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METHOD OF FIRING CERAMIC TUBES SUSPENDED IN A SHAFT OVEN

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Fig. 2

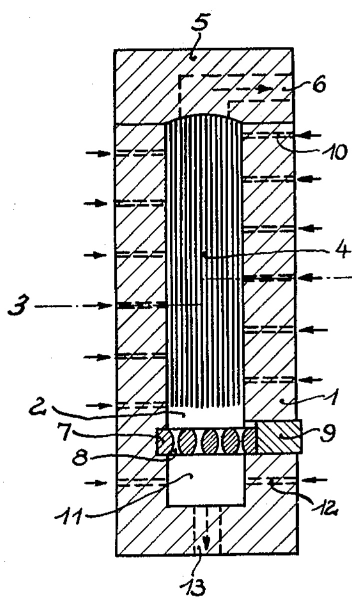


Fig. 1

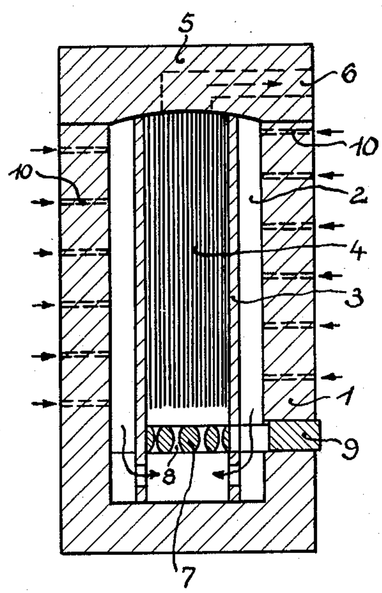
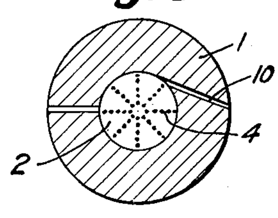


Fig. 3



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METHOD OF FIRING CERAMIC TUBES SUSPENDED IN A SHAFT OVEN

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The present invention relates to a method of firing ceramic tubes or bars.

It is known that it is possible to fire ceramic tubes, e.g. pyrometer tubes, gas delivery tubes, reaction tubes or the like and ceramic bars, by suspending these tubes on the roof or intermediate roof of a shaft oven. The shaft oven is heated over its entire height by a relatively large number of burners, so as to achieve uniform heating of the goods and thereby uniform shrinkage. In this way it is possible to prevent the tubes from becoming bent or distorted when being fired.

In carrying this method of firing into practice, a certain difficulty has been encountered, which it is the object of the present invention to overcome. With the hitherto conventional method of firing, the vertically suspended tubes or bars are made to swing about owing to the fact that considerable turbulences, which exert unilaterally directed forces against the tubes, are produced in the combustion gases flowing tangentially or radially and impinging against the tubes. The longer the tubes, the more effective are these forces. As has been found, it needs only very little flow energy, for example emanating from the lowest burner of the shaft, to cause tubes of 2 metres in length to swing about. Since the tubes do not all swing in the same direction and with the same frequency, in some cases they may impinge against one another. Then it may happen that one or other tube breaks off and in falling brings down other tubes with it, and maybe even the entire set of tubes. This phenomenon occurs more particularly in the temperature range which the ceramic material passes through when being heated up. Depending on the ceramic material, this temperature range extends up to 800°–1200°. Within this temperature range for the heating-up stage, the structure of the ceramic material is loosened by the driving-off of the water of hydration and by the combustion of the binding agent used in shaping of the goods. The tubes are then most sensitive to mechanical stressing. More particularly the uppermost part of the tubes is in especially great danger, since here the tensile stresses caused by the dead weight of the tube are added to by the alternating bending stresses produced by the swinging movement. In fact is has been observed that the tubes most frequently break off at the uppermost portion. Once the initial heating stage has been completed, i.e. when a temperature of above 800–1200° has been reached, depending on the material used, the tubes are mechanically less sensitive, since the material is increasingly consolidated by the firing.

The object of the present invention is to overcome the aforesaid difficulties. The method according to the invention for firing ceramic tubes or bars suspended in a shaft oven consists essentially in that the heat required for the initial heating of the goods to temperatures of 800°–1200°, is at least partly supplied by direct contact with ho' gases of combustion which are introduced only axially into the shaft oven and pass through the latter in a flow parallel to the longitudinal direction of

the goods, whereas the final firing is carried out by means of gases of combustion flowing in any desired direction.

