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FURNACE LINING, METHOD OF LINING
FURNACES, AND THE LIKE

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This invention relates to methods of lining furnaces and the like. It has special utility in repairing the worn or eroded linings of furnaces which have been in use for a period of time.

In general the larger furnaces, such as are used for steam power boilers, annealing furnaces, forges, metallurgical work, and the like, are constructed of refractory firebrick and are equipped with grates or burners, as the case may be, for the combustion of coal or oil with a suitable type of draft. The ordinary operating temperature of such a furnace is likely to be between 2,000 and 3,000 degrees Fahrenheit and after a period of time the exposure of the refractory bricks to such continuous heat is likely to result in spalling, eroding, or decomposition of the inner brick surfaces. It has been customary in the past, from time to time as the need arose, to shut the furnace down and, after it had cooled, to apply a patching or coating material to the surface areas which had been impaired by the heat. Often the entire interior wall surfaces were relined.

Such repairs necessitated the complete cooling of the furnace in order that an operator might enter to work therein. When the patching or coating had been completed the furnace was refired and after a short period of full heat operation the lining material vitrified and thus served to prolong the life of the furnace. Often the furnace was relined several times.

One method of restoring furnaces which has heretofore been known and practiced was described in Schwarz Patent No. 1,125,741. According to the Schwarz process the furnace was allowed to cool and its interior was examined. Those areas requiring restoration were then coated with a heavy liquid consisting usually of an oil or water vehicle in which a refractory powder was carried. The heavy liquid was blasted under pressure from a gun which was played directly upon the areas selected for coating. The gun included as a part thereof an oxyacetylene torch intended partially to vitrify the refractory powder as it was blasted against the wall. The equipment necessary for carrying out the Schwarz process was cumbersome and heavy. Moving it into a building to the place where it was to be used was troublesome and time-consuming. And of course the treatment called for a complete cessation of furnace operation and a cooling off period before restoration could begin.

I have discovered a way of repairing and restoring a furnace wall which does not require that the furnace be shut down and allowed to cool but which, on the contrary, can be carried out substantially without interruption to normal operations. In addition, my process can be used to apply a smooth coating of varying thickness to the interior walls of a working furnace which thickness is related to the need for restoration

so that those portions which require the most reinforcement receive the heaviest coating and the entire interior of the furnace is smoothly lined with a continuous vitreous refractory skin-like layer which may even extend a short distance from the furnace into the stack. An advantage of my process is that it can be performed with the use of very simple, easily carried equipment. Accordingly I can repair a worn lining without shutting down the furnace, without moving in heavy equipment and materials, and without otherwise disrupting normal operations in the area where the furnace is located.

It is an object of my invention to provide a method of and compound for lining furnaces and the like of the character described having to a notable extent the capabilities and properties set forth. A further object resides in the provision of a method of lining furnaces as well as a furnace lining each of which overcomes certain of the disadvantages inherent in the processes and linings heretofore known and used. Another object is to provide a commercially satisfactory, simple and efficient manner of restoring the lining of a working furnace which can be carried out without interfering with normal furnace operation. Another object is to provide a better furnace lining and a better furnace lining material. Other objects will in part be pointed out as the description proceeds and will in part become apparent therefrom.

The invention accordingly consists in the features of construction, combinations of elements, methods of operation and arrangements of parts as will be exemplified in the structure and sequences and groups of related steps to be hereinafter described and the scope of the application of which will be set forth in the accompanying claims.

In this specification I have described a preferred embodiment of my invention and suggested various modifications thereof; but it is to be understood that these are not intended to be exhaustive nor limiting of the invention but, on the contrary, are given for purposes of illustration in order that others skilled in the art may fully understand the invention and the principles thereof and the manner of applying it in various forms, each as may be best suited to the conditions of a particular use.

In practicing my invention I rely upon the heat of the working furnace to vitrify a powdered material which I blow into the hottest regions within the furnace. The composition of the powdered material which I blow into the furnace usually depends, at least in part, upon the highest temperatures reached within the furnace. By using a fine powder having a melting range slightly below the upper temperatures reached within the furnace I assure that the minute individual com-

ponent particles of the powder will be converted almost instantly in the furnace to gas-borne fluid or semifluid refractory material which will be disposed by the swirling furnace gases upon the walls of the furnace. When I speak of furnace "walls" herein it will be appreciated that I intend an interpretation including floors and ceilings.

