

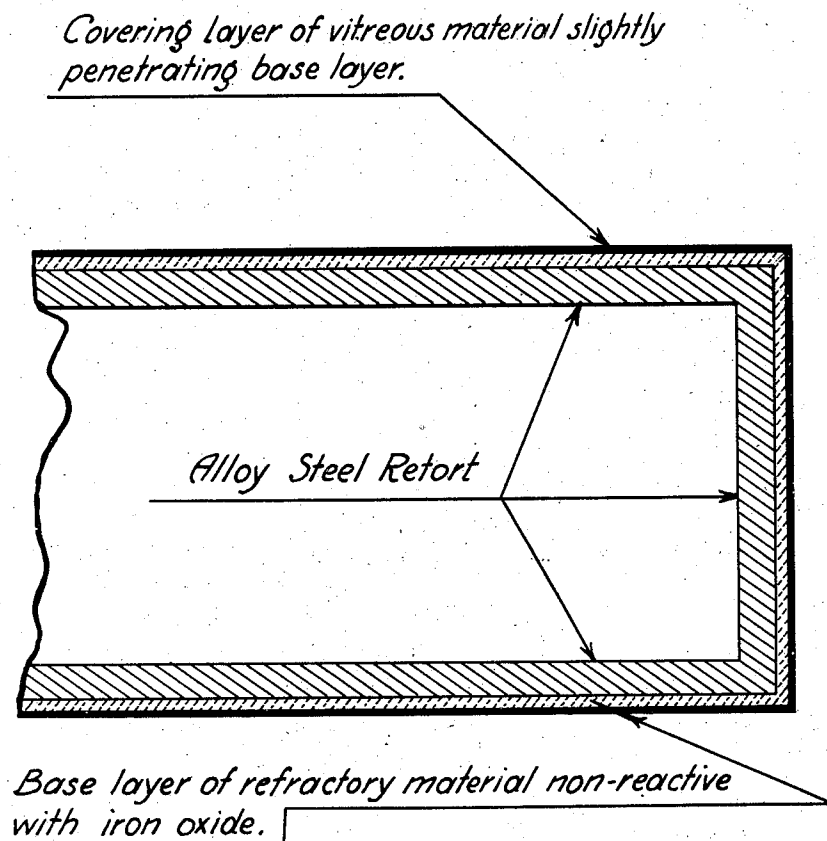
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CERAMIC COATED FERROUS ARTICLE

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CERAMIC COATED FERROUS ARTICLE

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This invention relates to the protection of iron and steel against oxidation when subjected to high temperatures such as 1000 to 1300° C., and has for its object the provision of a protective ceramic coating on iron and steel, and more particularly on externally heated retorts made of iron or steel. The invention is particularly applicable to iron or steel retorts in the production of magnesium by pyrometallurgical reduction or smelting, and that application of the invention is herein emphasized, but without thereby limiting the scope of the invention.

Magnesium reduction or smelting is customarily carried out in externally heated metal retorts, usually alloy steel tubes or cylinders having an internal diameter of about 10 inches and a wall thickness of about 1½ inches. The retorts are now customarily made of a steel alloy containing 25% chromium and 15% nickel. The retorts are mounted in a furnace structure with 5 feet or more of their length in the heated zone. The reducing charge consists of a briquetted mixture of calcined dolomite (or equivalent magnesian material) and ferrosilicon (or equivalent reducing agent). The operation is intermittent or batch, and the operating cycle comprises (1) charging the briquets to the retorts, (2) connecting the retorts to a vacuum line capable of maintaining within the retorts a vacuum of 200–250 microns of mercury during the initial stage of the reduction and of 50–100 microns of mercury during the final stage of the reduction, (3) heating the charge to a temperature of 1150–1250° C. for 7 to 8 hours, (4) removing the condensed magnesium vapor from the cold extension of the retort, and (5) discharging the worked-off briquets or spent residue from the retorts. The metal retorts are thus subjected to atmospheric pressure on the outside and to a relatively high vacuum on the inside during the reducing stage of the operating cycle. This results in a considerable compressive stress on the retort wall. The retort ultimately fails by gradually collapsing under this long continued compressive stress. In the heretofore customary practice, the retorts collapse and must be replaced after an operating period of from 60 to 90 days.

Attempts to replace the aforementioned alloy steel retorts with iron or ordinary steel retorts have heretofore failed because of the rapid oxidation of the iron or steel on the outside by the heating gases, usually the hot products of combustion of solid, liquid or gaseous fuel. In accordance with my present invention, the outside

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of the iron or steel retort is provided with a ceramic coating that effectively protects the iron or steel from oxidation and corrosion by the hot heating gases. Steel retorts so protected have much longer life than unprotected steel retorts.

The invention will be best understood from the following description taken in conjunction with the single figure of the accompanying drawing illustrating in section an alloy steel retort provided with the composite ceramic coating of the invention.

In its broad aspect the invention involves protecting ferrous articles, that is articles made of iron or steel, against oxidation at elevated temperatures (e. g. 1000 to 1300° C.) by a composite ceramic coating comprising a base layer of refractory material nonreactive with iron oxide and a covering layer of a vitreous material firmly adhering to the base layer and forming an impervious film thereover. It is now my preferred practice to use a magnesian refractory, such as magnesite or periclase, as the base layer, other suitable refractory materials for the base layer include chromite-magnesite, chrome, forsterite, alumina and the like. Feldspar is admirably adapted as the vitreous material of the covering layer. Feldspar fuses to a glass at temperatures around 1150–1250° C. If the operating temperature to which the ferrous article is to be subjected is substantially lower than 1150° C., a flux can be added to the feldspar to lower its fusion temperature correspondingly. Ceramic glaze compositions, common glass compositions of the soda-lime-silica type, and the like can be used as the vitreous covering layer where such compositions are adjusted to melt or fuse to an impervious film at the contemplated elevated operating temperature.

