

# 転炉補修用超速硬性焼付材

## Quick Hardening Hot Casting Repair Mixes for BOF

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### Abstract

In this study, we examined the possibility of developing quicker hardening and developed high-performance new quick hardening hot casting repair mixes.

### 1. 緒言

転炉補修用焼付材はバインダー系から水系、フェノールレジン系、ピッチ系の3種に大別され、水系およびフェノールレジン系はピッチ系に比較し接着強度がやや劣るため、耐用もピッチ系に劣る傾向にある。ピッチ系には湿潤タイプと粉末タイプとあり材料特性は同等であるが、転炉作業床での保管性すなわち経時変化を起こしにくいことから現在は粉末タイプが主流となっている。

本研究では、粉末タイプ焼付材のさらなる短時間硬化を目標に検討を行い、高性能な超速硬性焼付材を開発した。

### 2. 焼付材の施工と要求特性

焼付材の補修タイミングは出鋼、排滓後に実施され、一般的にスクラップシューターなどで転炉に投入される。投入された焼付材は燃焼しながら流動し、装入側～炉底～出鋼側のれんが損傷部位を被覆・充填し補修される。そのため素早く損傷部位へ流動し、素早く炎が消え硬化するといった特性が焼付材に要求される。そこで、高流動性（熱間高展開性）かつ短時間硬化を目的にピッチ系粉末焼付材の開発を行った。

### 1. Introduction

Hot casting repair mixes are characterized into three categories according to binder system type, such as water binder system, resin binder system and pitch binder system.

Performance in use of the water and resin binder systems is poor because the adhesion strength is lower than in pitch binder system.

There are dry types and wet types of pitch binder systems.

The properties of the dry pitch system and wet pitch system are almost the same. However, the dry pitch system is more popular because the quality can be retained during storage.

In this study, we examined the possibility of developing quicker hardening and developed high-performance new quick hardening hot casting repair mixes.

### 2. Installation and Required Properties of Hot Casting Repair Mix

Hot casting repair mix is mainly charged into the vessel after tapping and slag removal, and

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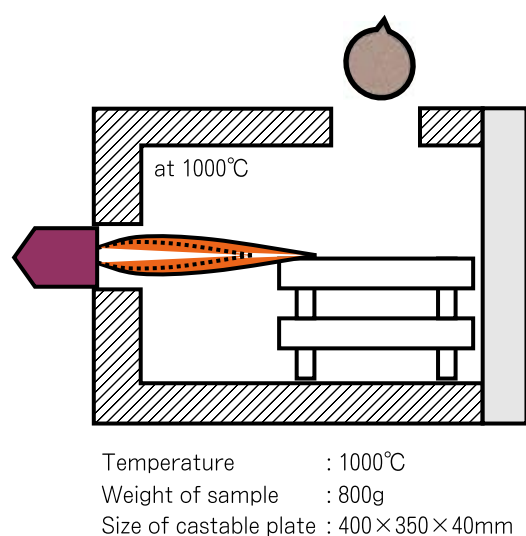


Fig. 1 Outline of small test furnace.

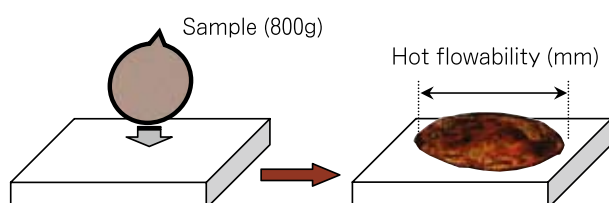


Fig. 2 Measurement of hot flowability.

### 3. 試験方法

#### 3. 1 熱間展開性試験

Fig. 1 に示す小型加熱炉を加熱し、十分に蓄熱させた後に熱間（1000℃）で試験を行った。キャストابل板の上にポリ袋入りの試料を載せ、燃焼が終了するまで保持した。その後キャストابل板

it is generally fed by iron scrap shooter into a converter.

The fed hot casting repair mixes flow while binder burning and spread over the damage area (charging side wall, bottom, tap hole area).

Therefore, required properties of hot casting repair mix are flowability for flowing to the target area and quick hardening with binder burning.

We have developed new pitch bonded hot casting repair mixes which have high hot flowability and quick hardening.

### 3. Test Method

#### 3. 1 Measurement of hot flowability

The hot flowability was measured in a small furnace at 1000℃ as shown in Fig.1.

The repair mixes were placed on a castable plate in the furnace until the end of combustion.

