

## GRATE BAR AND GRATE FOR A STEP-GRATE STOKER

The subject of this present invention is a grate bar and a grate for a stepped-grate furnace stoker. Its principal application is in the field of furnaces for waste conversion units, such as common refuse, industrial, domestic, or hospital wastes, water treatment sludges, or indeed flour, for example.

The question of waste incineration has long been a problem in our societies, which are producing more and more of it. Furnaces that have actually been designed for waste incineration have existed for many years, and have undergone constant development up to the present time. These include known furnaces such as grate furnaces, roller-hearth furnaces or fluidised-bed furnaces for example, in which the waste materials are emptied through a hopper onto a conveyor composed of mobile steps that blend and push the waste materials forward into the combustion chambers. These furnaces thus allow the combustion of the waste materials, and therefore a reduction in the production of pollution.

Nowadays, we speak of the recovery or re-use of waste materials. In fact, we no longer merely seek to make it disappear or to reduce its volume significantly, but also to recover the energy that comes from the combustion process. In a recovery unit, the furnace is the part in which the waste materials are dried and where their combustible content is oxidised. An efficient furnace should be designed so that the waste materials are well distributed over the combustion bed, and are correctly blended. This blending is used to bring the waste materials into contact with the hot air coming from the furnace in order to dry them, to distil the volatile substances, and to break down the products into simple molecules that finish by attaining their ignition temperature.

The quality of the combustion is linked mainly to oxygen content, which must be sufficient, to the temperature, which must be high, to the controlled turbulence which must be sufficient for good combustion while avoiding the releases of  
5 dusts composed of flying ash, and to an adequate time of presence of the waste materials on the grate.

Most of the known grates include bars whose main section has the shape of an inverted "U", meaning a flat part and two lateral legs, which are assembled so as to form a mobile step-  
10 feed, in which some bars move in limited translation in relation to the others, so as to move the particles forward and to empty them out. One of the drawbacks of this type of bar is that the path that the particles must travel along the legs of the bars, before they are completely emptied out below  
15 these bars, is a long one. It corresponds in fact to the length of the legs of the bar. One of the consequences is therefore that the particles are heated for longer and are liable to stick on, under, or between the bars.

We know of some grates whose bars have a main section, in the  
20 shape of a "T", meaning with a flat part and a longitudinal part projecting below the flat part. These bars partially limit the aforementioned drawback of the bars whose main section is in the shape of an inverted "U", since the path travelled by the particles being removed between the bars  
25 corresponds to the thickness of the flat part, and therefore is shorter.

However, these bars do not adequately prevent the progressive accumulation, between and under the bars, of the refractory materials. This accumulation can then, in particular, cause  
30 the shuttle motion of the bars to be paralysed. It can also give rise to the amplification of the separations between the bars, which contributes to blocking the movements of the grate and increases the difficulties of adjusting the combustion. In

fact this can necessitate shut-down of the production in order to clean or change one or more bars, especially because of mechanical wear following this progressive accumulation of the refractory materials.

5       The problem that then rises is therefore how to prevent the progressive accumulation of the refractory materials between and under the bars, in order to arrange for efficient removal of these refractory materials, and so guarantee the relative movement of the bars, increase the life expectancy of  
10 each bar, and facilitate adjustment of the combustion.

Embodiments of the present invention seek to provide a solution to the aforementioned problems, amongst others.

According to a first aspect of the present invention,  
15 there is provided a bar for a grate in the firebox of an incineration furnace that includes: a flat part whose top surface is intended to receive the elements to be incinerated, with the said flat part extending in a rear end and a front end each forming a return that acts as a support point for the  
20 said bar, a longitudinal projection located under the said flat part and that extends at least partially between the said rear and front ends, at least one angled cutting element located under the said flat part, against and perpendicularly to a first side of the said longitudinal projection,  
25 characterised in that the said angled element has a cross section in the shape of an essentially right-angle triangle, with firstly a first face essentially perpendicular to the bottom surface of the said flat part forming a cutting angle, and secondly a second face forming an angle non perpendicular  
30 to the bottom surface of the said flat part forming an expulsion angle. In a first variant, the bar of the invention includes at least one second angled cutting element located under the flat part, on a second side of the longitudinal

projection.

