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DEPARTMENT OF MINES

OTTAWA, CANADA

PRELIMINARY REPORT ON AN INVESTIGATION ON THE TREATMENT OF CERTAIN WESTERN CLAYS TO OVERCOME DRYING DEFECTS

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Introduction

At the request of the Mining Bureau of the Winnipeg Board of Trade, a study was made of the difficulties being encountered in the attempts to produce high-grade face brick in Manitoba. Visits were made to the various plants and the nature of their problems ascertained. The problem confronting the operators at Winnipeg was found to be serious. At Winnipeg two clays are available for brickmaking. A shallow surface clay which burns to a very light buff has been used for many years in the manufacture of common brick. The supply of this clay is being rapidly depleted and the cost of winning and transporting it to the brick plants is becoming a very serious item. Underlying this clay is a thick bed of red-burning, tender-drying clay, of the type known as gumbo, which would make good face brick were it not that, when moulded into bricks, it is almost impossible to dry them without cracking. At one of the Winnipeg plants, face brick is being manufactured from this underclay by mixing it with a silty clay obtained about one hundred miles west of

Winnipeg. But, as the cost of transportation is high and the results are not very satisfactory, the manufacturers, the Alsip Brick, Tile and Lumber Co., Ltd., are anxious for a means of overcoming the drying difficulties which would allow them to use the local underclay alone. The Ceramics division undertook an exhaustive research on this clay to determine means of processing it so as to overcome the cracking in drying. Coincident with the request from Winnipeg, the Redcliff Brick and Coal Co., Ltd., of Redcliff, Alberta, asked the help of the Department in overcoming the difficulty of drying their brick rapidly without excessive breakage. This problem, being similar to that of the Winnipeg brick manufacturers, was included in the research. The successful solution of this will mean much to the brick industry throughout the Prairie Provinces, as many of the brick clays of that section of the country are tender-drying to an extreme degree. A very comprehensive study of possible means for solving the problem has been made and a large amount of experimental work done on the clays from Winnipeg and Redcliff. By rendering the clay fit for rapid drying the brick plant capacities may be easily increased and the quality of the ware greatly improved.

High-grade brick from distances of five hundred to one thousand miles are finding their way into the local markets, so that a means of shortening this drying period, and of improving the quality of the brick, is very desirable in order to assist in overcoming this competition.

This being a preliminary report, the data will not be presented in detail, and only those results will be set forth that are considered applicable to the solution of this problem.

A review of the literature brings out three methods of clay treatment for remedying troublesome drying properties of clays:

1. The use of some non-plastic material, such as sand or grog, which would reduce shrinkage and stickiness, and provide for an easier capillary travel of the water to the surface of the brick.
2. The use of chemical coagulants.
3. A preheating treatment of the clay sufficient to reduce the stickiness and to destroy the colloidal property to such an extent that the clay would be more permeable to water.

The first two methods have found practical application in several cases of tender-drying clays. However, in no case was the tendency to crack so great as in the clays in question. In previous investigations the only effective treatment suggested for these particular clays was the last method, viz., preheating. However, rather exhaustive search has revealed only one plant that has tried preheating on a commercial scale, and in this case faulty design and operation prevented its success.

Preheating.

The effect of preheating on the clays was first investigated, and it was found that they respond quite readily to such a treatment. When preheated to temperatures between, approximately, 800°F. and 950°F., the clays showed decidedly improved properties. The percentage of tempering water was considerably reduced (in the case of the gumbo clay, from 54 per cent to 33 per cent), a great deal of the stickiness had disappeared (the working properties thus improved), and drying could be accomplished safely at rapid rates.

There is, however, a rather narrow margin within which preheating is effective. Our tests show that below 800°F. there is not a sufficient alteration of the clay to permit safe drying, and above 950°F. the plasticity has been reduced to so great an extent that the clay is left too short, and not workable. This brings up the problem in the commercial application of the process of how to control the temperature within these limits. While it is quite easy to control temperature in the laboratory within even much narrower limits, the problem becomes much more difficult when handling quantities of clay necessary to meet a plant capacity.