The diameter and thickness of each sample was measured after combustion. (Fig.2)

#### 3. 2 Measurement of adhesion strength

An iron ring was placed on a magnesia brick (114×112×30mm) and heated at 1000℃.

150g of the repair mix was supplied in a ring (φ70×40mm).

The time in which the flame disappeared was the hardening time. (Fig.3)

After hardening, adhesion strength was measured with the equipment shown in Fig.4.

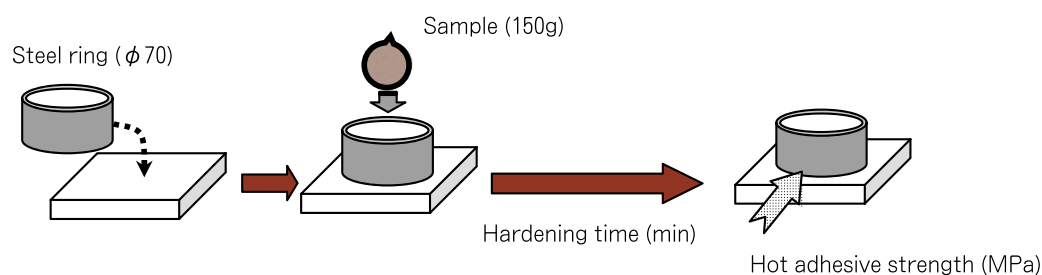


Fig. 3 Measurement of hardening time and adhesion intensity.

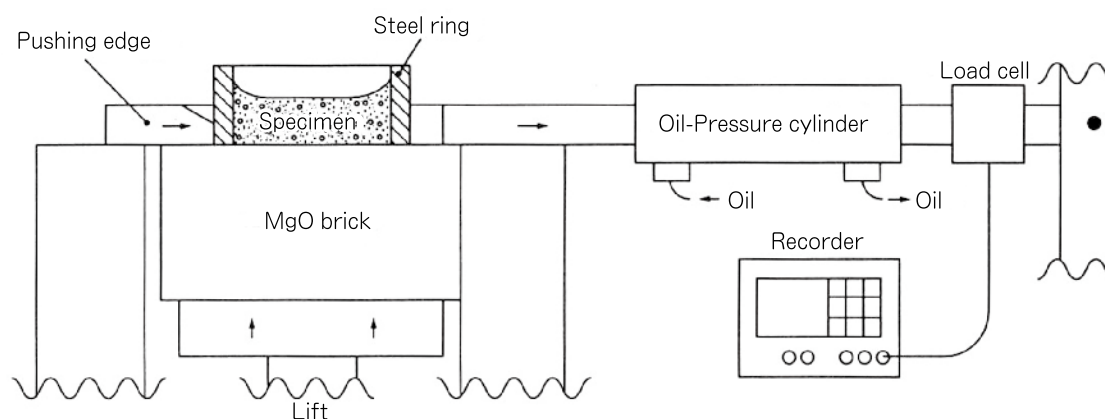


Fig. 4 Testing apparatus for adhesive strength.

Table 1 Properties of quick hardening hot casting repair mixes

| Brand name                   |     | Quick hardening hot casting repair mixes |             |             |              |
|------------------------------|-----|------------------------------------------|-------------|-------------|--------------|
|                              |     | FRX-M90-D69                              | FRX-M90-D74 | FRX-M90-D58 | FRX-M90-D42N |
| Chemical composition (mass%) | MgO | 78                                       | 78          | 77          | 78           |
|                              | CaO | 0.8                                      | 0.8         | 0.8         | 0.8          |
|                              | C   | 6.8                                      | 7.0         | 7.6         | 8.0          |
| Cast at 1000°C               |     |                                          |             |             |              |
| Apparent porosity(%)         |     | 25.2                                     | 25.5        | 25.7        | 26.0         |
| Bulk density(-)              |     | 2.43                                     | 2.43        | 2.42        | 2.34         |
| Adhesion strength(MPa)       |     | 1.5                                      | 2.2         | 2.5         | 2.6          |
| Hot flowability index(-)     |     | 81                                       | 86          | 100         | 104          |
| Hardening time index(-)      |     | 81                                       | 91          | 100         | 105          |

ごと取り出し、試料の流動後の直径を測定し流動性（熱間展開性）を評価した（Fig. 2）。

### 3. 2 接着強度の測定

Fig. 1 の炉内で1000℃に加熱したマグネシア質れんが（114×112×30mm）の上に内径70×40mmの鉄製リングを載せ、リング内に試料150gを投入し炎が消えるまでの時間を硬化時間として測定し評価した（Fig. 3）。また、接着強度は消火後直ちにFig. 4 に示すせん断接着測定装置で測定し評価した。

## 4. 試験結果

速硬性焼付材の当社ブランドFRX（フローレックス）シリーズの品質表をTable 1 に示す。ピッチと特殊助燃剤、さらには速硬性助剤を組み合わせることにより高流動性（熱間高展開性）と短時間硬化を実現した開発品の品質表をTable 2 に示

## 4. Examination Results

The typical properties of conventional quick hardening hot casting mixes in the FLOREX series are shown in Table 1.

