

SHINAGAWA TECHNICAL REPORT

LTC-FLの紹介 (イソライト工業株式会社)

Introduction to Microporous Insulation Material
with Flexibility, LTC-FL
(Isolite Insulating Products Co., Ltd.)

青山 知 弘
Tomohiro AOYAMA

上 道 健太郎
Kentaro UEMICHI

鈴木 秀 尚
Hidenao SUZUKI



製品紹介／PRODUCT

LTC-FLの紹介 (イソライト工業株式会社)

Introduction to Microporous Insulation Material with Flexibility, LTC-FL (Isolite Insulating Products Co., Ltd.)

青 山 知 弘^{*1}
Tomohiro AOYAMA

上 道 健 太 郎^{*2}
Kentaro UEMICHI

鈴 木 秀 尚^{*3}
Hidenao SUZUKI

要 旨

マイクロポーラス系断熱材は、高い断熱性能から省エネルギー、CO₂排出削減の効果が大きいため、今後益々需要が高まると予想する。当社では従来よりLTCシリーズとしてラインナップしているが、本報では可撓性を有するLTC-FLについて紹介する。

Abstract

The demand for microporous insulation material predicted to increase more and more, because of its great contribution to energy conservation and/or reduction of CO₂ emission realized by superior thermal insulation efficiency. In addition to the microporous insulation material products which have been provided as LTC series by the authors' company, microporous insulation material with flexibility, LTC-FL, is developed. Flexible microporous insulation material, LTC-FL, has been introduced in this article.

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溶鋼容器等の内張りに使用されている。低熱伝導率断熱材であるため、厚さ3～7mmで用いられることが多いが、薄くなると強度が低いため、脆く破損しやすい。このため、曲面に施工する際は短冊状に加工したものを組み合わせて施工したり、短冊状に加工した断熱材をガラスクロス等で被覆した形態で施工する必要がある。しかし、これらの形状では短冊状の各ピースの接合による目地の増加によって断熱性能が低下するおそれがある。断熱性

1. Introduction

Since, in comparison with conventionally used heat insulation materials, such as heat-insulating brick, ceramic fiber or calcium silicate board, microporous thermal insulation material which is composed of super-fine particle smaller than 100 nm size, inorganic fiber and infrared scattering agent exhibits ultra-low thermal conductivity, it is applied for variety of industrial furnace walls or as relining material for the molten metal vessel. Due to low thermal conductivity, 3-7 mm thick microporous insulation material is commonly used. In accordance with the thinner board thickness, microporous insulation material has low mechanical strength and fragility and tends to break easily. When microporous

^{*1} イソライト工業株式会社 技術研究所 技術開発室 研究員 Researcher, Technical Development Section, Research and Development Center, Isolite Insulating Products Co., Ltd.

^{*2} イソライト工業株式会社 技術研究所 技術開発室 室長 General Manager, Technical Development Section, Research and Development Center, Isolite Insulating Products Co., Ltd.

^{*3} イソライト工業株式会社 技術研究所 所長 Executive Officer, Research and Development Center, Isolite Insulating Products Co., Ltd.

能を低下させないためには、できるだけ接ぎ合わせがない単一の断熱材を施工し、目地の増加を抑えることが重要なポイントとなる。

当社はマイクロポーラス系断熱材としてLTCシリーズをラインナップしている¹⁻³⁾が、曲面への施工時に問題なく対応できるように可撓性を有するLTC-FLを開発したため、その特徴を紹介する。

2. LTC-FLの特徴

LTC-FLは他のLTCシリーズと同様、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。Fig.1にLTCシリーズに適用されている低熱伝導率化技術を示す。LTC-FLはLTC系の原料にバインダーとして有機繊維を配合した断熱材である。有機繊維が部分溶融する温度で加熱することでバインダーとして機能し、可撓性が発現する。Fig.2に可撓性発現メカニズムを概念的に示す。

insulation material is applied on a curved surface relining work needs to be conducted coordinating many pieces of strip formed microporous insulation material or using a prefabricated glass cloth covered body in which strip formed microporous insulation materials are arranged. In such relining manner, however, lowering of thermal insulation efficiency is a concern because of the increased number of joints between pieces of strip formed microporous insulation material. In other words, monobloc microporous insulation material needs to be relined with minimum patching work and joints in order to secure good thermal insulation efficiency.