As is well known, the walls of the ordinary furnace will not be at a uniform temperature nor in general at as high a temperature as the hottest regions where combustion is occurring. Accordingly a droplet of fused, vitreous lining material will adhere to the relatively slightly cooler walls upon contact therewith. A wall area at a temperature slightly below the melting range of a molten droplet will have a hardening effect on the droplet which will cause it to adhere upon contact with the area. In most furnaces the draft supply is such that the furnace gases swirl through the interior of the furnace with a fair velocity and I rely upon this fact to a certain extent to distribute gas-borne droplets of liquid vitreous refractory material upon the interior furnace walls.

Thus my coating material is laid down upon the walls when the pores of the walls are in their most open condition and when the heat of expansion has opened the various cracks and orifices to the maximum. The gas-borne powder particles of fused, vitreous material are deposited in all of these open cracks and pores and are laid down in a continuous coating over the entire interior of the furnace. Some of the gas-borne droplets will even be carried a short distance from the furnace into the stack before coming into contact with and adhering to any wall.

Certain portions of the furnace walls are subjected to a greater degree of heat erosion than others. For example, where a blast of an oil jet impinges constantly upon a certain area of a wall that area is likely not only to be somewhat more heat-worn than elsewhere but also to be at substantially the same temperature as the hot blast and accordingly the droplets of the refractory powder would not accumulate on this area because of any relative coolness. However, the blast effect of the burner itself would have a tendency to project the fused droplets forcibly against this particular area of the wall and to cause the droplets to adhere over the regions which are most in need of restoration. Thus by blowing a quantity of suitable refractory material into the hottest region of the furnace, the furnace itself serves to spread a continuous coating of fused droplets upon the entire interior of the walls, in some instances because of the relative coolness of the walls, in others because of the blast effect of the flames themselves which forcibly project the droplets into adhering contact with the walls, and in still others because of random motion of the particles which brings them into adhering contact with the walls. In this way the same agents which caused deterioration are employed to spread the restorative coating automatically and to apply it more heavily in those areas where greater heat resistance will be most needed.

I have discovered that in many instances the best results are achieved by first blowing into the furnace under treatment a charge of fusible powder having a melting range somewhat lower than the highest temperatures reached inside of the furnace, and thereafter blowing a second charge of fusible powder into the hottest regions of the furnace which second charge has a melting range

somewhat higher than the highest furnace temperatures commonly reached. Preferably the second charge will become fully fused at a temperature around 3600° F.; this temperature is not ordinarily reached except in electric furnaces. By laying down two coatings in this fashion a better result is sometimes achieved. The refractory powder having the lower melting range at once assumes a liquid droplet condition and readily adheres to the entire interior of the furnace. The refractory powder having the higher melting range will readily adhere to the fresh coating laid down by the lower melting range material and even if not fused when deposited upon the sticky undercoating it will admix with the under coating to produce a very good result. In this fashion I am able to coat the interior of the furnace with a relatively high melting point composite refractory coating which is firmly secured to the walls of the furnace.

In order to project my refractory material into the selected hot regions of the furnace I have found it advantageous to employ an air blast which entrains the powdered refractory material from a supply and which discharges the air and powder mixture from a pipe which may be applied to deliver at any desired point in the interior of the furnace. In using this apparatus the operator has only to insert a lightweight pipe for a minute or two through an opening in the furnace wall and to direct the dry blast from the pipe into the hottest regions of the furnace. The pipe may be inserted either through a peephole, if one is located at a suitable point, or through a partly open furnace door. In so doing the operator will, of course, be protected by asbestos coverings as are commonly available and used in routine observations of the interior of the furnace. Further, it will be observed that the operator need not examine the entire interior of the furnace and predetermine special areas for special treatment. All that is required is that he direct the discharge from the pipe into the hottest regions of the flames.

I have found that a satisfactory fusible refractory powder may be compounded from a considerable variety of known furnace lining materials including the following:

Powdered glass
Feldspar
China clay
Silica
Aluminum oxide-alumina
Lead oxide-litharge
Basic lead carbonate
Calcium fluoride-fluorspar
Bentonite
Calcium carbonate-whiting
Zirconium silicate-zircon
Graphite
Copper oxide
Manganese dioxide
Cobalt oxide
Ball clay
Sodium metaborate
Chrome ore
Titanium dioxide
Red lead
Borax
Boric acid
Magnesium oxide
Magnesium carbonate
Silicon carbide

Ordinarily the material should be of a fineness

such as to pass through at least a 100 mesh screen and in some instances sufficiently fine to pass through a 300 mesh screen. The finer the particles the more rapidly they will vitrify. And if the hottest part of the furnace is only slightly hotter than the melting range of the refractory powder a finer powder will ordinarily be more appropriate than a coarser powder so as to assure that the various particles will be sufficiently vitrified. Also if the furnace is of the type which has a high velocity of furnace gases therethrough a larger particle can satisfactorily be carried by the gases than would be the case if only a low gas velocity were present in the furnace.

