

Mineral Wool
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Fundamental Problems of

Rock Wool Manufacture

INSULATION

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IN ITS FUNDAMENTAL ELEMENTS, manufacture of rock wool is a very simple process. The rock is heated until it is fused, then blown with air or steam into rock wool. However, in actual practice the process is far from being so elementary and, when considered in its higher technical aspects, it is rather complicated.

The reasons for this complexity are that there are rocks and rocks and, although two rocks may analyze the same, the ingredients may be differently combined, and consequently act entirely different. Then the process of heating and melting is one that should puzzle even the most advanced combustion engineer. A statement on the part of anyone to the effect that he has mastered the thermodynamical phase of this subject, definitely reveals such a person as one who does not truly realize the intricacy of the process and, at best, knows very little about the subject.

As there is a desire for an ultimate product of definite fineness and color, it seems that there must be, all the way back through the entire range of operations, some standard that should not be deviated far from the ideal. This starts with the selection of rock in the quarry, the sizing of such rock, the proportioning of coke, the mode of charging, and uniformity of distribution of the charge.

Many Problems Involved

There is the matter of uniformity of coke, size and quality of coke. Rock of different kind will require different amounts of heat or different degrees of temperature. Some will fuse readily and directly without a chemical change, while others, before fusing, may have to pass through several transformations, some of which may require quantitatively a great deal of heat, a matter separate entirely from temperature requirements.

Other considerations include the matter of air blast, temperature of this blast, mode of preheating air, value of preheating air, combustion of coke, nature and temperature of

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gases leaving the cupola, and disposition and possible utilization of sensible and potential heat in these gases.

There are problems of steam for blowing, proper amount, proper pressure, degree of dryness, addition of oils, exactly correct method of application. Then incidental problems connected with the boiler, its proper size, availability of water, purity of such water, feed pump or injectors; hand firing or stokers, kind of coal, cost of coal, value of possible savings contrasted with possible investment.

Then the problems incidental to cooling the cupola into which again there is encountered the problems of water purity, pumping of water, and possible connection to and circulation through the boiler to conserve the heat.

In addition there are problems connected with arrangement of blowing room, the gathering of the product, the forming, the storing and loading, and the one dealing with protection of the men.

To thoroughly master the subject and correlate all of the incidental information, would require advice from people versed in geology, in chemistry, in combustion specialized to cupolas and combustion specialized to boilers, and from experts in material handling and other phases of mechanical engineering. It is possible that one person may be able to do it all, but such an individual certainly should appreciate the fact that he cannot possibly know it all and should be able to call in information from many other sources.

Different Rock Requires Different Treatment

Reverting back, we have the stone—if it was a previously melted slag the many possible chemical reactions requiring or giving off heat have taken place and then all that would be necessary would be to heat it to incandescence and supply the latest heat of fusion, when it would become fluid. The temperature requirement

may be as high but the heat requirement much less than in any other case. There would be no gas given off to carry heat to waste; there would be no carbonates to dissociate into oxides. What is more, one lump would have a great deal the same composition as the other; the fluid mass to be blown would be of the same consistency and therefore of the same viscosity. The time element necessary to combine various ingredients would be the least. In view of all this, cupola capacity would be the highest, cupola size the smallest, heat waste the least, fuel consumption the lowest and the product the most uniform.

Contrasting this ideal, there is the situation where the stone is a relatively pure limestone, to which siliceous ingredients would be added separately to form the low melting silicates and aluminates, which is rock wool. In this case, none of the above mentioned advantages would prevail. It would not be merely a matter of heating; the cupola would not be just a heater, but would be as well a lime kiln, a sintering kiln and a melting furnace. In the upper parts, the stone would just be preheated; lower down the iron carbonate; next the magnesium carbonate, and finally the calcium carbonate, would break down and give up their CO_2 . Through all of this the silica would pass as such, in no way entering the process, only considerably below the zone of dissociation of calcium carbonate would there be an incipient combination of the ingredients; as the temperature increases, semi-fluid slags would eat into the still solid ingredients, into the porous lime and solid silica or alumina. Through this whole process a great number of combinations would take place, all dependent upon temperature and the predominance of the various materials in any one given region of the fusing mass. There would be various silicates and aluminates and ferates of calcium and magnesium, and combinations of them, reactions numbering to a hundred or more. The many variables in all this would need time to aggregate themselves and average out to form

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a fairly uniform calcium aluminate silicate mixture, of proper viscosity for best results when it finally is blown with steam.

Calcining Problems

In the case of such material the cupola should be higher because it takes time to convert the limestone into lime. Say that stone contains 60 percent CoCO_3 and MgCO_3 and that cupola output is 12 tons, this means that some 4 tons of lime will be made, and to make this amount of lime efficiently, requires heat and time, the latter of which is not consistent with the size of most recommended cupolas. Of course, it is possible to force things, and limestone, when of small size, can also be converted into lime rapidly, but overly short time always results in high waste gas temperatures and fuel waste.

