

SHINAGAWA TECHNICAL REPORT

加熱炉向け軽量断熱キャストブル

Lightweight Insulating Unshaped Refractories
for Reheating Furnace

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品川技報

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要 旨

収縮を抑制することで長期使用時の安定性を改善した材料を開発した。また、種々施工方法に対応する材料を揃えた。

Abstract

The long term stability of the newly developed materials has been improved by reducing shrinkage. Moreover, the product lineup can be used for various construction methods including casting, pumping, troweling and gunning.

1. 加熱炉向け不定形耐火物

加熱炉は熱延工程に際して鋼片を加熱するための設備である。現在主流となっているウォーキングビーム式加熱炉において、不定形耐火物は壁部やスキッドパイプなどに使用され¹⁾、抜熱低減のために断熱性に優れるものが選定される²⁾。また、スキッドパイプにおいては鋼片から発生するスケールに対する耐性、衝撃に耐える強度も必要となる。また、長期間の稼動に供されるため容積安定性も求められる。

開発品は断熱性、耐スケール性に優れるカルシウムヘキサアルミネート(CA6)系の断熱流し込み材^{3,4)}をもとに、加熱後の収縮を抑えて長期安定性を高めた材料である。また、流し込み材のほか、こて塗り材、吹き付け材を開発した。

1. Unshaped Refractories for Reheating Furnaces

Reheating furnaces are used to reheat the steel slab during the hot-rolling process. In the most common walking-beam type reheating furnace, unshaped refractories are used for the wall or skid-pipe¹⁾, and require a high thermal insulation property to reduce heat loss²⁾. As skid-pipe materials, they are required to resist reaction with mill scale and to provide enough strength to withstand impact during operation. In addition, they are also required to have volume stability, which resists shrinkage during the thermal cycle because the furnaces run for longterms.

The long term stability of the developed

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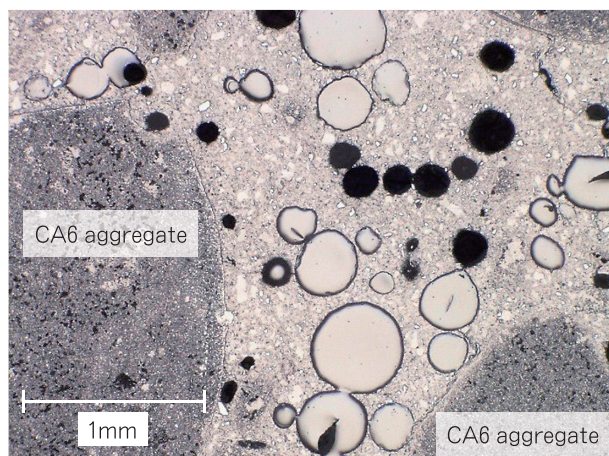


Fig.1 Microscopic image of developed material LX-160-1 after heating at 1500°C.

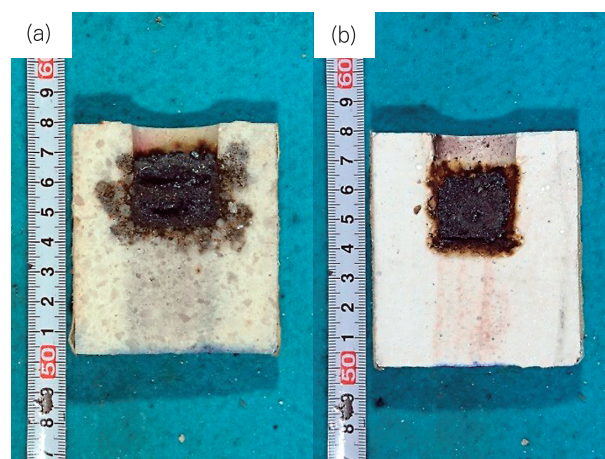


Fig.2 Cross section of the sample after cup test. (a) High-alumina low cement dense castable, (b) Light weight insulating castable LX-160-1.