I have found one particularly satisfactory lining compound consists of flint 45 parts, kaolin 45 parts, feldspar 56 parts, whiting 25 parts and white lead 155 parts; the compound should be fine enough to pass through a 200 mesh screen. A chemical analysis of the components is as follows:

White lead, 2PbCO_3 , PbOH_2
Whiting, CaCO_3
Feldspar, 7SiO_2 , $2\text{Al}_2\text{O}_3$, K_2O
Kaolin, $4\text{Al}_2\text{O}_3$, 4.5SiO_2 , $1.5\text{H}_2\text{O}$
Flint, SiO_2

From the foregoing it will be seen that a method of lining furnaces and the like in accordance with the present invention is well adapted to attain the ends and objects hereinbefore set forth and to be economically practiced since the method is suited to common production operations and is susceptible to a wide latitude of variations as may be desirable in adapting the invention to different applications.

As various embodiments may be made of the above invention and as changes might be made in the embodiments above set forth, it is to be understood that the matter hereinbefore set forth is to be interpreted in the first instance as illustrative rather than in a limiting sense.

I claim:

1. In the art of applying a smooth and continuous refractory coating to a wall of a furnace, that improvement which includes the steps of: operating the furnace within the upper reaches of its normal temperature range, blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusible refractory powder of melting range slightly below the highest temperatures reached within the furnace and thus forming finely-divided fused gas-borne particles, and employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent coating on the walls thereof.

2. In the art of applying a smooth and continuous refractory coating to a wall of a furnace, that improvement which includes the steps of: operating the furnace within the upper reaches of its normal temperature range, blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusible refractory powder of melting range somewhat below the highest temperatures reached within the furnace and thus forming finely-divided fused gas-borne particles, employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent adhesive coating on the walls thereof, thereafter blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusi-

ble refractory powder of melting range higher than that of the previously used powder and thus forming finely-divided gas-borne particles of the higher melting range material, and employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent coating over the coating formed by the particles of lower melting range material.

3. In the art of applying a smooth and continuous refractory coating to a wall of a furnace, that improvement which includes the steps of: operating the furnace within the upper reaches of its normal temperature range, blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusible refractory powder of melting range somewhat below the highest temperatures reached within the furnace and thus forming finely-divided fused gas-borne particles, employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent adhesive coating on the walls thereof, thereafter blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusible refractory powder of melting range around 3600°F. , and thus forming finely-divided gas-borne particles of the higher melting range material, and employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent coating over the coating formed by the particles of lower melting range material.

4. In the art of applying a smooth and continuous refractory coating to a wall of a furnace, that improvement which includes the steps of: operating the furnace within the upper reaches of its normal temperature range, blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusible refractory powder of melting range somewhat below the highest temperatures reached within the furnace and thus forming finely-divided fused gas-borne particles, employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent adhesive coating on the walls thereof, thereafter blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a finely-divided fusible refractory powder of melting range higher than the highest temperatures reached within the furnace and thus forming finely-divided gas-borne particles of the higher melting range material, and employing the draft-induced swirling action of the furnace gases to carry the particles throughout the furnace and deposit them in an adherent coating over the coating formed by the particles of lower melting range material.

5. In the art of applying a smooth and continuous refractory coating to a wall of a furnace, that improvement which includes the steps of: operating the furnace within the upper reaches of its normal temperature range, and blowing into those regions within the furnace where the hot gases are at substantially their highest temperatures a 200 mesh powder consisting of 45 parts flint, 13 parts kaolin, 56 parts feldspar, 25 parts whiting and 155 parts white lead.

6. A furnace lining composition consisting of a 200 mesh powder made up of 45 parts flint, 13

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parts kaolin, 56 parts feldspar, 25 parts whiting
and 155 parts white lead.
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