The authors' company provides microporous thermal insulation material with various specifications under the brand name LTC series¹⁻³⁾. Newly developed flexible microporous insulation material, LTC-FL, which is applicable to curved surfaces without difficulties, is introduced in this article.

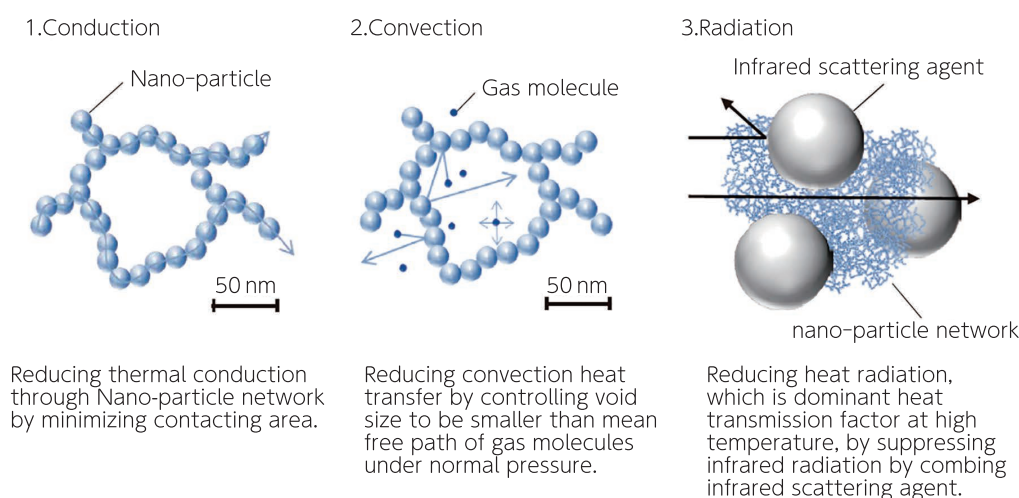


Fig. 1 Technologies applied for LTC series microporous insulation materials to achieve ultra-low thermal conductivity.

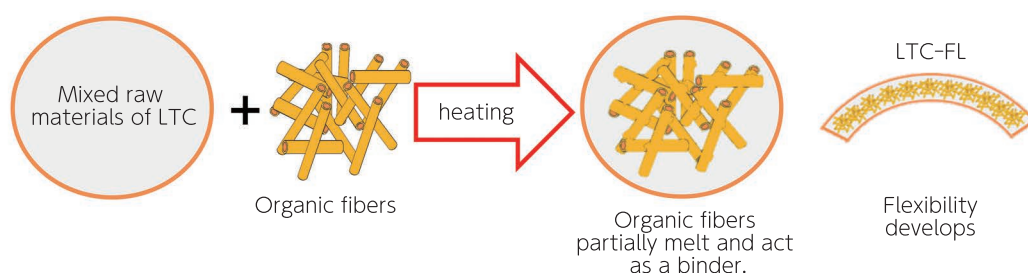


Fig. 2 Conceptual diagram of flexibility developing mechanism in LTC-FL.

Table 1 Major physical properties of LTC-FL and LTC series products

		LTC-FL			LTC-A	LTC-ES	LTC-HT
Size / mm		300 × 600			300 × 600	600 × 900	300 × 600
Thickness / mm		3	5	7	25, 50	25, 50	15
Radius of curvature / mm		200	300	400	—	—	—
Bulk density / kg·m ⁻³		300			410	250	430
Max temperature grade / °C		900			900	1000	1400
Linear shrinkage / % (at 24 hours)	at 900°C	2.9			0.8	—	—
	at 1000°C	—			—	0.3	—
	at 1400°C	—			—	—	2.2
Modulus of rupture / MPa		0.3			1.1	0.3	0.6
Thermal conductivity / W·m ⁻¹ ·K ⁻¹	at 600°C	0.03			0.04	0.03	0.09
	at 800°C	0.04			0.05	0.04	0.10
Ig. loss / %		5.9			—	—	—
Water resistance		×			○	×	○



Fig. 3 Appearance LTC-FL (3 × 300 × 600) bent by hand.