Preferably, the bar includes a multiplicity of angled cutting elements distributed under the flat part, on a first side or on each side of the longitudinal projection.

- 5        Again preferably, each of the angled cutting elements is located against the bottom surface of the said flat part and perpendicularly to this bottom surface, and/or each of these

angled cutting elements is located against one or other side of the longitudinal projection and perpendicularly to this side.

Thus, during the relative movements of a bar in relation to the neighbouring bar, the angled cutting elements may favour the removal of the refractory materials that accumulate progressively between, on, and under the bars.

In another variant, possibly in combination with one or more of any of the previous variants, the bar according to embodiments of the invention includes at least one wing positioned under the flat part, on a first side of the longitudinal projection.

Preferably, this wing, positioned under the flat part, is provided with at least one lateral hollow-out which, together with the lateral hollow-out of a wing of a first neighbouring bar, forms a passage for channelling the air up to the front end of the bar.

In another variant, possibly in combination with one or more of any of the previous variants, the bar according to embodiments of the invention includes at least one second wing positioned under the flat part, on a second side of the longitudinal projection. This second wing is provided with a lateral hollow-out which, together with the lateral hollow-out of a wing of a second neighbouring bar, may form a second passage for channelling the air up to the front end of the bar.

Preferably, the bar includes a multiplicity of wings distributed under the flat part, along the longitudinal projection, on a first side or on each side of this longitudinal projection. These wings are provided with respective lateral hollow-outs which, together with the respective lateral hollow-outs in the wings the neighbouring bar or bars, may form passages. In their turn, these passages may form a channel for guiding the air up to the front

end of the bar, on the first or on each side of the longitudinal projection.

In another variant, possibly in combination with one or more of any of the previous variants, the passages are  
5 outlined at the top, at least partially, by the bottom surface of the flat part, so that the channelled air may run just below this flat part.

In another variant, possibly in combination with one or more of any of the previous variants, the base of the front  
10 end of the bar has an attack angle  $\alpha$  that is greater than  $0^\circ$ .

This attack angle  $\alpha$  is preferably between  $2^\circ$  and  $10^\circ$ . Preferably again, this attack angle  $\alpha$  is essentially equal to  $3^\circ$ .

In another variant, possibly in combination with one or  
15 more of any of the previous variants, the front end of the flat part is provided, on at least one of the sides of the longitudinal projection, with a fin for redirection of the air coming from the passage or passages formed by the lateral hollow-outs, to at least one channel located in the top part  
20 of the front end of the bar.

Preferably, the channel starts at the bottom surface of the flat part and perpendicularly to the latter, and opens out onto the top of the top surface of the flat part, parallel to the latter.

25 According to a second aspect of the present invention, there is provided a grate for the firebox of an incineration furnace, characterised in that it includes at least one bar according to the first aspect of the present invention presented above.

30 According to a third aspect of the present invention, there is provided a grate for the firebox of an incineration furnace,

characterised in that it includes at least one group of three bars according to the first aspect of the present invention presented above, with the central bar in the group being mobile in relation to the two lateral bars in the group.

Preferably, the bars in at least one of the groups are assembled by means of a dowelling or pinning technique that locks the two lateral bars in relation to each other, and that leaves the central bar free in translation, between two  
5 extreme positions, in relation to the two lateral bars.

In particular during the relative movements of one bar in relation to the neighbouring bar, embodiments of the present invention therefore can advantageously allow the removal of refractory materials that accumulate progressively between,  
10 on, and under the bars. In fact, firstly the structure with a flat part and a longitudinal projection under this flat part that may provide the assembly with a main section, in the shape of a "T", may result in a short removal path of the particles between each bar, and secondly, during the relative  
15 movements of the bars in relation to each other, the presence of the angled cutting elements may result in cutting up any particles that might accumulate between the bars.

Thus paralysis of the shuttle motion of the bars, amplification of the separations between the bars, and  
20 therefore blocking of the movements of the grate, may thus be avoided. Adjustment of the combustion may therefore be facilitated. In addition, the mechanical wear on the bars may be reduced, since this accumulation of the refractory materials may be avoided, and the halting of production in  
25 order to clean or change one or more bars may therefore be less frequent.

