

# Optimizing Taphole Clay Technology

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## Abstract

Taphole clays, which are necessary for blast furnace operation, are one of the key products in our company. There is a large variety of taphole clay. The features of some typical examples from a large number of our products and a part of our activity in research and development for continued improvement of taphole clays will be introduced here.

## 1. Introduction

Taphole clay is a multifunctional material used for plugging the molten metal tapping hole, mainly the tapholes of blast furnaces. We started manufacturing taphole clays for steel plants in Japan in the 1960s and have been engineering and manufacturing taphole clays for over 50 years. In this period, in response to the development of blast furnace operating technology accompanied by the increase in size and the increasingly severe operating conditions, our taphole clays also have become very advanced. The performance of our products has been highly appreciated by customers not only in Japan but also all over the world, now, we are manufacturing and supplying taphole clays for about fifty blast furnaces in and out of Japan.

The experience and knowledge we have accumulated so far is one of the advantages of our company. It enables us contributions to safe and stable operation of blast furnaces by providing optimal taphole clays to our customers in quick response to various operating conditions and/or the properties they demand.

The features of our taphole clay products and a part of our activity in research and development for continued improvement of taphole clays will be introduced here.

## 2. Research and Development

### 1) Evaluation of structure formed under rapid heating conditions

The structure of taphole clays injected into a blast furnace through the taphole is considered to be quite different from the structure formed in gradual heating conditions such as heating by electric furnace for experiments. Therefore, it is important to know what kind of structure actually forms in the blast furnace in order to accurately estimate the performance of taphole clay. For this purpose, we have been evaluating the structure of

taphole clay formed under the rapid heating condition by the molten iron dipping test as shown in Fig. 1. Fig. 2 shows an example of test results, which indicate that many cracks are generated by gas volatilization under the rapid heating conditions. The degree of crack generation depends on the materials.

### 2) Evaluation of structure formed in hot coke bed by simulator of taphole clay injection

Taphole clay has the role of not only plugging the taphole but also building a sedimentary deposit commonly called a "mushroom", formed by taphole clay being pushed into the furnace. The stability of the mushroom is important in view of maintaining taphole length and

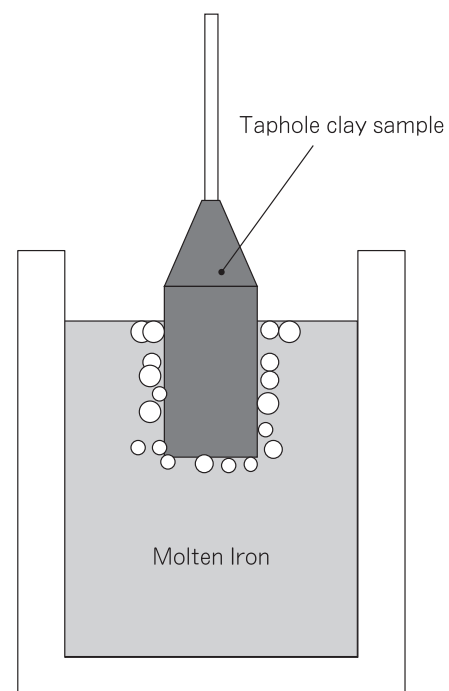


Fig. 1 Molten iron dipping test.

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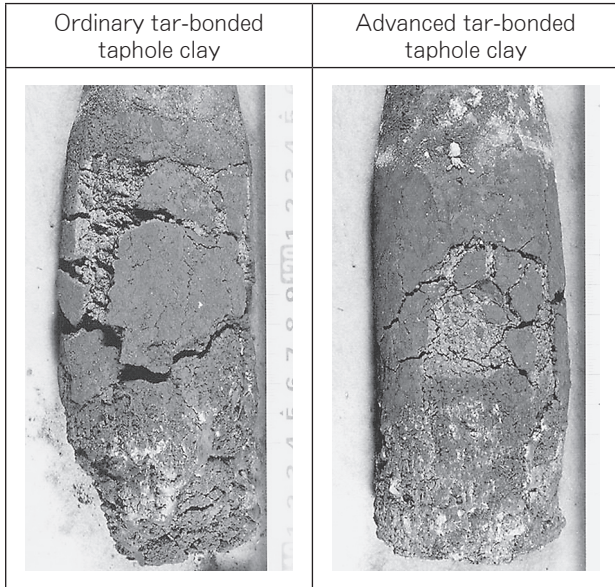


Fig. 2 External appearances of the post dipping test specimens.