The method according to the invention can be carried out in various ways, depending on whether the initial heating and the final firing of the ceramic goods are to be carried out exclusively or only to a considerable extent by direct contact with hot gases of combustion. In one mode of carrying out the method according to the invention, the heat necessary for heating up the goods can be supplied mainly by direct contact with gases of combustion flowing parallel to the goods, and partly also by using the heat radiation of the inner wall of a muffle which completely surrounds the goods and which is arranged within the shaft oven, by heating the muffle from the outside, introducing gases of combustion radially or tangentially into the annular space between the inner wall of the shaft and the outer wall of the muffle, the said gases then being conveyed into the muffle in the axial direction. This mode of carrying the method according to the invention into effect does in fact give a very uniform and easily regulated temperature in the whole firing chamber, i.e. over the whole length of the ceramic goods. However when firing tubes which require particularly high sintering temperatures, more particularly temperatures above 1800°, the high-quality lining material entails particularly great expense. In such a case it is particularly advantageous to use a further mode of carrying the method according to the invention into effect, namely effecting both the initial heating and also the final firing of the goods exclusively by direct contact with hot gases of combustion, in that after the goods have been heated up by gases of combustion which enter at one end of the shaft oven and flow axially therethrough, a further temperature increase in the goods (final firing) is effected by combustion gases entering radially or tangentially into the shaft oven over the entire length thereof.

Irrespective of which mode is preferred, it is essential to the means for carrying the method according to the invention into effect that during the initial heating operation the gases of combustion must be guided as axially parallel as possible. For this purpose, the shaft oven is so constructed that a ceramic closure slab provided with perforations is arranged at the lower end of the firing chamber filled with goods for firing, the perforations (holes, slots) being so distributed and constructed that the gases of combustion passing therethrough are distributed as uniformly as possible over the entire cross-section of the combustion chamber and flow in axially parallel manner about the goods, forming the least possible turbulence.

The ceramic slab can also be provided at the upper end and the outlet flue for the combustion gases can accordingly be provided at the lower end.

Two apparatus for carrying the method according to the invention into effect are illustrated diagrammatically in the drawings wherein:

Figure 1 is a view of a shaft oven wherein the articles to be fired are arranged within a fixed muffle.

Figure 2 is a view of a shaft oven wherein the goods are suspended freely within the shaft.

Figure 3 is a cross sectional view of the embodiment shown in Fig. 2 taken along line 3—3 thereof and showing introduction of combustion gases radially as well as tangentially to the shaft oven.

The refractory masonry **1** of the shaft oven surrounds a firing chamber **2** within which is fixedly arranged the muffle **3** which can be, for example, of cylindrical shape. The goods **4** which are to be fired, e.g. ceramic tubes, are suspended on the roof **5** in a manner which is not described in detail here. Also situated in the roof is the outlet flue **6** for the gases of combustion. The muffle

3 is closed at the bottom end by a ceramic slab 7 comprising perforations 8. These perforations are in the form of circular holes whose cross-section widens towards the interior of the muffle, so as to provide the most uniform possible distribution of the combustion gases over the entire free cross-section of the muffle, and also to ensure parallel gas flow. The ceramic slab 8 can be pulled out of the oven laterally through a slot in the masonry 1, this slot being sealed during a firing operation by an additional piece 9. The fuel-air mixture is introduced into the firing shaft 2 through nozzles 10, the construction of which need not be explained in more detail, and the said mixture, in burning, produces hot gases which heat the muffle from the outside and bring it to the desired temperature. The heat supplied to the muffle from the outside is dissipated by the said muffle by radiation at its inner side to the tubes or the like. The hot gases of combustion move downwards through the shaft 2 and then, as indicated by the flow-direction arrows, pass through the holes 8 of the ceramic closure slab 7 into the interior of the muffle. Inside the muffle, the flow, distributed uniformly over the cross-section, in the longitudinal direction relatively to the tube and parallel to one another, in the upward direction and pass out of the shaft oven through the outlet flue 6.

In the apparatus according to Figure 2, the construction of the shaft oven is left substantially unaltered in its essential components from the apparatus illustrated in Figure 1; but there is no muffle, so that the goods hang in the shaft oven 2 without any particular shielding. The space existing below the ceramic slab 7 is constructed as an independent combustion chamber 11 which is heated by separate nozzles 12 and comprises an outlet flue 13.

When heating up the goods, the fuel-air mixture is first of all introduced through the nozzles 12 into the combustion chamber 11, where it is ignited. The hot gases of combustion pass through the perforations 8 in the closure slab 7 into the firing chamber 2 and flow upwards parallel to the tubes. They leave the shaft oven through the flue 6. After the heating-up temperature has been reached, which will be between 800° and 1200° depending on the type of goods, the nozzles 10 are supplied with a fuel-air mixture. The hot gases of combustion enter radially or tangentially into the firing chamber 2 and wash about the goods in an initial direction which can be selected optionally. Since after the heating-up temperature has been reached, the goods have attained a certain mechanical strength, there is no longer any danger from undesirable swinging movements of the tubes. The hot combustion gases leave the shaft oven through the shaft flue 6. If necessary, part of the hot combustion gases can also be discharged through the outlet flue 13 and the uniformity of temperature distribution can be further improved in this manner.

