

SHINAGAWA TECHNICAL REPORT

環境配慮型セメントロータリーキルン用 Green Refractory

Environmentally Friendly Green Refractories Bricks for Cement Rotary Kilns

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製品紹介／PRODUCT

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要 旨

リサイクル原料を使用した環境配慮型セメントロータリーキルン用れんがを開発した。従来材質と同等に使用可能であり、これに置き換えることでライフサイクルにおけるCO₂の排出削減が可能になる。当社はこのような環境配慮型耐火物をグリーンリフラクトリーと名付け、開発を推進中である。

Abstract

Utilizing recycled raw materials, environmentally friendly bricks, which are labeled “Green Refractories”, for cement rotary kilns were developed. Similar performance to that attained by the original bricks, completely composed of virgin raw materials, is achievable with Green Refractories brick products, which contribute to the reduction of the life cycle CO₂ emission volume, namely, reduction of CO₂ emission volume derived from natural resources and energy consumed for production of raw materials. Deployment and development of Green Refractories for various fields is presently being actively pursued.

1. 諸言

近年、地球温暖化による気候変動が顕著になっており従来の産業活動が困難になることが予想されている。これらの問題に対して、2015年には持続可能な開発目標 (SDGs)¹⁾が採択され、品川リフラクトリーズもサステナビリティ経営方針²⁾を策定して取り組んでいる。リサイクルの推進はその一つで使用後耐火物、耐火物以外の使用後窯業製品、他産業で発生する副生成物などが対象になっている。これらの原料を使用することにより、バージン原料を生産する際に発生するCO₂排出量やエネルギーを削減できる。当社は、このような実質的にCO₂排出をゼロとみなすことが出来る原料を20mass%以上含有した耐火物を「グリーンリフラクトリー (Green Refractory)」と名付け、

1. Introduction

Since climate change, induced by global warming, has become more conspicuous in recent years and world activities aim to solve the issue, it is thought that conventional industrial activities may encounter various kinds of difficulties. In this regard, sustainable development goals (SDGs)¹⁾ were adopted at the United Nations in 2015. The author's company, Shinagawa Refractories Co. Ltd., is engaged upon these challenging issues by formulating a “Sustainability Management Policy”²⁾. Promoting application of spent refractory recycling, spent ceramics materials other than refractories, and by-products generated in various industries is one of the challenging issues. Doing so allows the reduction of CO₂ emissions and consumed energy, which are emitted the by the production of virgin

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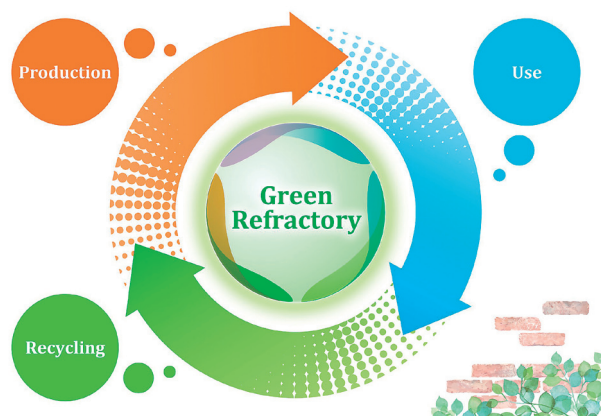


Fig. 1 Conceptual image of “Green Refractories” recycling loop.

各種製品の開発を推進している（Fig.1）。本報告ではセメントロータリーキルン用Green Refractoryについて紹介する。

2. 使用れんがリサイクルプロセス

セメントロータリーキルンでは内張に耐火物が使用されている³⁾が、鉄皮（シェル）に直接施工されている上に、炉修は半年から1年に1回実施され、炉修以外の期間は基本的に連続運転される。炉修時には炉内状況の点検を行うため、稼働面の付着物（コーティング）は基本的に除去され、使用後れんがはコーティング等が無い状態で回収が可能になっている。

セメントロータリーキルンの使用後れんが処理フローをFig.2に示す。回収したれんがは目地鉄板などの除去後に粉碎処理し、篩掛けと脱鉄を実施して再原料化している。再原料化では一部れんがに内に浸潤した不純物成分が残存するが、粒度構成の調整や製造プロセス適正化により一定量

refractory raw materials. The author's company labels refractory products, in which over 20 % of the materials which can be qualified with substantially zero CO₂ emission are blended, “Green Refractories” and promotes the development of various types of “Green Refractories” products. A conceptual image is shown in Fig. 1. The development of “Green Refractories” brick products for cement rotary kilns is described in this article.