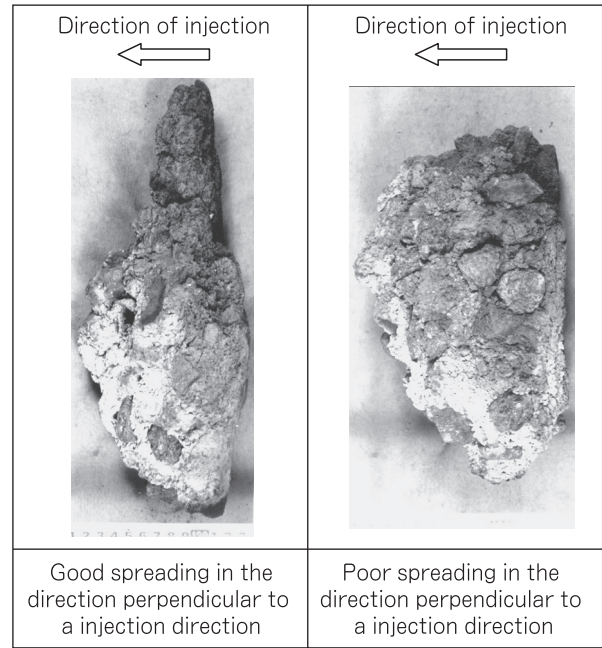


Fig. 4 External appearances of the specimens injected in the injection simulator.

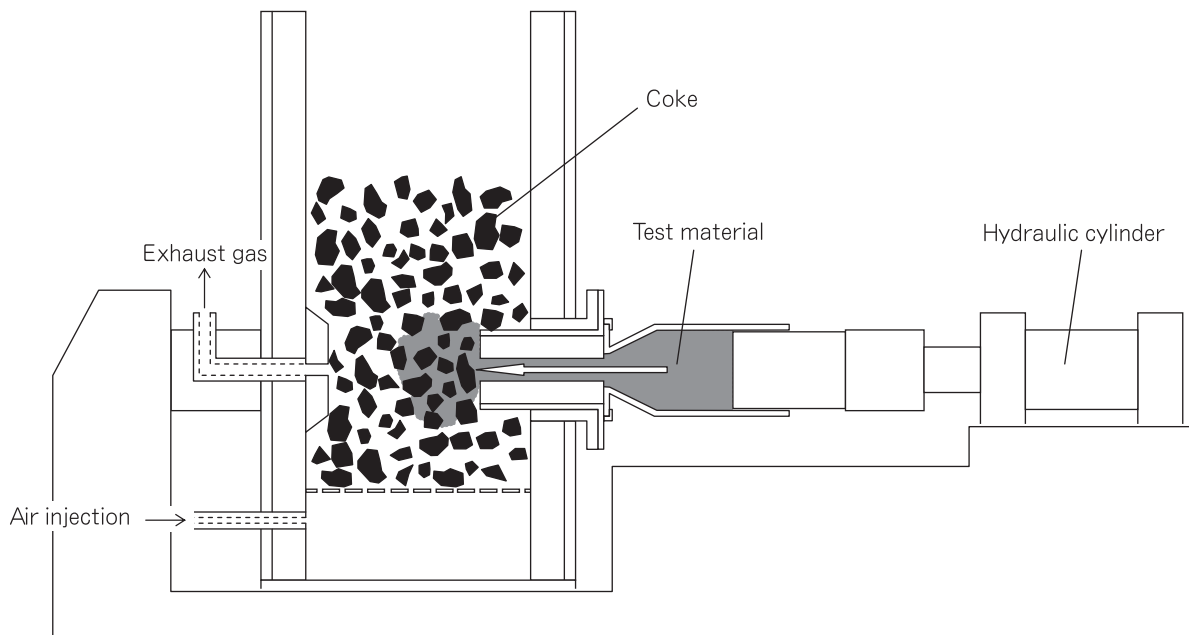


Fig. 3 Simulator for taphole clay injection.

protecting the blast furnace hearth. The apparatus shown in Fig. 3 which is designed to simulate the behavior of taphole clays inside actual furnaces can extrude taphole clay into heated coke packed in a small furnace and we can observe the condition of taphole clay spreading in packed coke.