2. 低収縮軽量断熱材LX-160シリーズ

2. 1 LX-160シリーズの特徴

LX-160シリーズは軽量高断熱性の不定形材料である。Fig.1に微構造写真を示す。気孔、空隙が多い多孔質の組織となっている。Table 1に開発品の代表品質を示す。高純度な Al_2O_3 -CaO質の材料であり、耐熱性、耐食性に優れる。また、同系統の材料の課題であった加熱後の収縮を大幅に低減し、長期安定性を向上させた。

Fig.2にミルスケールを侵食剤としたるつば試験後の試料断面を示す。ハIALルミナ質の流し込み材では大きな浸潤部がみられたが、LX-160-1では浸潤部はごくわずかで、ほとんど変質はみられなかった。

materials was increased by reducing shrinkage after heating based on Calcium hexa-Aluminate (CA6) series insulating unshaped refractories, which have the good thermal insulating ability and resistance to reaction with mill scale^{3,4)}. Furthermore, troweling and gunning materials have also been developed in addition to castable materials.

2. LX-160 Series Low-shrinkage Lightweight Insulator

2. 1 Characteristics of LX-160 series

The LX-160 series is a product group within lightweight and high thermal insulating unshaped refractories. A microscopic image is

Table 1 Specifications of developed materials

		LA-150-2	LX-160-1	LX-160T-1	LX-160G-1
Chemical composition	Al_2O_3	87	89	89	89
/ %	CaO	13	11	11	11
Permanent linear change	110°C-24h	-0.10	-0.10	-0.10	-0.11
/ %	1500°C-24h	-1.11	-0.28	-0.26	-0.63
Modulus of rupture	110°C-24h	2.5	1.1	1.6	4.8
/ MPa	1500°C-24h	3.6	4.8	5.0	6.7
Notes		Conventional material	Material developed for casting or pumping	Material developed for troweling	Material developed for gunning

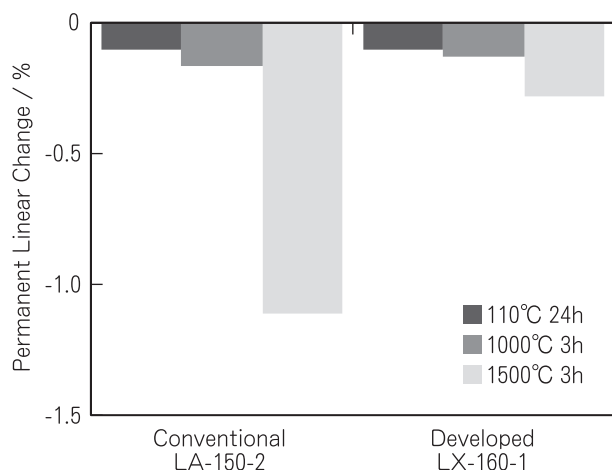


Fig.3 Permanent linear changes on conventional material and developed material.

Fig.3 に従来品のLA-150-2³⁾と開発品のLX-160-1の残存線変化率を示す。LX-160-1は高温加熱後の収縮が小さく、炉内で特に高温となるバーナー近辺においても安定して使用できる。また、バッチ式の窯炉でも安定して使用できる。Fig.4 に従来品と開発品の加熱後試料のXRDスペクトルを示す。開発品はカルシウムアルミネート系鉱物が高アルミナ組成となっていた。高温での収縮に寄与するカルシウムジアルミネート(CA2)が抑制され、膨張に寄与するCA6^{5,6)}が増えたことによって収縮が抑制されたものと考えられる。

2. 2 流し込み材LX-160-1

LX-160-1は、流し込み施工にて使用する材料である。軽量の骨材の活用に加え、多量の水分添加によって低かさ比重の施工体得ることができる。また、材料分離がなく自己流動性を有し、ポンプ圧送施工にも対応する。

2. 3 こて塗り材LX-160T-1

LX-160-1をもとに、保形性やこて作業性の特性を賦与したこて塗り材である。Fig.5にれんがに対して試験施工を行った状況を示す。施工体が垂れ落ちたり剥がれ落ちたりすることなく施工することができ、良好な作業性を有している。少量施工や補修等の用途に適する。

