

SHINAGAWA TECHNICAL REPORT

イソライト工業株式会社
「耐水性に優れた高強度マイクロポーラス系
断熱材 LTC-A」

Isolite Insulating Products Co., Ltd.
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with Water-resistance”

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品川技報

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要 旨

イソライト工業は、低熱伝導率で強度が高く、加工性と耐水性に優れた断熱材LTC-Aを開発、製品化した。LTC-Aは他のマイクロポーラス系断熱材と比較し、曲げ強さ5倍以上、圧縮強さ2倍以上となり、取り扱い性が向上し、複雑加工が可能で、強度が必要な組み付け部分に使用出来る。さらに結露や水蒸気に対する耐水性に優れることから、これまで使用が困難であった部位にも適用の可能性が広がっている。強度、耐水性を活かし、各種工業炉の内張りに採用され始めている。

Abstract

ISOLITE developed and commercialized LTC-A, with has low thermal conductivity, high strength, and is excellent in processability and water resistance. LTC-A was compared with other microporous insulation materials. The modulus of rupture was found to be more than 5 times greater, and compressive strength more than 2 times greater than the other microporous insulation materials. Furthermore, it can be handled more easily, complex processing is possible, and it can be used for assembling that requires strength. Furthermore, since it is excellent in resistance to dew condensation and water vapor, it can be applied to sites where other microporous insulation materials have not been usable so far.

Making use of the high strength and water resistance, it is beginning to be adopted to the linings of various industrial furnaces.

1. 緒言

マイクロポーラス系断熱材は100nm以下の超微粒子と無機繊維、赤外線散乱材を用いて成形された断熱材であり、断熱れんがやセラミックファイバーボード、ケイ酸カルシウムボード等の断熱材と比較して熱伝導率が低く、各種工業炉の炉壁や

1. Introduction

Microporous insulation materials are composed of ultrafine particles of 100nm or less, inorganic fiber and infrared scattering material, and it has lower thermal conductivity compared with insulation brick, ceramic fiber board, and

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溶鋼容器等の内張りに使用されている¹⁻²⁾。一方で強度が小さいため、脆く破損しやすい。また他の断熱材と比較して水分を吸収した際に大きく収縮し、亀裂が発生するため断熱性の低下が懸念される点があることから、使用用途が限定されており、これらを補う製品が求められている。

イソライト工業は強度と耐水性に優れたマイクロポーラス系断熱材LTCボード-UH³⁾を2年前に開発しているが、今回さらにRCFを含まないLTC-Aを開発、製品化した。LTC-AはLTCボード-UHと同等の品質特性を有するものであり、その特徴について紹介する。

2. LTC-Aの特徴

LTC-Aは他のマイクロポーラス系断熱材同様、超微粒子、赤外線散乱材、補強繊維を用いて成形された断熱材である。また、RCFフリーのため厚生労働省による特定化学物質障害予防規則対象外であり、CLP規則、ドイツ規制（TRGS 905）による規制対象からも除外されている。

2.1 基本物性

LTC-A及び比較として他のマイクロポーラス系断熱材の基本物性値をTable 1に示す。また、熱伝導率について、セラミックファイバーボード、ケイ酸カルシウムボード及び従来のマイクロポーラス系断熱材と比較し、Fig.1に示す。

LTC-Aの最高使用温度は他のマイクロポーラス系断熱材と同等であり、曲げ強さが5倍以上、圧縮強さが2倍以上である。熱伝導率はセラミックファイバーボードやケイ酸カルシウムボードよ

calcium silicate board. They are used as backup heat insulation for various industrial furnaces and molten metal containers¹⁻²⁾. On the other hand, they are brittle and easily damaged because of lower strength. In addition, as compared with other insulation materials, they shrink greatly when absorbing moisture, cracks are generated, and there is a concern that it may cause deterioration of the heat insulation property. So application is limited, and products that supplement these are required.

ISOLITE produced microporous insulation LTC board-UH³⁾ which is superior in strength and water resistance two years ago. Recently, we developed and commercialized RCF free LTC-A. LTC-A has the same quality characteristics as the LTC board-UH, and in this report, we introduce its features.

