

SHINAGAWA TECHNICAL REPORT

鑄鋼鍋の改善

～ 不焼成アルミナ・マグネシア質ALTIMA
れんがの適用による寿命延長 ～

Improvement of Steel Casting Ladles

～ Extension of Service Life by Application of Unfired
Alumina-Magnesia Brick, ALTIMA ～

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品川技報

特別寄稿
CONTRIBUTION

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Improvement of Steel Casting Ladles
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Abstract

This article describes the history of steel ladle refractory improvement implemented in Akimoku steel Co., Ltd. in association with Ceratechno Co., Ltd. While newly developed unfired alumina-magnesia brick ALTIMA showed a much smaller wear rate, it wasn't enough to extend its service life. Thanks to another several technological developments such as inhibition of steel skull adhesion, improvement of well block durability and suitable application of troweling repair, its service life improved from 100 heats to 180 heats, resulting in 47 % reduction in the overall specific cost of steel ladle refractories.

1. 緒言

当社は10Tエルー式アーク炉で製鋼し8Tまたは7T取鍋で受鋼して鋳造を行っている。2016年にステンレス鋼種の比率増加に対してアーク炉の炉床スタンプ材の掘れ損傷の改善を報告したが現在まで床起こし無しで安定した状態である。一方、取鍋においても受鋼鋼種の多品種化により平均耐用回数が100回前後で安定しないため、コスト及び築炉作業面で課題となっていた。そこで今回取鍋れんがの改善に取り組むことで、安定耐用を実現し寿命が1.8倍に延長し、耐火物総合原単価が47%低減できた事例を報告する。

1. Introduction

Akimoku steel smelts steel in a 10 T-Heroult electric arc furnace and the molten steel is tapped to a 8 T or 7 T steel ladle, followed by steel casting. In 2016, we reported a countermeasures for improving excavation damage of the hearth ramming material of the electric arc furnace that had been caused by the increase in the stainless products. Since then, it has maintained a stable condition without large repairs until now.

On the other hand, in the case of the steel

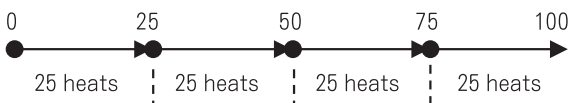
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※一般社団法人 日本鋳鍛鋼会「鋳鋼と鍛鋼」 No.550, pp.18-25 (2019)より転載（英訳は弊社による）

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Table 1 Conventional repair pattern

100 heats pattern (Conventional)					
[Repair method]					
• Bottom brick replacement		○	○	○	< Dismantle >
• Well block replacement		○	○	○	
• Impact area replacement		—	○	—	

2. 取鍋の修理パターン

2. 1 従来のライニングと修理パターン

従来取鍋のウェアれんがは、側壁と敷湯当り部はジルコン質、敷の一般部はハIALルミナ質を使用している。表 1 に従来の修理パターン示す。敷湯当り部及びノズル受けが25回、側壁湯当り部が50回で交換する必要がある、計100回で全修理（解体）となっている。

3. 適用材質の検討

ジルコン質れんがは、原料のジルコンの産地が限定されることから需給により価格が影響される。一方、アルミナ・マグネシア質は原料供給面が安定し、高耐用を示すことから多くの高炉メーカーの取鍋で流し込み材として使用されている。しかし流し込み材ではミキサーや厳密な温度コントロールが可能な乾燥装置が必要である。不焼成アルミナ・マグネシア質れんが（ALTIMA）はアルミナ・マグネシア質流し込み材の特徴を有したれんがであるので流し込み設備は不要である。表 2 に品質表を示す。

Table 2 Typical properties of ALTIMA

	Alumina-Magnesia brick ALTIMA
Chemical composition / mass%	
Al ₂ O ₃	88
MgO	7
Apparent porosity / %	10.0
Bulk density / -	3.40
CCS / MPa	63

ladle, the average number of heats between full lining repairs was unstable at around 100 heats due to the diversification of the type of smelted steel. It has been a problem in terms of cost and furnace construction work load. This report describes a result of ladle refractory improvement that achieved stable service life and extended life by a factor of 1.8, resulting in a reduction of the overall refractory material cost by 47%.