2. Recycling of Used Refractories Relined in Cement Rotary Kilns

In the cement rotary kiln, which is relined with refractory bricks³⁾, bricks are relined directly on the kiln's steel shell. Except for relined refractory overhauling work which is conducted once every half year or once a year, cement calcinating operation continues, in principle, ceaselessly. Since the coating layer adhering to the relined refractories is completely removed in order to inspect the kiln conditions during relined refractories overhauling work, used refractories can be retrieved without a coating layer.

The recycling process of used refractories from being retrieved from a cement rotary kiln to being turned into raw materials for Green Refractories products is shown in Fig. 2. After removing the steel sheet which is used for joint adjustment, used refractories are crushed and sieved for grain size adjustment along with removal of iron components for recycling as refractory raw materials. Even though impure elements, which have infiltrated deeply into the brick body remain in recycled raw materials to some extent, raw materials are blended with optimized particle size adjustment and operational conditions in the brick production process to obtain the necessary qualities.

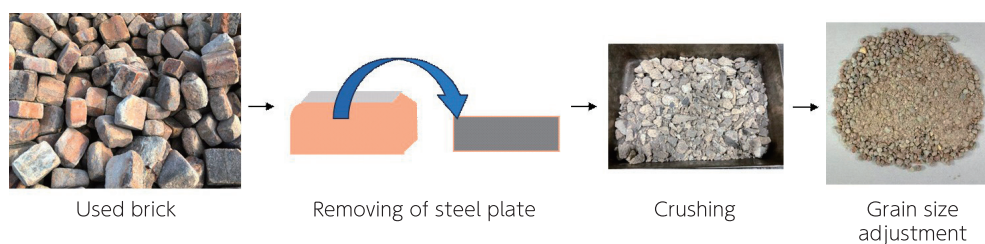


Fig. 2 Green Refractories recycling process from used refractory to raw material.

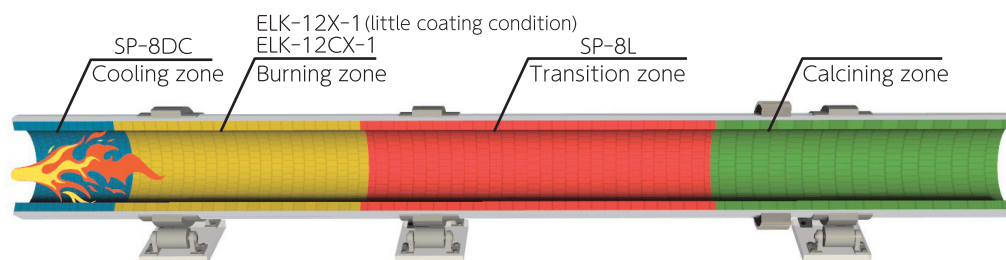


Fig. 3 An example of relining arrangement of magnesia-spinel brick in cement rotary kiln.

Table 1 Comparison of major properties between original and Green Refractories magnesia-spinel bricks

		Cooling zone (SP-8DC)		Burning zone (ELK-12CX-1)		Burning zone little coating condition (ELK-12X-1)		Transition zone (SP-8L)	
		Green	Original	Green	Original	Green	Original	Green	Original
Apparent porosity / %		16.8	15.3	16.2	14.5	16.0	14.5	16.8	15.5
Bulk density / g·cm ⁻³		2.96	3.05	2.98	3.04	2.98	3.03	2.93	2.95
Cold crushing strength / MPa		58	57	57	56	52	54	49	48
Chemical composition / mass%	MgO	78.7	79.5	83.1	84.6	84.4	85.4	80.7	81.0
	Al ₂ O ₃	17.9	17.6	12.0	12.2	12.3	12.3	17.6	17.7
	Fe ₂ O ₃	1.5	1.5	1.1	1.0	-	-	-	-
	CaO	-	-	-	-	-	-	0.7	0.6

