

SHINAGAWA TECHNICAL REPORT

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Maintenance Period by Application of
Large-sized Precast Blocks

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製品紹介／PRODUCT

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Improvement of Blast Furnace Iron Runner Refractory Durability and Shortening of Overall Maintenance Period by Application of Large-sized Precast Blocks

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要 旨

高炉樋はオンラインで補修される事が一般的であり、工期短縮と省力化が望まれている。そこで、高炉溶銑樋への大型プレキャストブロックの適用を試みた。その結果、従来の現地流し込み施工と比較して、工期が約1/4、作業時間が約1/5にまで短縮可能となり、大幅な工期短縮と省力化を達成した。また、大型プレキャストブロックに当社独自の高熱間強度化技術を適用したケミカルボンドキャストブルを使用したことで、耐用が約1.8倍に向上し、施工頻度が減少、更なる省力化が可能となった。

Abstract

Shortening of blast furnace troughs and runners refractory online repair maintenance operation period, which is periodically conducted usually with on-site castable refractory relining, is strongly required along with the reduction of labor. Thus, large-sized precast blocks are developed and applied for refractory repairing maintenance of the iron runner. As a result, marked shortening of overall operation period was achieved along with significant labor reduction. Specifically, working hours in the iron runner maintenance operation were reduced to one-fifth (1/5) associated with shortening of overall maintenance period to one-fourth (1/4). Furthermore, by applying a chemical-bonded castable refractory, which is our company's original refractory, characterized by superior mechanical strength at high temperature for precast blocks, the durability of the iron runner refractories was improved by roughly 1.8 times, which contributes to the prolongation of periodical iron runner maintenance interval.

1. 緒言

高炉樋は高炉で生成された溶銑滓を次工程に流す溝状の流路であり、耐火物の補修方法はキャストブルによる流し込み施工であることが多い。流し込み施工は、解体、枠セット、流し込み、養生、脱枠、乾燥と多数の工程があり、工期が長くなる。オンラインで補修されることが一般的な高炉

1. Introduction

The troughs and runners of a blast furnace are channels for molten metal and slag drained from the blast furnace tap hole to the next process. Online refractory relining maintenance repairs in blast furnace troughs and runners are periodically conducted usually with on-site castable refractory

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樋では、ミキサーレス材の適用による施工時間の短縮が実施されていたこともある¹⁾など、工期の短縮が重要な課題である。また、高炉鑄床での補修作業は作業環境が悪く、省力化が望まれている。

そこで、当社独自製品である高熱間強度ケミカルボンドキャストابل²⁾を使用した大型プレキャストブロック (Fig.1)を高炉樋に適用することにより、工期短縮、省力化および高耐用化による補修頻度の減少を図った。ここでは、溶銑樋での適用事例について報告する。

2. 製品特徴

大型プレキャストブロックに使用したキャストابلには、セメントレスのケミカルボンド品を適用した。ケミカルボンドキャストابلは、一般的にセメントキャストابلに比べ耐スポーリング性に優れることが知られている³⁻⁵⁾。Table 1に化学組成、加熱後の品質特性を示す。

Fig.2に熱間曲げ強さを示す。開発したケミカルボンドキャストابلは、当社独自の高熱間強度化技術を適用することによって従来品のセメントタイプキャストابلと比較して非常に高い熱間強度を有しており、この熱間強度向上が流れに対する耐性に有効であると考えられ⁶⁾、溶銑樋に

relining. Since repairing maintenance on troughs runners with castable refractory relining requires a sequence of several processes, namely, demolition of used-up refractories, setting of molds, castable refractory casting, curing, removal of molds and drying, the overall repairing maintenance period is lengthy. In order to shorten the overall maintenance period of refractory repairing, a variety of innovative optimizations have been introduced. A typical example is application of castable refractory which does not require on-site mixing work in online repair maintenance¹⁾. However, further reduction of overall maintenance period is necessitated. Furthermore, since the working environment of online refractory maintenance at the blast furnace cast house is not very comfortable, efforts for labor reduction are required, too.

Under such circumstances, for the purposes of shortening the overall maintenance period, reducing labor in on-site refractory repair work and prolonging the periodical maintenance interval by service life extension of refractory, large-sized precast block made of chemical-bonded castable refractory are developed and applied for blast furnace iron runner. There are our company's original refractory products characterized by high mechanical strength at high temperature²⁾. Practical application of large-sized precast blocks for the iron runner is outlined in this article.