After the final firing has been ended, in both types of apparatus the roof part 5 of the shaft oven is removed so that the finished fired tubes are freely accessible and can be released from the roof. The oven is then ready for a new firing operation.

The interchangeability of the ceramic closure slab 7 is required when very different kinds of goods are fired in the same shaft oven in succession, or if the firing chamber is filled in different ways with goods. In both cases, by appropriate choice of the distribution of perforations in the slab, it is possible to obtain the most advantageous distribution of hot combustion gases for the actual filling of the oven and the actual goods used.

We claim:

1. In a process of treating elongated ceramic workpieces such as straight rods and tubes, the steps of suspending a plurality of said ceramic workpieces in a vertical position in a shaft kilns so that the axes of said workpieces, respectively, extend vertically and parallel to each other; and passing a stream of heating gas along said suspended ceramic workpieces in a direction of flow parallel to said axes, the temperature of said stream of heating gas being sufficiently high to heat said workpieces to a temperature of at least 800° C. while, due to the parallel direction of flow of said heating gas, lateral movement of said workpieces is prevented.

2. In a process of treating elongated refractory workpieces such as straight rods and tubes, the steps of suspending a plurality of said refractory workpieces in a vertical position in a shaft kiln so that the axes of said workpieces, respectively, extend vertically and parallel to each other; and passing a stream of heating gas along said suspended ceramic workpieces in a direction of flow parallel to said axes, the temperature of said stream of heating gas being sufficiently high to heat said workpieces to a temperature of between 800° and 1200° C. while, due to the parallel direction of flow of said heating gas, lateral movement of said workpieces is prevented.

3. In a process of treating elongated refractory workpieces such as straight rods and tubes, the steps of suspending a plurality of said refractory workpieces in a vertical position in a shaft kiln so that the axes of said workpieces, respectively, extend vertically and parallel to each other; and passing a stream of heating gas along said suspended ceramic workpieces in a direction of flow parallel to said axes, the temperature of said stream of heating gas being sufficiently high to heat said workpieces to a first temperature of between 800° and 1200° C. while, due to the parallel direction of flow of said heating gas, lateral movement of said workpieces is prevented; and burning said refractory workpieces at a temperature higher than said first temperature.

4. In a process of burning straight elongated refractory workpieces such as rods and tubes which in untreated condition possess little mechanical impact resistance and which upon being heated to a first elevated temperature which is lower than the temperature required for burning said workpieces, will become impact resistant, the steps of suspending in a shaft kiln a plurality of said refractory workpieces closely adjacent but spaced from each other in a vertical position so that the axes of said workpieces, respectively, extend vertically and parallel to each other; contacting the thus suspended workpieces with a stream of hot combustion gases flowing in a direction parallel to said axes in such a manner as to heat said workpieces to said first elevated temperature while simultaneously preventing lateral movement and contact between adjacent workpieces due to the direction of flow of said stream of hot gases parallel to the axes of said workpieces, said hot combustion gases contacting said workpieces, until said workpieces have become impact resistant; and further heating said workpieces in any desired manner until burning of the same has been completed.

5. In a process of burning straight elongated refractory workpieces such as rods and tubes which in untreated condition possess little mechanical impact resistance and which upon being heated to a first elevated temperature which is lower than the temperature required for burning said workpieces, will become impact resistant, the steps of suspending in a shaft kiln a plurality of said refractory workpieces closely adjacent but spaced from each other in a vertical position so that the axes of said workpieces, respectively, extend vertically and parallel to each other; contacting the thus suspended workpieces with a stream of hot combustion gases flowing in a direction parallel to said axes in such a manner as to heat said workpieces to said first elevated temperature while simultaneously preventing lateral movement and contact between adjacent workpieces due to the direction of flow of said stream of hot gases parallel to the axes of said workpieces, said contacting being continued until said workpieces have become impact resistant; and further heating said workpieces with combustion gases flowing in any desired direction until burning of the same has been completed.

6. In a process of burning straight elongated refrac-

tory workpieces such as rods and tubes which in untreated condition possess little mechanical impact resistance and which upon being heated to a first elevated temperature which is lower than the temperature required for burning said workpieces, will become impact resistant, the steps of suspending in a shaft kiln a plurality of said refractory workpieces closely adjacent but spaced from each other in a vertical position so that the axes of said workpieces, respectively, extend vertically and parallel to each other; contacting the thus suspended workpieces with a stream of hot combustion gases flowing in a direction parallel to said axes in such a manner as to heat said workpieces to said first elevated temperature while simultaneously preventing lateral movement and contact between adjacent workpieces due to the direction of flow of said stream of hot gases parallel to the axes of said workpieces until said workpieces have become impact resistant; and further heating said workpieces by heat radiation until burning of the same has been completed.

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