In addition, the presence of wings under the flat part, as explained earlier, may allow the creation, under the grate, of channels that direct the air running under the bars of this  
30 grate. The formation of these channels, and therefore the advantageous circulation of the air under a bar, may thus depend on the juxtaposition of this bar with the adjoining bars. This better circulation of air may cool the assembly while also

favouring and activating the combustion, since the oxidising air is channelled toward the front end of the bar.

The shape, the position, and the number of wings may combine to accelerate cooling of the bar from below.

5       The shape of the front end of the bar, in particular with the presence of the fin for redirection of the air coming from the passages formed by the lateral hollow-outs, to a channel located in the top part of the front end of the bar, may result in efficient blowing of the oxidising air, at the  
10       surface of the flat part, toward the rear end of the bar, and therefore of the grate, so that the air may be blown in the direction of removal of the products.

The angle of attack of the front end of the bar may prevent the accumulation of particles at this point and therefore the  
15       lifting of the bar.

All these advantages therefore may considerably reduce the risk of blocking the relative movements of the bars, since these movements are essential for efficient removal of the particles, which must not be pushed to the outside, as well as  
20       for effective and well distributed combustion on the grate. These limited relative movements may be rendered possible and controlled by means of a dowelling or pinning technique.

Other characteristics and advantages of the invention will appear more clearly and more completely on reading the  
25       description that follows of preferred variants of implementation of the system, which are given by way of non limiting examples and with reference the following appended drawings.

- figure 1 schematically represents a set of three bars  
30       according to the invention, in cross section,

- figure 2 schematically represents a portion of a bar according to the invention, in perspective,

- figure 3a schematically represents a portion of a bar according to the invention, as seen from the side,

- figure 3b schematically represents a portion of a bar according to the invention, as seen from above and in  
5 perspective,

- figure 4 schematically represents the front end of a bar according to the invention, as seen from the side,

- Figure 5a schematically represents a grate formed from several bars assembled according to the invention, as seen  
10 from below,

- figure 5b schematically represents a detail of the assembly of three bars according to the invention, as seen from below.

Figure 1 schematically represents a set of three bars  
15 according to the invention, in cross section.

Three bars 1, 9, 13 are represented in this figure. It can be seen that the main section of each bar has the shape of "T" with, in the case of bar 1, a flat part 3 that surmounts a longitudinal projection 6. This main section, in the shape of  
20 a "T", offers, amongst other advantages, an optimised level of geometrical and mechanical precision, and a good resistance to high-temperature deformations, due to its moment of inertia.

The material used is preferably a refractory alloy that offers high resistance to abrasion when hot, to corrosion when  
25 hot, to oxidation, and to thermal shock. A method of manufacture by casting allows the implementation of such highly alloyed and refractory alloys. The main section, in the shape of a "T", which is totally removable from its mould, allows the use of a "natural" casting method that has the  
30 particular advantage of being comparatively more convenient than other methods of casting that are more complex.

Under the flat part 3, a first wing 7 is positioned on a first side 6a of the longitudinal projection 6, and a second wing 11

can be positioned on another side 6b of this longitudinal projection 6. The wings 7, 11 respectively have lateral hollow-outs 7a, 11a. The adjoining bars 9, 13 also respectively have wings 8, 12. Wing 8, which is opposite to wing 7 of bar 1, has a lateral hollow-out 8a that is opposite to the lateral hollow-out 7a of wing 7 of bar 1. Wing 12, which is opposite to wing 11 of bar 1, has a lateral hollow-out 12a that is opposite to the lateral element 11a of wing 11 of bar 1.

Thus, a passage 10 is formed between bar 1 and bar 9, and a passage 14 is formed between bar 1 and bar 13. The position of the lateral hollow-outs in the wings, meaning the top corner opposite to the longitudinal projection of the bar to which each wing belongs, precisely allows the creation of passages just below the respective flat parts of the bars. The purpose of these passages is to channel the air up to the front end of each bar.

Figure 2 schematically represents a portion of a bar according to the invention, in perspective.

In bar 1, also represented in figure 2, we find the flat part 3 and the longitudinal projection 6. A bar 1 extends to a front end 5 forming a return that acts as a support point in the case of bar 1. This figure also shows that the longitudinal projection 6 actually extends under the flat part 3 from the front end 5 in the direction of the rear end (not shown). It could possibly extend only partially under the flat part 3 between the front end and the rear end.