2. 1 基本物性

LTC-FL及び比較として他のLTCシリーズの基本物性をTable 1に示す。

LTC-FLの寸法は300×600、厚みは3、5、7mmであり、他のシリーズより薄い。曲率半径は破断せずに施工できる曲面の半径であり、厚みが薄いものほど小さな曲面に施工できる。Fig.3に3mm品を示す。その他の基本物性は他のいずれかのLTCと同等程度である。有機物を含むため、Ig.lossは約6%程度である。また、耐水性を有していないため、使用条件によっては断熱材を水分から保護することを目的に被覆や防水・撥水コートをする形態も検討している。

2. Characteristics of LTC-FL

The technologies applied for the LTC series microporous insulation materials to achieve ultra-low thermal conductivity are namely, technologies to reduce three (3) modes of heat transfer (conduction, convection and radiation), and are shown in Fig. 1. Similar to other LTC thermal insulation materials, LTC-FL is composed of super-fine particles of smaller than 100 nm size, an infrared scattering agent and reinforcing fibrous material. In addition to the materials of which LTC series microporous insulation materials are composed, organic fiber is blended in LTC-FL. The microporous insulation material is heated at a certain temperature at which blended organic fiber is partially melted. Since the partially melted portion acts as a supporting point for bending and/or contortion deformation, flexibility of LTC-FL develops. A conceptual diagram of the flexibility developing mechanism in LTC-FL thermal insulation material is shown in Fig. 2.

2. 1 Physical properties

The major physical properties of LTC-FL are compared to other LTC series microporous insulation materials in Table 1. The thickness of 300 × 600 mm LTC-FL is 3 mm, 5 mm and 7 mm, which is much thinner than that of other LTC series boards. The radius of curvature is the radius of the curved surface on which LTC-FL can be relined with no breakage. Thinner LTC-FL thicknesses can be

3. 施工例

LTC-FLはサンプル提供を行っており、ニーズ探索や適用範囲拡大を進めている。施工された事例や、提案事例について一部を紹介する。

3. 1 円筒炉（二次燃焼炉）

直径950mmの円筒炉（二次燃焼炉）の側壁最外層として施工した。5 mm品を鉄皮内側に市販の接着剤を使用して4層積層した。施工時の様子をFig.4に示す。施工時に大きな破損や脱落はなかった。

3. 2 加熱炉スキッドビーム

加熱炉のスキッドビームにCFブロックが適用される事例がある。断熱性の向上のため、CFブロックとLTC-FLを組み合わせ一体形状としたものを作製した。CFブロックの内側を曲面状に加工し、曲面部にLTC-FLを施工し一体形状とした（Fig.5）。予め一体形状とすることで、簡易に施工することができる。



Fig. 4 Appearance of LTC-FL relined in cylindrical furnace.

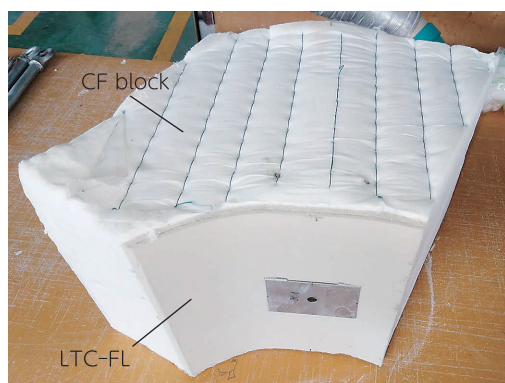


Fig. 5 One-piece CF block combined with LTC-FL.

applied on curved surface with smaller radii. Fig.3 shows the appearance of 3 mm thick LTC-FL bent by hand for demonstration. Other physical properties of LTC-FL are almost equivalent to those of other LTC series material. Because of blended organic fiber, LTC-FL exhibits approximately 6 % ignition loss. Since LTC-FL does not have water resistance, coating, covering or waterproof / water repellent finishing should be considered to protect LTC-FL from water components under certain relining conditions.

3. Examples of LTC-FL Application

We have been providing sample LTC-FL insulation products in order to research about increasing the application possibilities of LTC-FL are under way. Several examples of practical or proposed application uses of LTC-FL are introduced in this section.

3. 1 Application to cylindrical secondary combustion furnace

A four(4) layered outermost insulator on the side wall of a cylindrical secondary combustion furnace was relied with 5 mm of thick LTC-FL of 950 mm diameter using a commercially available adhesive agent. The appearance of LTC-FL relined in the cylindrical furnace is shown in Fig. 4. Neither breakage nor defluxion of LTC-FL took place during relining work.

3. 2 Application to reheating furnace skid beam

CF block is used for reheating the furnace skid beam. For better thermal insulation efficiency, one-piece CF block combined with LTC-FL was fabricated. As shown in Fig. 5, LTC-FL is relined on inner wall of CF block which is processed to fit the curved surface in advance. Construction work can be easily and smoothly conducted using pre-fabricating one-piece CF block combined with LTC-FL.