Commercially, preheating would best be carried out in a rotary type kiln. Many plants dry the clay as it comes from the bank in rotary driers, but in no case is the temperature carried very much above 212°F. Several rotary drier and rotary kiln manufacturers who were consulted suggested methods of adapting their machines to the process. Preheating can unquestionably solve the problem, and can very probably be carried out successfully on a commercial scale in rotary kilns. However, it would require a considerable initial expense, and some experimenting, to bring about the correct adjustment of flow of clay, temperature, etc.

The investigation has been carried as far as is possible in the laboratory, and there remains the solution of the engineering problems involved in applying the process commercially, which must necessarily be worked out in the plant.

It has been concluded, after considering experiences of clay manufacturers in the past with rotary driers, that, in order to obtain a uniformly preheated material, and to maintain accurate regulation of temperature, it will be necessary to first dry the clay before it is put through the preheater.

This would apply particularly in the case of one clay, which comes from the bank containing roughly 33 per cent moisture. In such a condition the clay when charged into the colder end of the kiln (as would be necessary to uniformly preheat the material) would undoubtedly ball together and stick to the sides of the kiln. However, in the case of drying the clay, it could be fed into the hot end and pass in a direction parallel to the flow of gases. In this manner, the wet clay in striking the comparatively hot surface of the kiln would tend to explode and the heat would prevent any sticking.

Thus, in order to preheat clay with a high initial moisture content, two operations would be necessary. First, the clay would have to be passed through a rotary drier, and the moisture content reduced to at least 4 or 5 per cent. The dried clay could then be mechanically conveyed to and charged into the preheater. It may be found necessary to pass the clay through a crusher, between drier and preheater in order to reduce the clay aggregate to such size that it will be uniformly preheated throughout.

In cases where the clay comes from the bank in a comparatively "dry" condition (not more than 10 per cent moisture), it could probably be charged directly into the preheater, and the preliminary drying process would be unnecessary.

The following are quotations on drying and preheating equipment from one of the rotary kiln manufacturers:

For a capacity of 180 tons of dry clay per day, when drying from 33 per cent initial moisture, there would be required - 1 drier, 104 inches diameter by 100 feet long. The price exclusive of brickwork, foundations, drives and motors, but including dust collector, would be $21,000, f.o.b. factory (Pennsylvania).

For preheating this same amount of clay to 850°F., one kiln 5 feet diameter by 40 feet long would be required. The price of this kiln complete, but without brickwork, foundations, drives and motors, would be $5,300, f.o.b. factory.

It is estimated that in drying clay with an initial moisture content of 33 per cent, 13.3 Imperial gallons (16 American gallons) of fuel oil would be required to produce one ton of dry clay. To preheat one ton of the clay with about 4 per cent moisture to 850°F. would require 4.4 to 5 Imperial gallons (5 to 6 American gallons) of fuel oil.

Non-Plastic Materials and Chemical Coagulants.

Considerable work has been done by previous investigators on the treatment of tender-drying clays with chemicals or with non-plastic materials. Our tests show that the addition of non-plastic material, or grog, finely ground, causes some improvement in drying, and the treatment of the clay with chemical coagulants brings about a considerable improvement in the drying properties, but neither method alone completely solves the problem.