2. Ladle Repair Patterns

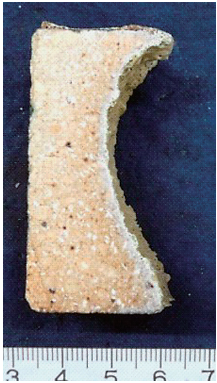
2. 1 Conventional lining and repair patterns

Conventionally, two types of bricks had been applied as the ladle's wear lining, one was zircon brick for the side wall and the bottom impact area and the other was high alumina brick for the general part. Table 1 shows a conventional repair pattern. The big repair, which replaces all bricks subsequent to dismantling of entire zone, was carried out every 100 heats while the small repair, which exchanges bottom impact area bricks and well block, was done every 25 heats and the medium repair, in which bricks of wall impact area are exchanged, was done every 50 heats.

3. Investigations of Suitable Materials for Steel Ladle

The price of zircon brick is unstable since it is strongly influenced by supply and demand. This is because of the uneven distribution

Table 3 Corrosion resistance

	Zircon brick	ALTIMA
Cut section after corrosion test		
Corrosion / mm	9.2	1.1
Index / -	100	15

Rotation crucible method
Temp. — Time : 1650 °C — 60 min
Slag : Actual slag for stainless steel refining.
Obtained from ladle of AKIMOKU Steel just after tapping.
Exchanged every hour during the test.

表3にジルコンれんがとALTIMAれんがの耐食性比較を示す。試験は回転ルツボ浸食試験装置を用い、ステンレス鋼の出鋼後スラグ (C/S=1.6) を使用し1650℃で60minの条件で評価した。試験後切断面写真に示すように、侵食指数はジルコンに100に対してALTIMAは15と非常に耐食性が優れていることから、このALTIMAれんがを取鍋に適用しテストを開始した。

4. ALTIMAれんがのテスト結果

4. 1 側壁のテスト結果

表4にALTIMAれんがの側壁適用テストの結果をジルコンれんがと比較して示す。使用回数はALTIMAれんがは湯当り部1～3段は50回、4～6段は109回、ジルコンれんがは湯当り部1～3段は25回、4～6段は75回である。

どちらも湯当り部となる1,2段目がもっとも薄い。損傷速度を比較するとジルコンの2.36mm/回に対してALTIMAは0.88mm/回と非常に損傷が小さい。

側壁は原寸114mmであり使用後の有効残厚を

of the natural resources. On the other hand, alumina-magnesia castables are used for steel ladles of many integrated steel mills because the raw material supply is relatively stable and the castables exhibit high durability. However, castables require mixers and dryers capable of precise temperature control. Hence, unfired alumina-magnesia brick (ALTIMA) is a candidate as an alternative. ALTIMA is a brick with the equivalent characteristics of alumina-magnesia castable, and therefore no casting facility is required. Table 2 shows the typical properties of ALTIMA.

Table 3 shows comparison of the corrosion resistance of zircon brick and ALTIMA brick. The evaluation was carried out by rotating crucible method for 60 minutes at a temperature of 1650 °C using a slag (C/S=1.6), which had been obtained from an actual steel ladle just after receipt of stainless steel tapped from an electric arc furnace. As shown in the cross-sectional photograph after the test, ALTIMA brick showed excellent corrosion resistance compared to zircon brick. The relative corrosion amounts were 15 for ALTIMA and 100 for zircon. Therefore, it was judged that ALTIMA brick was applicable to a commercial steel ladle and an industrial trial began.