On one side 6a or on each side 6a, 6b of the longitudinal projection 6, several wings can be positioned, namely wings 7, 7' and 7'' on a first side 6a, and wings 11, 11' and 11'' on the other side 6b. Wings 7, 7' and 7'' respectively have lateral hollow-outs 7a, 7a', 7a''. Wings 11, 11', and 11'' respectively

have lateral hollow-outs 11a, 11a', 11a'', which are shown only partially due to the perspective view.

5 The succession of lateral hollow-outs on each side of the longitudinal projection 6, in combination with the succession of lateral hollow-outs in the adjoining bars (not shown in figure 2), form, on each side of this longitudinal projection 6, and between bar 1 and its adjoining bars, a channel for guiding the air up to the front end 5.

10 The number of these wings on each side of the longitudinal projection 6 does not limit the invention of course, since bar 1 is not shown over all of its length. The number of these wings will depend essentially on the length of bar 1. In fact, this is an important parameter for accelerating the cooling of bar 1.

15 In this figure, wings 7, 7' and 7'' and 11, 11', 11'' are represented perpendicularly to the longitudinal projection 6, and slightly inclined in relation to the flat part 3, at the rear end (not shown) of bar 1. This position is only an example however and does not limit the scope of the invention.  
20 In fact, these wings could just as well be positioned in an inclined manner, to the rear for example, in relation to the longitudinal projection 6, and perpendicularly to the flat part 3. The position in the example of figure 2 nevertheless gives good results in relation to the objective sought, namely  
25 cooling of bar 1 by the oxidising air running between the wings.

The arrows shown in figure 2 symbolise the circulation of this oxidising air between the wings, in order to favour cooling of the bar.

30 In addition, figure 2 also shows angled cutting elements 15, 15', 15'', which can also be called just angled elements or knives, on the side 6a of the longitudinal projection 6, under the flat part 3. Here again, the number and the position of

these angled elements place no limitation on the invention. An appropriate position is one that results in an effective ability to cut any particles between an angled element of one bar and an angled element of a neighbouring bar.

5        A bar 1 can also have one or more of these angled elements on the other side 6b of this longitudinal projection 6, which are not visible here due to the perspective view.

10        Ideally, these angled elements or knives 15, 15', 15'' are located against the bottom surface 3b of the flat part 3, perpendicularly to the latter.

Preferably, they can be placed against the side 6a or 6b of the longitudinal projection 6, perpendicularly to this side.

15        These angled elements, which therefore play the role of knives, are thus used, during the relative movements of the bars in relation to each other, to cut any particles that might accumulate between the bars, by shearing these particles between a knife located on a first side of a given bar and a knife located on the side of a neighbouring bar adjacent to  
20        the first side of the given bar.

Figure 3a schematically represents a portion of a bar according to the invention, as seen from the side.

25        It highlights the inclination of wings 7, 7' and 7'' under the flat part 3, to the rear end (not shown and inverted in relation to figure 2), and perpendicularly to the longitudinal projection 6. The lateral hollow-outs 7a, 7a', 7a'' are also represented.

30        The angled elements 15, 15', 15'' are shown by solid lines, and the angled elements on the other side of the longitudinal projection 6 and/or of a neighbouring are shown by broken lines (but not referenced).

Figure 3b schematically represents a portion of a bar according to the invention, as seen from below and in perspective.

It highlights the distribution of the angled elements on each side of the longitudinal projection 6, in one particular embodiment. In the latter, the angled elements are positioned precisely under the flat part 3, against and perpendicularly to the bottom surface 3b of this flat part 3. They are distributed on each side of the longitudinal projection 6, respectively against and perpendicularly to the sides of this longitudinal projection 6.

Figure 4 schematically represents the front end of a bar according to the invention, as seen from the side.

The front end 5 of the bar forms a return whose base 5a acts as a support point for the bar. This base 5a has an attack angle  $\alpha$  that is greater than  $0^\circ$ . Thus, during the movements in longitudinal translation of the bars in relation to each other, this angle of attack prevents the accumulation of particles under the front end 5 of the bar and therefore the lifting of this bar.