In practicing the invention, the surface of the ferrous article to be protected, e. g. the exterior surface of a steel magnesium reducing retort, is covered with a relatively thick (e. g. ⅜ to ⅞ inch) base layer of the refractory material, and the base coat is then covered by a relatively thin cover coat of a vitreous material adapted to fuse to form an impervious film at the elevated operating temperature to which the ferrous article is to be subjected. The covering layer of vitreous material firmly adheres to the base coat and forms an impervious film thereover. Preferably, the vitreous material slightly penetrates the base layer to form a vitreous bond therewith.

The base layer of refractory material may be applied to the ferrous article in any appropriate manner. Thus, for example, the refractory ma-

terial may be made into a slurry with water, and the slurry applied to the surface to be protected by dipping, spraying, or the like. The base layer may be dried before applying the covering layer, or the covering layer may be applied to the still wet base layer. The covering layer may be applied to the base layer in any appropriate manner, but when applied to the still wet base layer it is advantageous to apply the covering layer by spraying a slurry of the vitreous material and water. The covering layer should be thinly applied, since an excess amount of this layer may penetrate through the base layer and react with the ferrous article. The layers should be slowly dried and fired to prevent disintegration by too rapid expulsion of water. The firing may be effected by exposing the dried coating to the elevated temperature of its contemplated place of use, as for example in the case of an ordinary steel magnesium reducing retort by installing the retort, coated as herein described, in the magnesium reduction furnace. However effected, firing fuses or melts the covering layer and covers or encloses the refractory layer with an impervious vitreous film.

By way of example, the coating of the ferrous article with a base layer of magnesite or periclase and a covering layer of feldspar will be particularly described as follows: The magnesite or periclase is made up in slurry form by milling with water and a small amount of clay in order to maintain the magnesia particles in water suspension. About 5% of clay is generally needed, though this depends upon the suspensive properties of the clay. The clay has the further function of contributing strength to the dried and fired coating. Magnesia grain, whether in the form of magnesite or periclase, has no bonding properties itself and is too refractory to develop any fired strength at a temperature as low as 1200° C.

The consistency of the slurry is adjusted, by the addition of water, to the desired method of applying the layer—either spraying or dipping. It may be desirable to adjust the yield value of the slurry by adding some electrolyte, such as, for example, a few tenths of one per cent of magnesium sulfate, to the slurry. The addition of an appropriate amount of an electrolyte will permit the deposition of a coating of the desired thickness without running or drainage of the coating. The base coating should be applied to a thickness of from $\frac{3}{8}$ to $\frac{1}{8}$ of an inch.

In many cases it is desirable to mill the magnesite or periclase till the final slurry is through 100 mesh. In other cases, however, it is desirable to mill only finely enough to permit spraying, when the coating is to be applied by spraying. Relatively coarse milling reduces the shrinkage of the coating and thus prevents cracking that might otherwise occur on large surface areas.

The feldspar is prepared for coating by milling in water to a slurry with the addition of a small amount of clay. In view of the thinness of the covering layer, it is not necessary to add an electrolyte. The slurry may be milled to a fineness of through 100 mesh, though such a degree of fineness is not ordinarily necessary.

The function of the covering layer is twofold:

- (1) to form an impervious film over the base layer to prevent access of oxidizing gases to the ferrous article; and (2) to slightly penetrate the base layer and form a vitreous bond therewith. The magnesia base layer has no bond strength at all aside from that contributed by its small clay content, and a limited penetration by the covering layer is desirable in order to increase the mechanical durability of the composite coating.

I claim:

1. A ferrous article protected against oxidation at elevated temperature by a ceramic coating comprising a relatively thick base layer of refractory material non-reactive with iron oxide selected from the group consisting of magnesite, periclase, chrome-magnesite, chromite, forsterite and alumina, and a relatively thin covering layer of a vitreous material slightly penetrating the base layer to form a vitreous bond therewith and forming an impervious film thereover, said vitreous material being selected from the group consisting of feldspar, ceramic glaze compositions and glass compositions characterized by melting to an impervious film at temperatures of from 1000 to 1300° C.

2. A ferrous article in accordance with claim 1, in which the base layer is principally of magnesite from $\frac{3}{8}$ to $\frac{1}{8}$ inch thick and the covering layer is an impervious film of fused feldspar.

3. A steel retort having its exterior surface protected against oxidation at elevated temperature by a ceramic coating comprising a relatively thick base layer of refractory material non-reactive with iron oxide selected from the group consisting of magnesite, periclase, chromite-magnesite, chrome, forsterite and alumina, and a relatively thin covering layer of a vitreous material slightly penetrating the base layer to form a vitreous bond therewith and forming an impervious film thereover, said vitreous material being selected from the group consisting of feldspar, ceramic glaze compositions and glass compositions characterized by melting to an impervious film at temperatures of from 1000 to 1300° C.

4. A steel retort in accordance with claim 3, in which the base layer is principally of magnesite from $\frac{3}{8}$ to $\frac{1}{8}$ inch thick and the covering layer is an impervious film of fused feldspar.

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