2. 4 吹き付け材LX-160G-1

LX-160-1を吹き付け施工可能になるようバイ

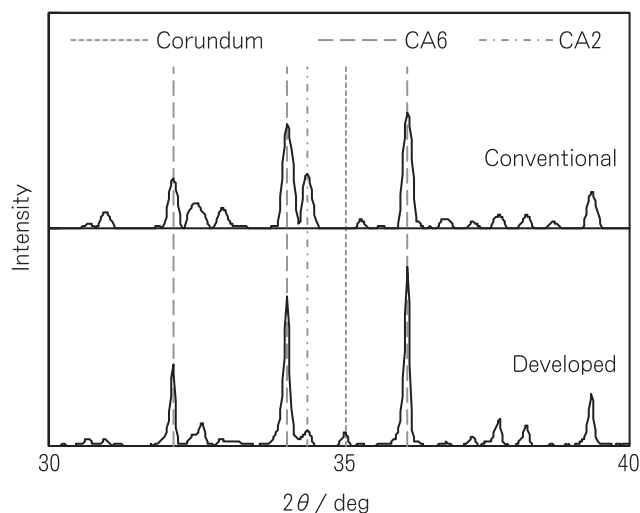


Fig.4 XRD patterns of conventional material and developed material after heating at 1500°C.

shown in Fig.1. The texture has many pores and cavities, which means it is porous. The typical properties of the developed materials are summarized in Table 1. The high purity Al_2O_3 -CaO composition of materials renders high heat resistance and high corrosion resistance properties. In addition, The LX-160 series has achieved drastically improved long term stability, which was an issue with this category of materials, by reducing shrinkage after heating.

The cross sections of the samples after cup test with mill scale as an erosion agent are shown in Fig.2. A large penetrated area was observed in the high-alumina castable sample. On the other hand, in the LX-160-1 sample, no changes were detected and the penetrated area was very small.

The permanent linear change data of conventional material LA-150-2³⁾, and developed material LX-160-1, are shown in Fig.3. Because LX-160-1 material has low shrinkage after heating, it performs stably near the heating burners where the temperature is especially high. Moreover, it can also be used in batch type furnaces without any problems. The



Fig.5 Appearance of troweling material LX-160T-1 application test.



Fig.6 SRG (Shinagawa Refractories Gun).

ンダーおよび粒度構成を変更した材料である。SRG (Fig.6) 等の吹付装置と組み合わせて乾式吹き付けで施工を行うことができ、補修や炉壁等への施工に適する。

Fig.7に吹き付け試験後の施工体を示す。施工体は垂れ落ちたり剥がれ落ちたりすることなく強固に接着した。また、施工体の断面をFig.8に示す。骨材の偏析等もみられず、良好な施工体を得ることができた。

XRD patterns of the conventional and developed materials are shown in Fig.4. The chemical composition of the calcium aluminate compounds in the developed product shifted to high alumina content. It is assumed that the crystal formation shift to CA6, which yields expansion^{5,6)}, from Calcium di-Aluminate (CA2), which yields shrinkage, resulted in reduced shrinkage of the material.

2. 2 LX-160-1 castable material

Newly developed LX-160-1 is a castable material. It can provide a low bulk density construction body by using lightweight aggregates and large amount of water addition. In addition, this material is also available for pumping construction because of its non-segregating and self-fluidity properties.

2. 3 LX-160T-1 troweling material

Troweling material LX-160T-1 has been developed by imparting shape retainability and troweling workability to LX-160-1. The appearance of the application test on a brick is shown in Fig.5. The material can provide favorable workability without any drooping or peeling problems during construction. Thus, it is suitable for small scale construction and repair work.

2. 4 LX-160G-1 gunning material

The binder system and the grain size distribution of LX-160G-1 have been adjusted for gunning work based on LX-160-1. This material is suitable for construction with gunning equipment such as SRG (Fig.6), and repair and construction of the furnace wall.

The appearance of the gunning test sample is shown in Fig.7. The material stuck to the wall strongly without drooping or peeling. A cross section of the construction sample is shown in Fig.8. No problems, including segregation of aggregates, were found in the texture at the actual construction site.



Fig.7 Structure appearance of gunning material LX-160G-1 application test.



Fig.8 Cross section of gunning sample LX-160G-1.

3. 結言

高断熱・軽量の断熱不定形耐火物について紹介した。流し込み, ポンプ圧送, こて塗り, 吹き付けに対応できるラインナップを揃えている。また, 従来品に比較して加熱後収縮を低減しており, 長期安定性に優れる材料となっている。

3. Conclusion

Newly developed high insulation and light weight insulating unshaped refractories were introduced in this article. The product lineup can be used for various construction methods including casting, pumping, troweling and gunning. Moreover, the developed materials can provide excellent long term stability due to their lower shrinkage characteristic after heating as compared with the conventional materials.

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