Much better than separate sources of lime and silica is the condition where stone is available from the quarry already having the desired combination. But quarries that are reliable in this respect are scarce. If stone too high in calcium accidentally should be charged to the cupola, operation would soon come to a stop. As capacity of the fluid zone is very small, not many charges would be required to upset everything, and even one would have a deleterious effect on operation. If the ledge is not uniform or when stone is obtained from different ledges, chemical testing should be resorted to. The simplest test would be an apparatus that would indicate the amount of gas a sample of stone gives off when tested with an acid which is indicative of the quantity of carbonates present in the sample.

The rock should be reasonably uniform. Large lumps will heat, dissociate and melt too slowly and will reduce the capacity very greatly. Too small particles, on the other hand, will block the cupola and be the cause of blow holes and channeling of gases through the charge.

Heat Losses Too High in Rock Wool Manufacture

To a great extent, too, in case of coke, if it is small, it will burn up high in the cupola and do little good in the hot zone. If too large, it will present too small a combustion area. The ideal would be where all coke is completely burned at the base, with the gases giving up their heat as they pass up through the charge. This would give the lowest top tempera-

ture as well as the lowest loss due to incomplete combustion.

The stone and coke layers, the size of stone and coke with temperature and pressure of air blast, all have an important influence on cupola efficiency.

Dissociation of carbonates is an endothermic reaction requiring heat, while formation of calcium and magnesium silicates and aluminates is an exothermic reaction giving off heat. The amount of heat generated by the exothermic reaction is a rather high figure in proportion to the endothermic reaction and should aid greatly in obtaining high efficiency. Still, the efficiency of any ordinary rock wool installation is very low; although the ratio of fuel to rock wool may be one to three or one to four, efficiency may be only 10 percent or less. The reason for this is the high radiation loss, the heat carried to waste by the jacket water, the escape of hot gases from the cupola, the presence of carbon monoxide in these gases in considerable quantities. The sensible heat of the fluid mass is also high and it is all lost; the air for combustion enters cold and requires immense quantities of heat to be preheated to the very intense temperature existing above the hearth.

Most installations follow the ordinary cupola practice which is intermittent, while this is a continuous operation. It seems that if better results are to be obtained the procedure should be more along the line of blast furnace practice, which is particularly careful about preheating air. Wherever reactions are at a high temperature level, as in the case of blast furnaces, glass furnaces, open-hearth steel furnaces, preheating of air is vital. The difference is only that in these cases operations are very large, fuel consumptions very great, and the value of any saving runs into big money.

Cupolas for rock wool were designed where the cupola was connected with the boiler carrying the heat to the boiler drum to aid in generating steam. Also the cupola was designed to connect to the boiler furnace and the gases passed through the boiler, both giving up much of their sensible heat, as well as burning the carbon monoxide. However, such installations are costly, and the question is, do they pay? The problem always is to find where higher efficiency stops being economical. However, preheating of air is comparatively simple and should be of such thermal value that

it should be the minimum requirement in the effort to raise the installation above the ordinary. It does seem a pity though that where so much heat is wasted, still more fuel is burned for the generation of steam.

Cupola Design

While on the subject of cupolas, it may be well to mention that rather likely in cases of unhomogenous raw materials, the cupola should be followed by a small tank on the order of a glass tank, where the mass will have time and opportunity to mix thoroughly, which would be conducive to a better product though not necessarily to higher efficiency. However, the idea of using tanks only without cupolas, which is the tendency in certain quarters, is also wrong. There is hardly anything less efficient than a glass tank because there is no such intimate contact between the product and the hot gases. Of the heat, little is transferred by convection, but principally by radiation, which is decidedly limiting.

It is true, of course, that there are simple rock wool plants; in fact extremely crude, but they bear the stamp of not being anywhere near as profitable as the common idea of rock wool manufacture would have it. With more plants being built, plants designed for quality of product, efficiency of operation and volume of output, competition will be such that any plant that is not right will be more of a worry than money maker to the investors.

The plant will have to be right, not only along lines commented upon thus far, but also as to material handling. For 24 tons of wool a day, some 32 tons of rock will have to be handled, and not rock just taken at random, but rock with limitations in size and quality. This will have to be charged continuously during 24 hours in correctly proportioned and comparatively small amounts. In addition there is the handling of coke and firing of the boiler. The gathering, storing and loading of the rather bulky rockwool and the many other operations.

Labor can become quite a factor and great care needs to be exercised if it is not to eat up much of the expected profit. However, if the requirements are realized, are kept in mind, and difficulties overcome by careful design, the manufacture of rock wool should be profitable. The first requirement, however, is to abandon the prevailing idea that the process is simple.