Preferably, an effective angle of attack will be between  $2^\circ$  and  $10^\circ$ . A particularly good result is achieved with an angle of attack that is essentially equal to  $3^\circ$ .

On one side, or on each side, of the longitudinal projection 6, this front end 5 of the bar also has a fin 16 for redirection of the air (redirection being symbolised by the upwardly-pointing arrow) coming from the passages formed by the lateral hollow-outs in the wings (not shown) along the longitudinal projection 6. The internal curved shape of this fin 16 actually favours the redirection of the air. This air is redirected to a channel 18, on one side, or on each side, of the longitudinal projection 6. This channel 18 starts at the bottom surface 3b of the flat part 3, perpendicularly to

this flat part 3. It then emerges at the top of the top surface 3a of the flat part 3, parallel to this flat part 3. The air exiting from this channel 18 is symbolised by the arrow in the direction of the rear end (not shown) of the bar.

5 This channel 18 can have a circular section, possibly with an input diameter, meaning at the bottom surface 3b of the flat part 3, that is greater than its output diameter, meaning at the top of the top surface 3a of the flat part 3.

Thus, the oxidising air is blown in an optimised manner  
10 to the rear, meaning in the direction of removal of the products.

Figure 5a schematically represents a grate formed from several bars assembled according to the invention, as seen from below.

15 In this figure, grate 2 includes two groups 20, 20' each of three bars, 1, 9, 13 and 1', 9', 13' respectively. In each of these groups, the central bar 1 or 1' is mobile in relation to the lateral bars 9, 13 or 9', 13' which remain fixed. The movements of these central bars 1, 1' relatively to their  
20 respective adjoining bars 9, 13 and 9', 13' are symbolised by arrows in the direction of the longitudinal axis of the bars, in both directions.

Assembly of the bars in each group is effected by means of a dowelling or pinning technique 21, 22, 23 for group 20,  
25 highlighted in the circled zone D, which will be described in greater detail with reference to figure 5b, and 21', 22' and 23' for group 20'.

Figure 5b therefore schematically represents zone D of the assembly of the three bars 1, 9, 13 of group 20 in Figure  
30 5a, as seen from below.

Assembly is effected at the front ends of the bars by means of a dowelling or pinning technique that include a threaded axial rod 21 and two locking pins, one 22 at the

level of a first lateral bar 9 with a right-hand thread, and the other 23 at the other lateral bar 13 with a left-hand thread. The round heads of the pins 22, 23 (the head of the pin 22 is referenced 24 in Figure 5a) each have a locking flat part (reference 25 for pin 22 in Figure 5a), and each fit into a circular housing (reference 26 for the head 24 of pin 22 in Figure 5a) provided in the longitudinal projection of each bar 9, 13, with these circular housings each also having a locking flat part. The role of these locking flats is in fact to lock the bars, both in rotation about the axis of the rod 21, and in the translation of one neighbouring bar 9 in relation to the other neighbouring bar 13.

In addition, the circular housings in the longitudinal projection of each bar have a longitudinal extension at the rear in the form of a groove 27 of sufficient width to allow the passage of the rod 21.

Thus, this assembly system by means of a dowelling or pinning technique provides for the freedom in translation of the central bar 1, 1' in each group 20, 20', between two extreme positions, in relation to the two lateral 9, 13 and 9', 13' respectively. In fact the travel in translation of the central bars 1, 1' is limited by the length of the groove 27. Thus, the limited translation movement described above, which is essential for efficient removal of the particles, which must not be pushed to the outside, as well as for effective and well distributed combustion on the grate, is rendered possible and controlled by the assembly system just described. All of the description above is given by way of an example, and does not limit the scope of the invention.

**CLAIMS**

1. A bar for a grate in the firebox of an incineration furnace that includes:

5        -a flat part whose top surface is intended to receive the elements to be incinerated, with the said flat part extending in a rear end and a front end each forming a return that acts as a support point for the said bar,

10       -a longitudinal projection located under the said flat part and that extends at least partially between the said rear and front ends,

      -at least one angled cutting element located under the said flat part, against and perpendicularly to a first side of the said longitudinal projection,

15       characterised in that the said angled element has a cross section in the shape of an essentially right-angle triangle, with firstly a first face essentially perpendicular to the bottom surface of the said flat part forming a cutting angle, and secondly a second face forming an angle non perpendicular  
20 to the bottom surface of the said flat part forming an expulsion angle.