2. Features of LTC-A

LTC-A is an insulation material molded using ultrafine particles, infrared-scattering materials, and reinforcement fibers. Also, because it is RCF-free, it is excluded from the Ordinance on Prevention of Hazards Due to Specified Chemical Substances (Japanese law) by the Ministry of Health, Labor and Welfare, and it is also excluded from CLP regulation and German regulation (TRGS 905).

2.1 Basic properties

The basic physical property values of LTC-A

Table 1 Comparison of LTC-A and other microporous insulation

Properties	LTC-A	Conventional 1	Conventional 2	Conventional 3
Max service temperature / °C	900	1000	1000	950
Bulk density / kg·m ⁻³	410	366	251	226
Liner shrinkage at 900°C / % (at 24 hours)	0.8	0.9	0.7	1.8
Modulus of rupture / MPa	1.1	0.2	0.2	0.1
Compressive strength / MPa (10% compressed)	1.5	0.7	0.7	0.3

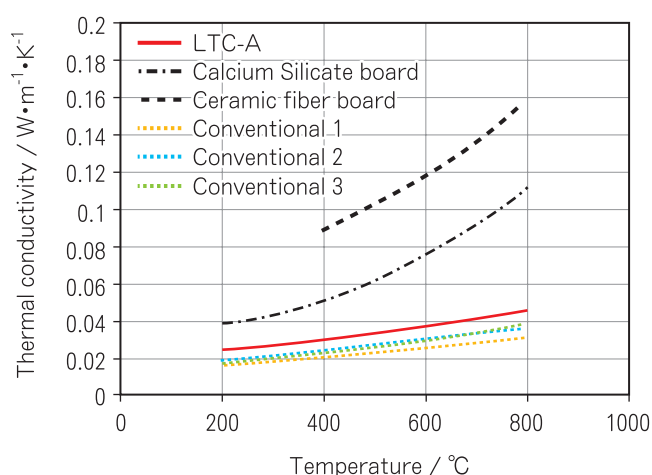


Fig.1 Thermal conductivity of LTC-A and other microporous insulation.

※measured value

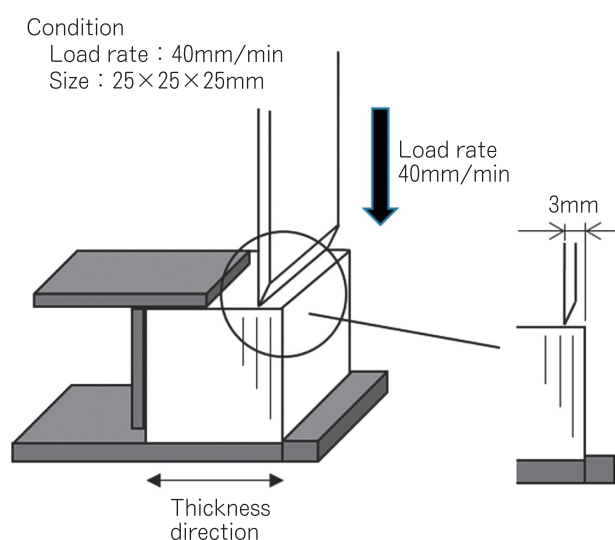


Fig.2 Test method.

りも低く、他のマイクロポーラス系断熱材と同程度である。

2.2 ハンドリング性評価

マイクロポーラス系断熱材は手で持った際に層間が剥離して厚み方向に欠けが生じやすい。そこで厚み方向に角が欠けることを想定して欠け易さの評価を実施した。

試験方法：試験サンプルの厚み方向に3mmの位置に荷重をかけ、亀裂が生じた際の荷重値(N)

and other microporous insulation materials are shown in Table 1. In addition, the thermal conductivity of LTC-A is shown in Fig.1, and compared with ceramic fiber board, calcium silicate board and conventional microporous insulation.

The maximum service temperature of LTC-A is equal to that of other microporous insulation materials, the modulus of rupture is 5 times or more, and the compressive strength is 2 times or more. The thermal conductivity of LTC-A is lower than that of ceramic fiber board and calcium silicate board, which is comparable to that of other microporous insulation materials.

