of said surfaces.

35 The accompanying figure is a diagram showing a method of cleaning tubes 2 of a cylinder furnace 1 of an oil refinery unit.

The furnace 1 is kept in operation, being heated by a burner (not shown). The tubes 2 extend inside the furnace between a first end 2a and a second end 2b. Hydrocarbons flowing in said tubes 2 are heated between  
5 said two ends by exchanging heat with the combustion gas.

The presence of a deposit on the outsides of the tubes 2 thermally isolates the fluid for heating (in this case the hydrocarbons) from the combustion gas, thus requiring an increase in the power delivered by the  
10 burner in order to maintain the same level of heat exchange.

In order to detach the deposit, an injector nozzle 4 is passed through an opening 8 formed in the wall 10 of the furnace. This nozzle projects solid particles 6  
15 against one of the tubes. The nozzle 4 is fed with compressed air at a pressure of about 5 bars to 10 bars and with solid particles 6 by a device provided for this purpose.

The particles 6 are substantially spherical and of  
20 size lying in the range 1 millimeter (mm) to 5 mm, and advantageously in the range 2 mm to 4 mm. They reach the tube 2 at a speed of at least  $50 \text{ m.s}^{-1}$ , and advantageously lying in the range  $100 \text{ m.s}^{-1}$  to  $200 \text{ m.s}^{-1}$ . The formulation of the particles preferably contains about 98% carbamide  
25 -  $(\text{NH}_2)_2\text{CO}$  - and about 2% magnesium carbonate, by weight. On coming into contact with the tube 2, which is at a temperature of at least  $250^\circ\text{C}$ , the particles 6 detach a fraction of the deposit, all of the carbamide contained in the particles vaporizes, and only a very small  
30 quantity of solid residues drops onto the hearth of the furnace.

Acidic derivatives of the deposit are neutralized by the gas obtained by the formulation decomposing, which advantageously gives off sulfur oxide, nitrogen, and  
35 water vapor. The user then moves the injection nozzle, as represented by arrow 12, between the first and second ends 2a and 2b of the tube 2 in order to remove the

deposit over the entire tube. As necessary, the user passes the nozzle through other existing openings or through openings made specially through the walls of the furnace and proceeds in analogous manner with the other  
5 tubes 2.

## CLAIMS

1. A method of cleaning surfaces (2) of furnaces (1) in operation, in particular the flue gas side of metal heat-exchange surfaces in industrial furnaces, and also in industrial boilers, which method comprises the following steps:
- generating a jet of gas that is directed towards the surfaces to be cleaned;
  - integrating particles (6) in the solid state in the jet of gas and projecting the particles at a speed such that the particles disintegrate on coming into contact with said surfaces for cleaning; and
  - moving the jet of gas and particles along the surfaces to be cleaned;
- said method being characterized in that the particles used have a formulation that is constituted by a majority of carbamide.
2. A method according to claim 1, characterized in that at least 95% of carbamide is introduced into the formulation of the particles.
3. A method according to claim 1 or claim 2, characterized in that a magnesium salt is added to the formulation of the particles.
4. A method according to claim 3, characterized in that 0.5% to 5% of magnesium salt is added to the formulation of the particles.
5. A method according to claim 3 or claim 4, characterized in that magnesium carbonate is added to the formulation of the particles.
6. A method according to claim 3 or claim 4, characterized in that magnesium silicate is added to the formulation of the particles.

7. A method according to any preceding claim,  
characterized in that the furnace is adjusted so that the  
temperature of the surfaces for cleaning is higher than  
5 250°C.

8. A method according to any preceding claim,  
characterized in that the particles are projected into  
contact with the surfaces for cleaning at a speed of at  
10 least 50 m.s<sup>-1</sup>.

9. A method according to any preceding claim,  
characterized in that for a duct containing a fluid to be  
heated and extending inside the furnace between a first  
15 end (2a) and a second end (2b), the fluid jet is moved  
from the first end to the second end.