By using this simulator, we can evaluate the shape of taphole clay formed in coke. Fig. 4 shows an example

of the test result utilizing two taphole clays which were different in grain size distribution and binder properties. Taphole clays which tend to grow in the injection direction are considered to be effective in lengthening the taphole in a short time but are not stable. On the contrary, taphole clays which tend to grow in the direction perpendicular to the injection direction are considered to be advantageous in respect to the maintenance of long and

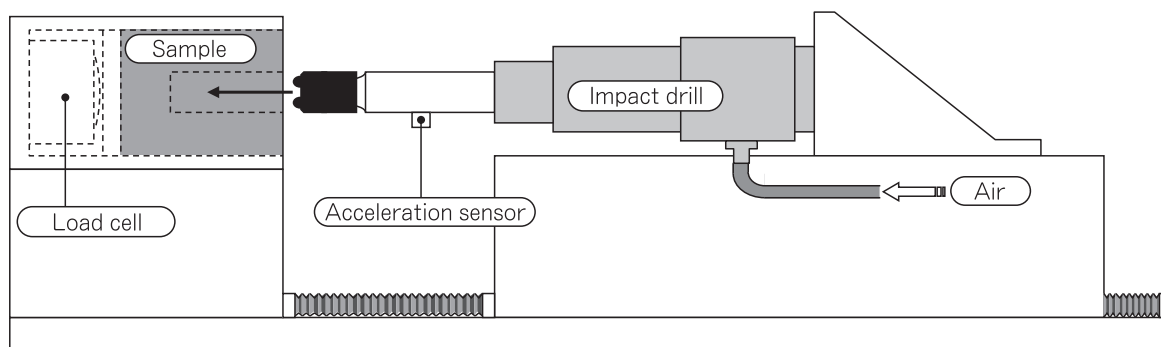


Fig. 5 Drilling tester.

Table 1 Typical taphole clay products

Product name		CAM-AN-28	CAM-RN-86	MUD-K33	EMR-3
Binder type		tar	tar	special tar	resin
Chemical composition (mass%)					
Al <sub>2</sub> O <sub>3</sub>		25	9	9	10
SiO <sub>2</sub>		14	19	25	22
SiC+C		28	32	27	35
Others		20	25	21	18
Grain size distribution					
Max. diameter (mm)		3	3	3	3
> 1000 μm		21	19	21	21
< 75 μm		57	56	56	57
Bulk density	1400°C-3h	2.26	2.07	1.99	2.05
MOR (MPa)	1400°C-3h	12.5	5.0	4.1	5.5
Performance*	Long tapping time	+++	++	++	++
	Short tap interval	++	+	+++	+++
	Long taphole length	+++	+++	++	+++
	Easy drilling	+	+++	+++	+++
	Less benzo[a]pyrene	+	+	+++	—

\* The larger number of star means better ability.

stable taphole length because the sedimentary deposit is gradually and stably grown. Good spreading ability in the direction perpendicular to the injection direction is one of the most important properties which we focus on in designing of taphole clay.

### 3) Evaluation of openability

Easy openability is one of the basic characteristics required of taphole clay, however, accurate evaluation of taphole clay openability is often difficult because the openability is complexly affected by not only strength and elasticity but also the hardness of the raw material grain and the compatibility with the taphole opener.

In order to solve this problem, we measured the drilling speed and drilling impact by drilling tester (Fig. 5) which drills taphole clay by rotation and hammering in the same manner with an actual taphole opener. This enabled us to supply taphole clay with openability suitable for each customer.

### 3. Taphole Clay Product Line

We have a large number of taphole clay products corresponding to the requirement of the user. Table 1 shows typical examples among them. They are divided into three types based on the binder used: taphole clay with coal tar, phenolic resin, and low benzopyrene (BP) tar in which carcinogenic benzopyrene in coal tar is greatly reduced.