2.2 Handling property evaluation

When the microporous insulation material is handled, its interlayer peels off and chipping tends to occur in the thickness direction. Therefore, evaluation of ease of chipping was performed assuming that chipping occurs in the thickness direction.

Test method: A load was applied to the position of 3 mm in the thickness direction of the test sample, and the load value (N) at the time when the crack occurs was set as an index value of chipping easiness. The outline of the test is shown in Fig.2.

The test was carried out using LTC-A and other microporous insulation materials (Conventional 1-3), and the results are shown in Table 2.

LTC-A is more than 5 times larger than other microporous insulation materials, hardly causing chipping, indicating that the handling property is good.

2.3 Processing performance evaluation

Because the microporous insulation materials are mainly produced by press molding, it is considered that there is a difference in processing performance when the pressing direction and the processing direction are different. Therefore, as processing performance evaluation,

Table 2 Results of handling test

	LTC-A	Conven- tional 1	Conven- tional 2	Conven- tional 3
Applied load / N	98	18	16	11

を欠け易さの指標値とした。Fig.2に評価試験の概要図を示す。

LTC-A及びConventional 1-3を用いて評価試験を実施し、得られた結果についてTable 2に示す。

LTC-Aは他のマイクロポーラス系断熱材よりも5倍以上大きく、従来よりも欠けにくいものとなっており、ハンドリング性が良いものとなっていることがわかる。

2. 3 加工性評価

マイクロポーラス系断熱材はプレス成形で主に製造されるので、プレス方向と加工する方向が異なると加工性に差が生じると考えられる。そこで加工性評価として、厚み方向及び面方向の2面で加工を実施し、他のマイクロポーラス系断熱材と加工後の外観の比較を行った。加工については砥石加工機にて行った。Fig.3に加工試験の概要図を示す。

processing was carried out on two sides in the thickness direction and plane direction, and the appearance after processing was compared with other microporous insulation materials (Conventional 1-3). Processing was done with a grindstone processing machine. The outline of the processing test is shown Fig.3.

The appearance photographs after processing are shown in Tables 3 and 4.

When LTC-A was processed at a speed of 400mm/min, no chipping occurred, the ridgelines were clear, and when processed at a speed of 800mm/min, slight chipping occurred. On the other hand, for other microporous insulation materials, chipping and ridgeline defects occurred even at a processing speed of 400mm/min, which is larger in the thickness direction. These results show that LTC-A is superior to other microporous insulation materials in processing performance.

2. 4 Water resistance evaluation

For water resistance evaluation, LTC-A and other microporous insulation materials (Conventional 1-3) were immersed in water, and after drying the appearance and physical prop-