4. Results of ALTIMA Brick Trial

4. 1 Sidewall wear

Table 4 shows the results of the sidewall application trial of ALTIMA brick compared to zircon brick. The number of heats for ALTIMA brick was 50 heats for layer 1 to 3, which corresponds to the impact are, and 109 heats for layer 4 to 6, while those for zircon brick were 25 heats for layer 1 to 3 and 75 heats for layer 4 to 6. For both cases, the thinnest residual thicknesses were observed for layer 1 and 2 to where the tapped molten steel impacts

Table 4 Residual thickness of side wall after use

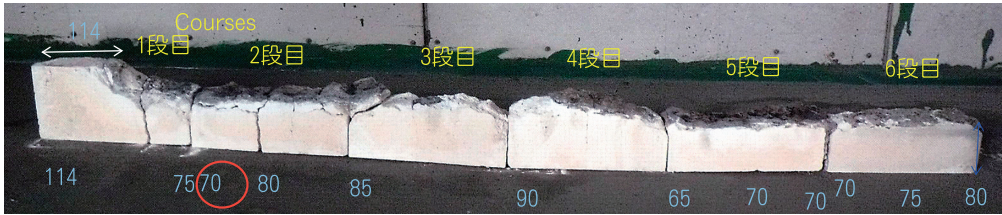
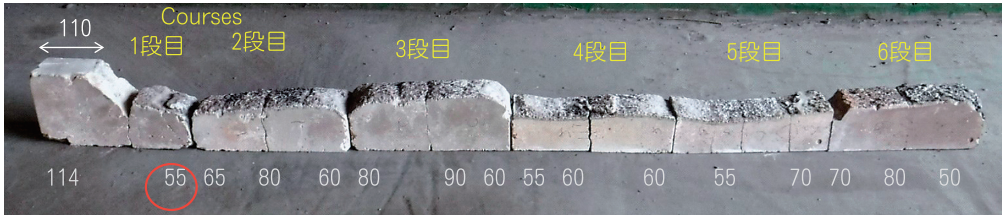
	Side wall course 1 to 6
Tested ALTIMA [109 heats] 1-3 : 50 heats 4-6 : 109 heats	 Impact area 0.88 mm·heat ⁻¹
Conventional Zircon brick [75 heats] 1-3 : 25 heats 4-6 : 75 heats	 Impact area 2.36 mm·heat ⁻¹

Table 5 Target repair pattern

100 heats (Conventional)	0 — 25 — 50 — 75 — 100 25 heats 25 heats 25 heats 25 heats
180 heats (Trial)	0 — 45 — 90 — 135 — 180 45 heats 45 heats 45 heats 45 heats
Repair methods	Bottom brick replacement Well block replacement Troweling repair for wall impact area Bottom brick replacement Well block replacement Wall impact area brick replacement

30mm以上と想定する場合には、今回の寿命延長テストでは側壁湯当り部の耐用目標を90回（湯当り以外の側壁は180回）、敷部れんが及びノズル受けの使用回数を45回と設定することにした。なお側壁湯当り部は90回後の残厚は34.8mmと試算され操業変動に対して余裕を持つため、途中の損傷状態に応じてコテ塗り補修材を併用することにした。今回のテストの目標修理パターンを表5に示す。

4. 2 敷の溶鋼付着

従来敷部では湯当り部はジルコン、一般部はハIALミナであったが、テストではオールALTIMAれんがで置換した。その結果、鑄造完了後の排滓、整備時に敷部れんが表面に溶鋼が付着して酸素で洗い流す必要が発生した。

severely.

With respect to the wear rate, the ALTIMA showed 0.88 mm/heat, which is much smaller compared to the 2.36 mm/heat that was observed for zircon brick. Thus, considerable extension of ladle service life is expectable. In order to achieve it, improvements in durability of the well block and impact area are necessary. Taking the original thickness of the side wall (114 mm) into account and assuming an effective residual thickness of 30 mm, target service lives of the well block, impact area and general wall were set as 45 heats, 90 heats and 180 heats, respectively. While theoretical calculation predicts 34.8 mm for the residual