CAM-AN-28 has high corrosion resistance due to a large amount of alumina and forms a closely packed structure due to our original formulation design (Figs. 1 and 2), therefore, it is suitable for needs like suppressing the enlargement of taphole diameter and/or long cast duration.

CAM-RN-86, which uses a coal tar binder, is a taphole clay excellent in drilling-ability, that is to say, openability by optimizing strength while retaining a dense structure.

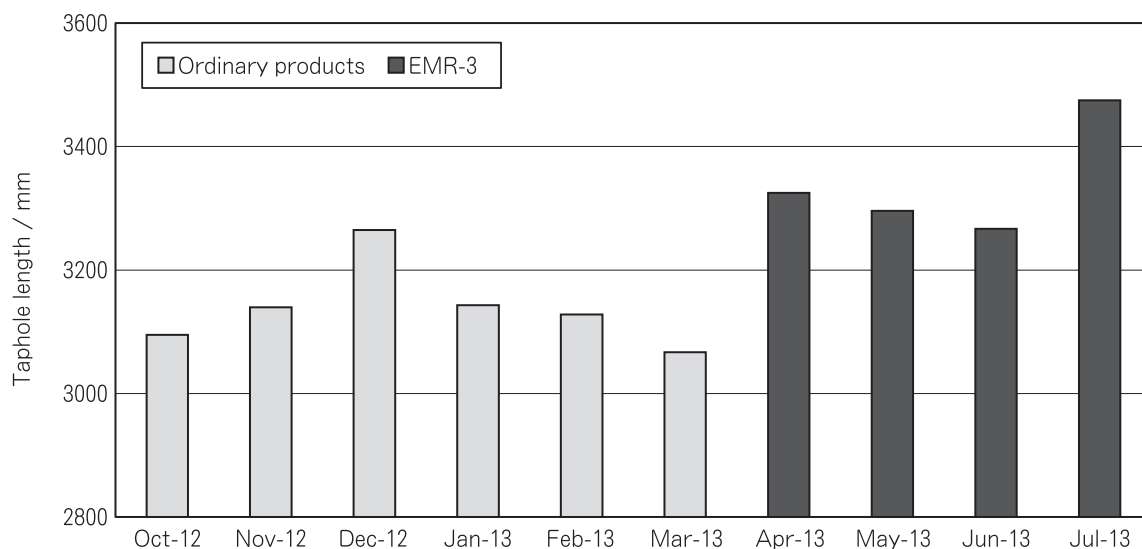


Fig. 6 Improvement in taphole length by using “EMR-3”.

In addition, as this product is designed to pay considerable attention to the spreadability inside the furnace after injection, which was described in the previous section, it can form robust sedimentary taphole clay deposits inside furnace, which is effective for maintaining stable taphole length and protecting the hearth of the furnace. Therefore, it is suitable for long term use in large blast furnaces with alternating consecutive tapping operation.

MUD-K33, which has adopted a low BP tar binder, shows almost the same performance as one of the tar binders, but it contains only one thirtieth of the benzopyrene compared to ordinary taphole clays with a coal tar binder. Because it also has the advantage of a far more excellent dried property than ordinary taphole clays utilizing a coal tar binder, it is more suitable to be used under short tap-to-tap time interval conditions as in one taphole operation.

EMR-3 is a phenol resin bonded taphole clay. It contains no harmful materials derived from coal tar and has a very good drying ability. Ordinary resin bonded taphole

clays have the disadvantage of poor adhesiveness under high temperature conditions in contrast to their good drying property, therefore, it is inferior in the ability to maintain taphole length comparing to coal tar bonded ones. However, the adhesive performance of EMR-3 was improved by improving the phenol resin property and it shows the remarkable effect of increasing taphole length in actual use in a large blast furnace in comparison to ordinary resin bonded taphole clays (Fig. 6).

#### 4. Conclusion

As described above, customers have various demands of taphole clay depending on blast furnace operating conditions. Providing optimal taphole clays to our customers in quick response to various operating condition and/or the property requirements, by using our accumulated experience and original evaluation system enables us to continue to contribute, we believe, to a safe and stable blast furnace operation.