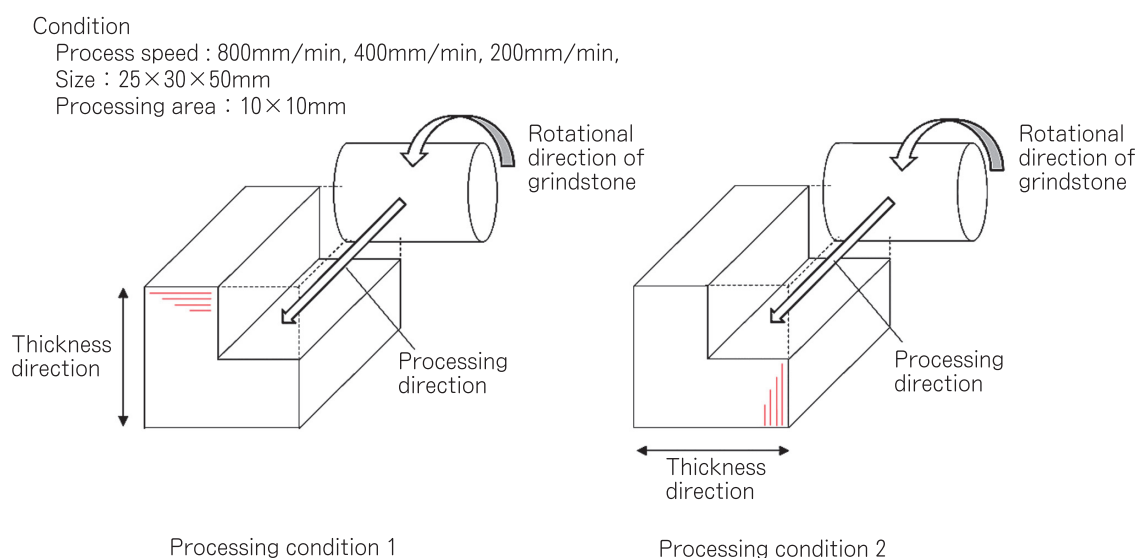
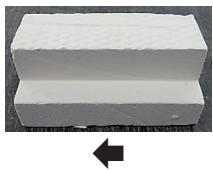
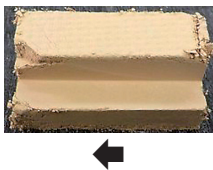
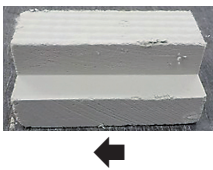
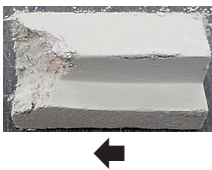
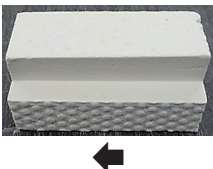
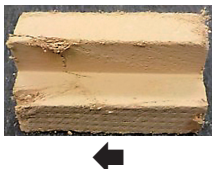
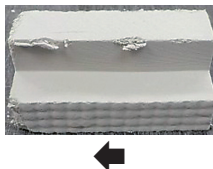
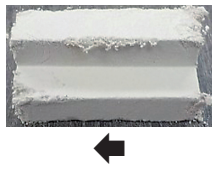


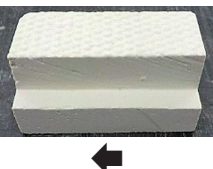
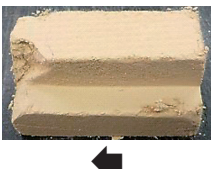
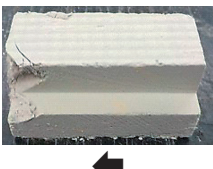
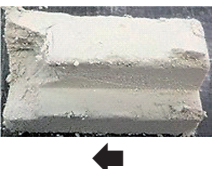
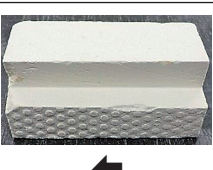
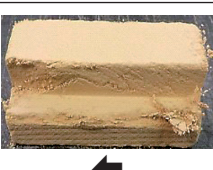
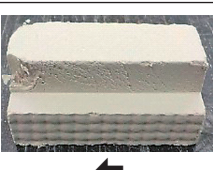
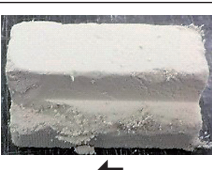
Fig.3 Processing condition due to thickness direction.

Table 3 After processing appearance (processing speed 400mm/min)

	LTC-A	Conventional 1	Conventional 2	Conventional 3
Processing condition 1				
Processing condition 2				

←: processing direction

Table 4 After processing appearance (processing speed 800mm/min)

	LTC-A	Conventional 1	Conventional 2	Conventional 3
Processing condition 1				
Processing condition 2				

←: processing direction

加工後の外観写真をTable 3, 4に示す。

LTC-Aは400mm/minの速度で加工した際には欠けは発生せず、稜線が明瞭であり、800mm/minの速度で加工した際も微小な欠けが発生するだけにとどまっている。一方、他のマイクロポーラス系断熱材については400mm/minの速度の加工でも欠けや稜線不良が発生しており、厚み方向の方が大きく生じている。切削時の加工性について他のマイクロポーラス系断熱材よりもLTC-Aが優れていることがわかる。