2. Characteristics of Products

In order to manufacture the large-sized precast block shown in Fig. 1, cementless chemical-bonded castable refractory is applied. It is well acknowledged that, in comparison with cement-bonded castable refractory, chemical-bonded castable refractory generally exhibits superior spalling resistance³⁻⁵⁾. The chemical compositions of two types of castable refractories are compared along with their modulus of ruptures (MOR) in Table 1.

The hot modulus of ruptures (HMOR) at 1000℃ and 1400℃ of two types of castable refractories, a conventional cement-bonded castable refractory and developed chemical-bonded castable refractory, are compared in Fig.2. The developed chemical-bonded castable refractory, for which our company's original technology was used to create

Table 1 Chemical compositions and MOR of two types of castable refractory

		Conventional	Developed
Binder type		Cement-bonded	Chemical-bonded
Chemical composition / mass%	Al ₂ O ₃	78	77
	SiC	12	14
	C	1	2
Physical properties	MOR / MPa 1000℃-3h	3	14
	1500℃-3h	4	12



Fig. 1 External appearance of large-sized precast block.

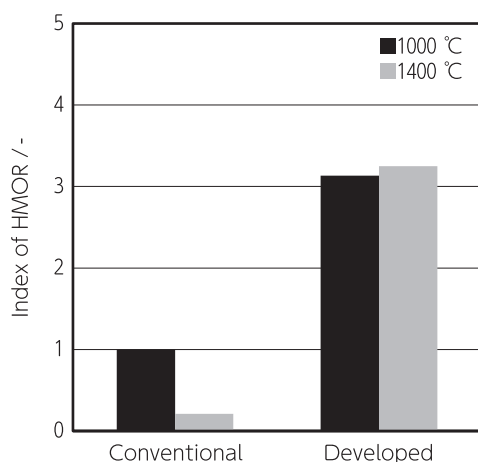


Fig. 2 Comparison of HMOR at 1000 °C and 1400 °C between two types of castable refractories.

適用した際、耐摩耗性向上による高耐用化が期待できる。

ケミカルボンドキャストابلは養生強度が低い、養生収縮による亀裂が発生しやすいなど、大型プレキャストブロック化が困難な材質であるが、材質設計、製造技術の両面からこれらの課題を解決し、長さ数m、重量数tの大型プレキャストブロック化に成功した。

3. 実機施工結果

プレキャストブロックの適用により枠セット、流し込み、養生の時間が省略可能となった。一方でプレキャストブロックの設置が必要となるが、プレキャストブロックの大型化により設置個数を減らすことで、設置に必要な時間も最小限に留めることができた。また、プレキャストブロックは製造工程で乾燥を実施しているため、実機での乾燥工程が省略可能となった。さらに、プレキャストブロックとパーマキャストابلの間にはスタンプ材を施工し、容易にプレキャストブロックを取り外す事が可能な構造とすることで、使用後の解体作業の省力化を図った。

以上により、溶銑樋の補修にかかる工期が約1/4、作業時間が約1/5にまで短縮可能となり、大幅な省力化を達成した。Fig.3に各工程の作業時間の比較を示す。

4. 実機使用結果

Fig.4に耐用比較を示す。開発した大型プレキャストブロックは、従来の低セメントキャストابلを使用した流し込み施工と比較して、補修間の通銑量が約1.8倍に向上した。また、大型化によりプレキャストブロック間の目地数が減り、プレキャストブロック適用の懸念事項である目地

high mechanical strength at high temperature was applied, exhibits superior hot strength. It is prospected that such superior hot strength will be effective in enduring the hot metal stream running on the iron runner⁶⁾. In other words, it is expected that, because of the superior abrasion resistance of the developed chemical-bonded castable refractory, durability of iron runner refractory would be markedly improved.

Because of the disadvantageous aspects of chemical-bonded castable refractories, namely, low mechanical strength after curing and relatively high crack sensibility by curing shrinkage, its application for precast block is accompanied by some practical difficulties. However, these difficulties were solved by optimization of refractory material design as well as of precast block manufacturing process, resulting in successful manufacturing of large-sized precast block, several meters of length and several tons of product weight.

3. Practical Application of Large-sized Precast Block for Iron Runner Maintenance

By applying precast block to the iron runner, operation time for setting and removal of mold, castable refractory casting and curing can be curtailed. Precast block setting time, which is alternatively required, is minimized by an elaborate maintenance design plan in which iron runner repairing is achieved with an optimal number of precast blocks which is enabled by precast block enlargement technologies. Furthermore, since precast block is well dried at its manufacturing site, the on-site drying process can be omitted. In precast block setting work, ramming refractory material is relined between permanent relining of iron runner and outside of precast block so that used-up precast blocks are easily removed with no muscular demolishing work necessary at the next periodical maintenance.