2. A bar according to claim 1, characterised in that it includes at least one second angled cutting element located  
25 under the said flat part, against and perpendicularly to a second side of the said longitudinal projection, with the said second angled cutting element having a cross section in the shape of an essentially right-angle triangle, with firstly a first face essentially perpendicular to the bottom surface of  
30 the said flat part forming a cutting angle, and

secondly a second face forming an angle that is not perpendicular to the bottom surface of the said flat part, forming an expulsion angle.

5        3. A bar according to either of claims 1 and 2, characterised in that it includes a multiplicity of angled cutting element distributed under the said flat part, against and perpendicularly to one or other of the first and second sides of the said longitudinal projection, with the said  
10 angled cutting elements having a cross section in the shape of an essentially right-angle triangle, with firstly a first face that is essentially perpendicular to the bottom surface of the said flat part forming a cutting angle, and secondly a second face forming an angle that is not perpendicular to the bottom  
15 surface of the said flat part, forming an expulsion angle.

4. A bar according to any of claims 1 to 3, characterised in that it includes at least one wing positioned under the said flat part, on a first side of the said  
20 longitudinal projection.

5. A bar according to any of claims 1 to 4, characterised in that the said wing is provided with at least one lateral hollow-out so that this lateral hollow-out,  
25 together with the lateral hollow-out of a wing of a first adjacent bar of the said bar, forms a passage for channelling the air up to the said front end of the said bar.

6. A bar according to claim 5, characterised in that it  
30 includes at least one second wing positioned

under the said flat part, on a second side of the said longitudinal projection, with the said second wing being provided with a lateral hollow-out which, together with the lateral hollow-out of a wing of a second adjacent bar of the said bar, forms a second passage for channelling the air up to the said front end of the said bar.

7. A bar according to either of claims 5 and 6, characterised in that it includes a multiplicity of wings distributed under the said flat part, along the said longitudinal projection, on a first side or on each side of this said longitudinal projection, with the said wings being provided with respective lateral hollow-outs which, together with the respective lateral hollow-outs of the wings of the neighbouring bar or bars of the said bar, form passages, with these said passages forming, on the said first side or on each side of the said longitudinal projection, a channel for guiding the air up to the said front end of the said bar.

8. A bar according to any of claims 5 to 7, characterised in that the said passage or passages are outlined at the top at least partially by the bottom surface of the said flat part, so that the channelled air circulates just below the said flat part.

9. A bar according to any of claims 1 to 8, characterised in that the base of the said front end of the said flat part has an attack angle that is greater than  $0^\circ$ .

10. A bar according to claim 9, characterised in that the said attack angle is between  $2^{\circ}$  and  $10^{\circ}$ , and preferably essentially equal to  $3^{\circ}$ .

5        11. A bar according to any of claims 1 to 10, characterised in that the said front end of the said flat part is provided, on at least one of the sides of the said longitudinal projection, with a fin for redirection of the air coming from the said passage or passages, to at least one  
10 channel located in the top part of the said front end of the said flat part.

12. A bar according to claim 11, characterised in that the said channel starts at the bottom surface of the said flat  
15 part and perpendicularly to this said flat part, and opens out onto the top of the top surface of the said flat part, parallel to this said flat part.

13. A grate for the firebox of an incineration furnace,  
20 characterised in that it includes at least one bar according to any of claims 1 to 12.

14. A grate for the firebox of an incineration furnace, characterised in that it includes at least one group of three  
25 bars according to any of claims 1 to 12, with the central bar in the said group being mobile in relation to the two lateral bars in the said group.

15. A grate for the firebox of an incineration furnace  
30 according to claim 14, characterised in that each angled cutting element on one side of a central bar is

symmetrical and offset in relation to the angled cutting element, on the side of a lateral bar, with which it mates when the central bar is in movement in relation to the lateral bar.

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16. A grate according to any of claims 15 and 16, characterised in that the said bars in at least one of the said groups are assembled by means of a dowelling or pinning technique that locks the two lateral bars in relation to each other, and that leaves the central bar free in translation, between two extreme positions, in relation to the two lateral bars.

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