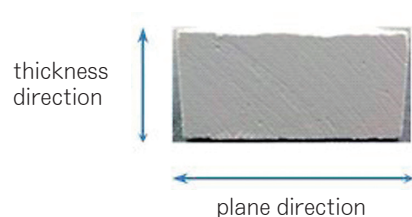
2. 4 耐水性評価

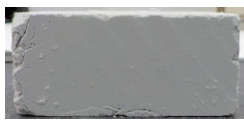
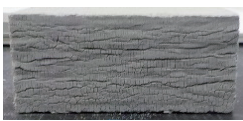
耐水性評価として水に浸漬し、乾燥後の外観と物性を比較した。具体的には試料を10秒間完全に水中に浸漬させた後、90℃×24hで乾燥させた。

erties were compared. Specifically, they were completely immersed in water for 10 seconds and then dried at 90℃ for 24 hours. After drying, the appearance of the end face and shrinkage in the plane direction and the thickness direction were confirmed. The photographs before immersion and after immersion and after drying, and the results of the shrinkage ratio in the plane direction and the thickness direction are shown in Table 5.

In the results, LTC-A showed little shrinkage and almost no cracks occurred. On the other hand, for other microporous insulation, much cracking occurred. In addition, shrinkage in

Table 5 Appearance of water resistant test



	LTC-A	Conventional 1	Conventional 2	Conventional 3
Before test				
After test				
Linear shrinkage / %	0.1	0.9	0.7	2.4
Thickness shrinkage / %	1.0	3.6	6.6	8.7

乾燥後に端面の外観及び面方向、厚み方向の収縮を確認した。Table 5に浸漬前と浸漬乾燥後の写真、及び面方向収縮率、厚み方向収縮率の結果を示す。

LTC-Aは試験後も収縮が小さく亀裂はほぼ生じていない。他のマイクロポーラス系断熱材については亀裂が大きく生じている。また、面方向の収縮率は0.1%、厚み方向の収縮率は1.0%であり、他のマイクロポーラス系断熱材と比較して収縮が小さい。このことからLTC-Aが耐水性に優れていることがわかる。

2. 5 長期加熱後の物性

実炉使用を想定し、長期加熱後(850℃×300h)の強度及び耐水性を確認した。その結果をTable 6に示す。

長期加熱後の強度は、2.1MPaあり、十分な強度を維持していた。また、長期加熱後も耐水性が消失することはなかった。長期加熱後も強度、耐水性が維持されていることから、実炉使用においても問題ないと言える。

the linear direction was 0.1%, and shrinkage in the thickness direction was 1.0%. The shrinkage was small compared to other microporous insulation materials. With these results, LTC-A is evaluated to be excellent in water resistance.

2. 5 Properties after long-term heating

Based on the supposition of an actual furnace, we confirmed strength and water resistance after long-term heating (850℃×300h). The results of test are shown in Table 6.

The modulus of rupture after long-term heating was 2.1MPa, and sufficient strength was maintained. In addition, the water resistance was maintained even after long-term heating. Since strength and water resistance are maintained even after long-term heating, it can be said that there is no problem with applying it to an actual furnace.

Table 6 Results of long-term heating test (850°C×300h)

Properties		Before test	After test
Liner shrinkage at 850°C x300h / %		—	0.7
Modulus of rupture / MPa		1.3	2.1
Compressive strength/ MPa (10% compressed)		1.5	5.4
Water resistance test	Before water resistance test		
	After water resistance test		
	Linear shrinkage / %	0.1	0.0
	Thickness shrinkage / %	1.0	0.0

3. まとめ

今回実施した評価試験の結果より、LTC-Aはマイクロポーラス系断熱材で低熱伝導率でありながら、高強度、耐水性を兼ね備えた性能をもつことが検証できた。現在実炉に採用されており、強度や耐久性において評価を頂いている。さらに、耐水性からキャストブルの内張りとして採用頂いている。

3. Conclusion

Experimental results demonstrated that LTC-A has high strength and water resistance, though it is a microporous insulation material having low thermal conductivity. LTC-A is adopted to various industrial furnaces, it has garnered good reviews in terms of strength and durability. Furthermore, LTC-A has been be more specific adopted for application to the backup heat insulation of castable lining in terms of water resistance.

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