We have developed a new product which has high flowability and short hardening time by combining the pitch with a special flammable agent and using a hardening accelerator in the binder.

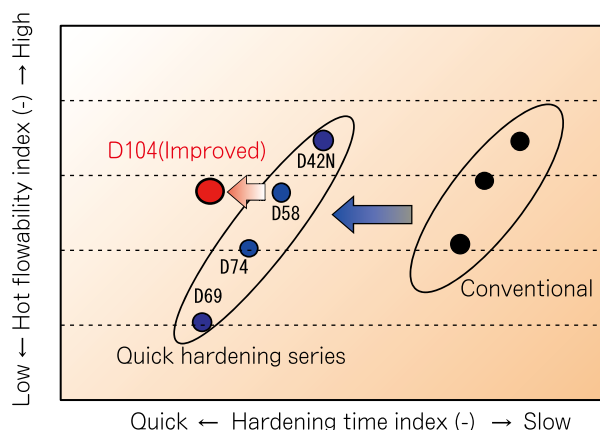
Table 2 shows the properties of the new quick hardening hot casting repair mix.

The hardening times and hot flowability of these new mixes are compared to the conventional ones in Fig.5.

The hardening time of the new mix is approximately 16% shorter than that of the

**Table 2 Properties of new quick hardening hot casting repair mix**

| Brand name                   |     | Newly developed mix |
|------------------------------|-----|---------------------|
|                              |     | FRX-M90-D104        |
| Chemical composition (mass%) | MgO | 77                  |
|                              | CaO | 0.8                 |
|                              | C   | 7.6                 |
| Cast at 1000°C               |     |                     |
| Apparent porosity(%)         |     | 25.5                |
| Bluk density(-)              |     | 2.46                |
| Adhesion strength(MPa)       |     | 2.6                 |
| Hot flowability index(-)     |     | 100                 |
| Hardening time index(-)      |     | 88                  |

**Fig. 5 Flowability and hardening time of improved repair mixes.****Table 3 Performance results for New quick hardening hot casting repair mixes**

| Customer's Plant                          | Plant A-a          | Plant A-b           | Plant B-a             | Plant B-b           |
|-------------------------------------------|--------------------|---------------------|-----------------------|---------------------|
| Repaired part of converter                | Tapping pad        | Bottom              | Tapping pad<br>Bottom | Charging pad        |
| Repairing temperature                     | 1400°C             | 1200°C              | 1300°C                | 1100°C              |
| Amount used                               | 700kg              | 500kg               | 600kg                 | 300kg               |
| Curing time Conventional<br>↓<br>Improved | 15min<br>↓<br>8min | 60min<br>↓<br>40min | 40min<br>↓<br>20min   | 35min<br>↓<br>15min |
| Durability                                | 7ch                | 6ch                 | 15ch                  | 12ch                |

す。また、これらの製品の硬化時間と流動性（熱間展開性）の位置付けをFig.5に示す。流動性（熱間展開性）が同等の品質（FRX-M90-D58）と比較すると開発した超速硬性焼付材（FRX-M90-D104）は硬化時間が約16%速硬化されている。

## 5. 実炉適用結果とまとめ

今回開発した超速硬性焼付材は、実炉においては約30%～約60%の硬化時間短縮が確認できた。実炉適用結果をTable 3に示す。高流動性（熱間高展開性）でかつ短時間硬化する超速硬性焼付材は、各所において転炉稼働率向上に貢献しており好評を得ている

conventional one if the fluidity of each mix is almost equal.

## 5. Performance Results and Summary

We were able to confirm the results of the hardening time of the new mix being from about 30% to 60% shorter than that of the conventional one in an actual furnace.

Table 3 shows the actual use results in an actual furnace.

The application of new quick hardening hot casting mixes is contributing to improved BOF performance and getting a favorable reception.