3. 3 Application on circular cylindrical heater for semiconductor

Application of LTC-FL as outer sleeve of a circular cylindrical heater with 600 mm diameter which is used for semiconductor was proposed. Upon request of a customer, laminated LTC-FL with curvature retained so as to fit the outer wall of a cylindrical heater was fabricated. Fig.6 shows laminated LTC-FL with retained curvature. The outer sleeve of the heater can be constructed by assembling several pieces of laminated LTC-FL.

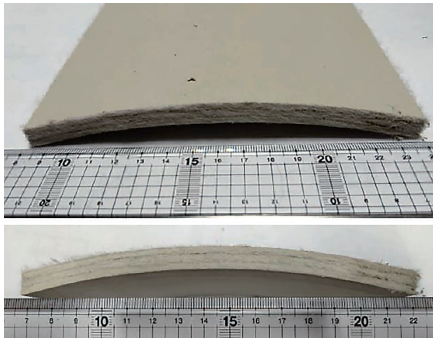


Fig. 6 Laminated LTC-FL with retained curvature.

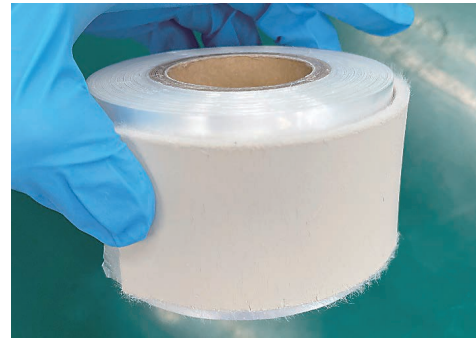


Fig. 7 Appearance of LTC-FL with improved flexibility, which is around 80 mm diameter core material.

3. 3 半導体用円筒ヒーター

直径600mmの円筒ヒーターのアウトースリーブとして提案した。ユーザー要望により、予めR形状をつけて積層し保持したものを作製した (Fig.6)。組付けることによって、スリーブ形状にすることができる。

4. 可撓性および耐熱性向上の取り組み

LTC-FLについて、更に可撓性を高める取り組みを行っている。可撓性を高めた小片試作品 3 mm品を直径80mmの芯材に巻き付けた様子をFig.7に示す。将来的に大判化、長尺化することによって、小型円筒炉やダクトに巻いて施工する、スリーブ形状にする等の展開をしていきたい。また、高温耐用性を高める要望に応えるべく、各種原料の調整による耐熱性向上の取り組みも行っている。

5. まとめ

可撓性を有するマイクロポラス系断熱材として、LTC-FLを紹介した。可撓性を有することによって、これまで困難であった円筒形状に施工することができ、適用範囲の拡大が期待できる。断熱性能も優れていることから、省エネルギー、CO₂排出削減の効果が大きいため、社会的ニーズの高まりに応える断熱材として貢献が期待できる。

4. Attempts for Improved Flexibility and Heat Resistance

Study for improved flexibility of LTC-FL is under way. Fig.7 shows the appearance of a small piece of 3 mm thick LTC-FL with improved flexibility, which is rolled around 80 mm of diameter core material. It is expected that, by enlarging size or lengthening length, LTC-FL with improved flexibility will be used for a variety of applications, such as rolling around small size cylindrical furnaces or ducts, prefabrication to sleeved shape and so on.

In addition, research on the improvement of the heat resistance of flexible LTC-FL is being conducted by adjusting raw materials so as to respond requirements for improved heat resistance.

5. Conclusion

Microporous insulation material with flexibility, LTC-FL, was introduced in this article. Since microporous thermal insulation material to which flexibility is provided can be applied for curved surfaces of target facilities, applications of microporous insulation material are being broadened. Due to inherent superior thermal insulation efficiency and newly given flexibility, wider application uses of flexible microporous insulation material, which contributes to energy conservation and/or reduction of CO₂ emissions, are anticipated.

References

- 1) A. Sueyoshi, N. Sumimura and K. Uemichi : Taikabutsu, **68** [6] 245-248 (2016).
- 2) K. Miyake, A. Sueyoshi and T. Hashimoto : Taikabutsu, **70** [3] 126 (2018).
- 3) K. Asakawa, Y. Suzuki, M. Iida and S. Suetake : Shinagawa Technical Report, **65** 43-56 (2022).