It was considered possible that a combination of the two treatments might be effective. Accordingly an extensive investigation was carried on as to the effect of additions of grog with varying percentages of different chemicals on the drying properties of the clays. The work of previous investigators was studied and additional information was obtained by a preliminary investigation on the flocculating power of the various chemicals in the following manner: Into each of a number of settling-tubes two grammes of the clay was placed. The various chemicals were then added in proportions of 0.5 per cent, 0.8 per cent, 1 per cent, 2 per cent and 3 per cent of the weight of the clay, making a series of five trials for each chemical. A fixed amount of distilled water was added to all the tubes which were then shaken vigorously for five minutes. The tubes were then allowed to stand one hour after shaking and the amount of settle measured. These tests brought out very well the comparative coagulating power of the various chemicals, and also gave an indication of the amount of chemical necessary to produce marked coagulation. Among the chemicals which gave particularly good results was ferric chloride. The writers find no record of previous investigators having used it for this purpose. Having selected those chemicals which, in conjunction with additions of grog, gave the greatest promise of overcoming the drying defects of the clays, many mixtures of clay, grog and chemical were made up. The grog was added in percentages varying between 25 and 50, and beginning with 0.5 per cent, the additions of the different chemicals selected for study were successively increased, but only to the limit of the range of their economic practicability.

In all cases the grog, which consisted of completely dehydrated clay, was ground to pass a 16-mesh screen.

The resulting mixtures were tempered with water and full size bricks were moulded as well as briquettes for water of plasticity determinations and air and fire shrinkage measurements. Water of plasticity was determined by taking the wet and dry weights of the briquettes, and linear shrinkage measurements were made for air and firing shrinkage.

The bricks and the briquettes, immediately after being formed, were placed in an electric drier which was accurately maintained at 150°F., and were allowed to remain in the drier until completely dry. Observations were made as to the nature of any cracking, and degree of improvement resulting from the various additions, from which results further variation of chemical and grog was governed.

All bricks and briquettes were labelled, and set aside to be fired to several temperatures in order to observe the effect of the chemicals on the fired colour.

Without giving the data in detail, this investigation of the effect of additions of grog plus different chemicals has brought out the following observations:

The Redcliff clay responded quite readily to the treatment with small additions of several separate chemicals, and a minimum of 25 per cent of 16-mesh grog. The Winnipeg gumbo clay was much more resistant to the treatment and required greater quantities of chemical and grog.

Hydrochloric acid in small quantities (0.5 per cent to 1 per cent) with a minimum of 25 per cent grog completely corrected the drying defect of the Redcliff clay, but was entirely unsuccessful in the case of the Winnipeg gumbo. The corrosive action of hydrochloric acid would probably be an objectionable feature in the brick plant.

Ferric chloride was effective in the case of both clays. However, a larger amount with a greater percentage of grog was necessary in the case of the Winnipeg gumbo. The drying defects were corrected in the Redcliff clay with additions of 1 per cent ferric chloride and 25 per cent grog, while the gumbo clay required 2 or 3 per cent ferric chloride with 40 per cent grog.

Ferric chloride being rather expensive, it would be practical only within certain limits. Sodium chloride plus a small percentage of ferric chloride was tried, and a mixture of

40 to 50 per cent grog plus 1 per cent sodium chloride and 0.5 per cent ferric chloride was found to be effective in the case of the more resistant gumbo.

Aluminium chloride was found to be less effective than ferric chloride and was rejected.

Lime was tried on the Winnipeg gumbo clay only, and was found to be very effective. When 2 per cent is added to the clay with 33 per cent grog, there is a pronounced change in the working properties, and the clay can be easily dried at 150°F. without any cracking. Lime has a detrimental effect on colour, but could well be added to the clay used for common brick. When 1 per cent sodium chloride is added with the lime, this detrimental effect is considerably decreased.

It has also been found, after firing briquettes of the various mixtures in the laboratory kiln, that ferric chloride, sodium chloride, and mixtures of the two reduce scumming and improve colour.

To summarize: It has been demonstrated in the laboratory that the drying defects of the two clays in question can be overcome by either of two methods:

(1) By preheating the material to a temperature between 400°C. and 500°C. (752°F. and 932°F.);

(2) By the use of grog plus one or more chemical coagulants.

There remains, then, the application of these processes to plant scale and, finally, the selection of the most effective and most economical method.