Table 2 Cross sections of original and Green Refractories magnesia-spinel bricks

		Cooling zone (SP-8DC)	Burning zone (ELK-12CX-1)	Burning zone little coating condition (ELK-12X-1)	Transition zone (SP-8L)
Cross section	Green				
	Original				

のリサイクル原料を使用しても従来品と同様の特性確保を可能とした。

3. Green Refractoryのラインナップ

セメントロータリーキルンでは部位によって使用される材質が異なっており³⁾、当社でもFig.3のように使い分けられている。各材質の従来品とGreen Refractoryの標準品質と切断面写真をTable 1, 2に示す。各材質共にGreen原

3. Line-up of “Green Refractories” Products for Cement Rotary Kilns

The various types of magnesia-spinel brick are relined in the cement rotary kiln according to zone. An example of the relining arrangement of magnesia-spinel brick in a cement rotary kiln, which is commonly adopted by the author's customers, is shown in Fig. 3. The major physical and chemical properties, as well as cross section photographs of

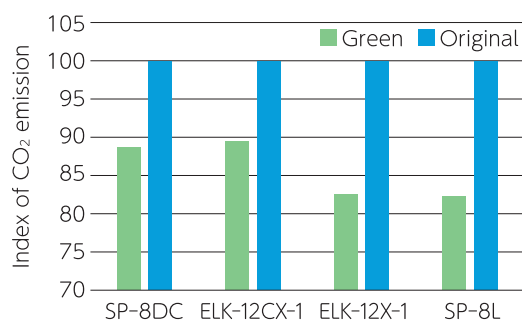


Fig. 4 Comparison of CO₂ emission volume derived from blended raw materials between original and Green Refractories bricks.

料を使用することで、かさ比重の低下に伴う軽量化が図られており、実炉における耐火物使用重量の削減に寄与できる。なお、白色のマグネシアを主原料としたELK-12X-1とSP-8Lではリサイクル原料を使用することで一部色味が異なるが、従来品と同等使用が可能な材質を開発した。

Fig.4に従来材質とGreen Refractoryの原料・燃料由来のCO₂発生量を指数で示す。いずれの材質もGreen RefractoryとすることでCO₂発生量が低減しており、当社独自のデータベースによる見積では、年間3,000～4,000tのCO₂削減が見込まれる。

4. まとめ

今回、原料の一部にリサイクル原料を適用したセメントロータリーキルン用Green Refractoryについて紹介した。れんがの総重量の削減や原料に由来するCO₂の排出削減等、環境改善に寄与できる材質であり、積極的な展開を進めていく。

“Green Refractories” brick are compared with those of original brick products which were produced with virgin raw materials in Table 1 and 2. Because of slightly reduced bulk density caused by application of recycled raw materials, all the Green Refractories bricks exhibit smaller unit weight, which will contribute to reduction of total weight of relined refractory bricks or refractory unit consumption. It is noted that Green Refractories bricks ELK-12X-1 and SP-8L, in which the original products white-colored magnesia is mainly blended, exhibit slightly different color tone. Needless to mention, however, there are no differences in qualities and performance between Green Refractories and original bricks.

In Fig. 4, the CO₂ emission volume derived from the natural resources and energy consumed for production of blended raw materials is compared between original and Green Refractories brick products by index value. It can be understood that the blended raw material related CO₂ emission volume is reduced by 10-20 % in all the Green Refractories brick products. It was estimated with the proprietary database of the author's company that 3,000-4,000 tons of CO₂ emission volume per year can be reduced.

4. Conclusion

Green Refractories bricks for cement rotary kilns, in which used refractories are applied as part of the blended raw materials, were introduced in this article. Since usage of Green Refractories bricks contributes to environment improvement in the reduction of the blended raw material related CO₂ emission volume as well as total weight of relined refractory bricks, deployment of Green Refractories products in various fields needs to be actively pursued.

References

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- 3) Y. Toda, K. Igabo and T. Suwa: Shinagawa Technical Report, **65** 79-90 (2022).