As per Fig.3, in which repairing working hours (index) in major repairing processes are compared between conventional repairing maintenance with on-site castable refractory relining and that with precast block setting, the working hours in the maintenance operation is lowered to one-fifth (1/5) associated with shortening of overall maintenance

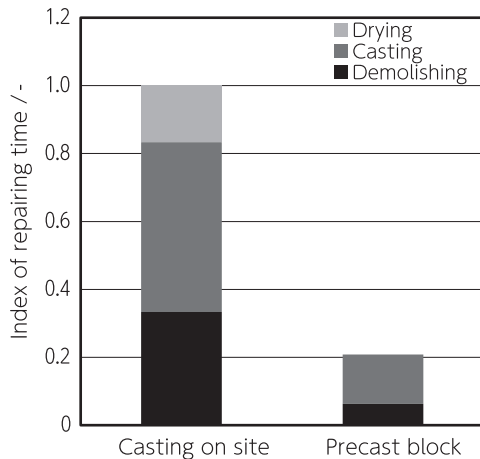


Fig. 3 Comparison of repair work hours between conventional maintenance with on-site castable refractory relining and that with precast block setting.

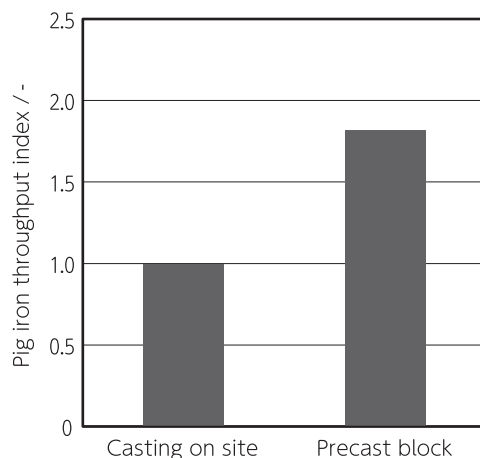


Fig. 4 Comparison of durability between cement-bonded castable refractory on-site relined in conventional iron runner maintenance and chemical-bonded castable refractory applied for precast block in novel precast block setting maintenance.

損傷を減らすことで安定した耐用性が確保できた。これにより、施工頻度が減少し、更なる省力化が可能となった。

5. 結言

高炉樋の補修工期短縮、省力化について、溶銑樋での実施例を紹介した。

大型プレキャストブロックを適用することで、従来の現地流し込み施工と比較して工期が約1/4、作業時間が約

period to one-fourth (1/4). In other words, marked labor reduction is achieved in iron runner repairing maintenance associated with shortening of overall maintenance time.

4. Performance Achieved by Iron Runner Maintenance with Large-sized Precast Blocks

In order to evaluate the durability of cement-bonded castable refractory on-site relined in conventional iron runner maintenance and chemical-bonded castable refractory applied for large-sized precast block used in novel iron runner maintenance, pig iron throughput or service life of these two types of castable refractories is compared in Fig. 4. In comparison with on-site relined cement-bonded castable refractory, pig iron throughput, i.e., the service life of chemical-bonded castable refractory applied for precast block is extended to roughly 1.8 times. Localized damage at joint between neighboring precast blocks, which is concerned in application of precast block for iron runner repairing maintenance, is insured by optimal minimization of joints (i.e. optimum number of large-sized precast blocks) as well as proper setting work of precast blocks.

Extension of chemical-bonded precast block iron runner refractory service life is reflected in prolongation of periodical maintenance interval, another outcome of labor reduction in iron runner refractory maintenance.

5. Conclusion

For the purposes of shortening overall operation period of blast furnace troughs and runners repairing maintenance and achieving labor reduction in trough refractory repairing work, large-sized precast blocks are applied. By applying large-sized precast blocks for iron runner repairing maintenance, marked reduction of overall operation period is achieved along with significant labor reduction. Specifically, working hours in iron runner maintenance operation are reduced to one-fifth (1/5), associated with shortening of overall maintenance time to one-fourth (1/4). By applying chemical-bonded castable refractory, our company's original refractory product characterized by high mechanical strength at high

1/5となり、大幅な工期短縮と省力化を達成した。また、当社独自の高熱間強度ケミカルボンドキャストブルを適用したことで、従来の低セメントキャストブルを使用した流し込み施工と比較して耐用が約1.8倍に向上し、施工頻度の減少も可能となった。

temperature, for precast blocks, durability of iron runner refractory is improved by roughly 1.8 times, which contributes to prolongation of periodical iron runner maintenance interval.

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