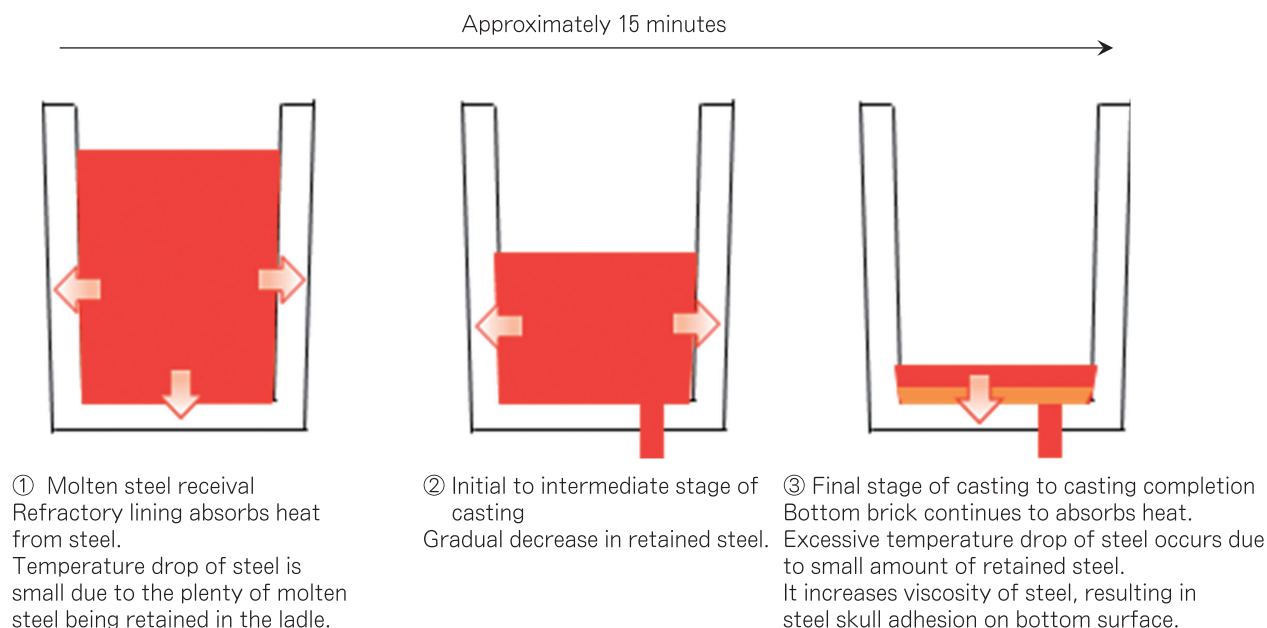


Fig. 1 Hypothesis for steel skull adhesion on bottom.

この原因について溶鋼かられんがへの流入熱量が、ジルコンとALTIMAは同じ程度であるものの、ハIALミナはそれらの材質に比較して流入熱量が小さいことによるものと考えた。すなわち、一般部のハIALミナの範囲までも流入熱量の大きいALTIMAに置換したために casting 末期に鍋内の溶鋼量が少なくなった時に敷れんがに溶鋼の熱が奪われ粘性が増加し溶鋼が付着した（酸素洗いしないと流れ落ちにくくなった）と考えた。この推定モデルを図1に、れんがへの流入熱量の試算グラフを図2に示す。

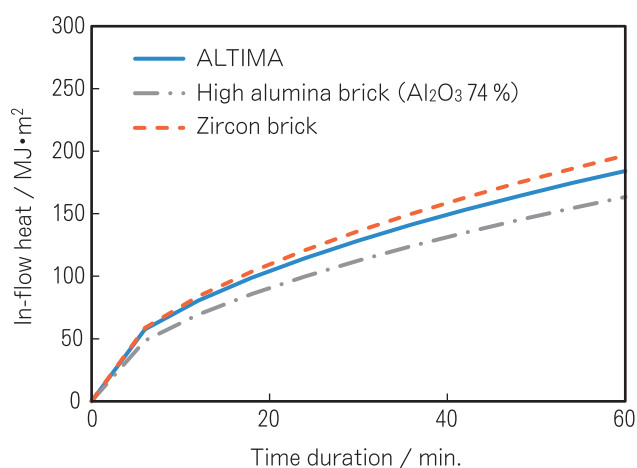


Fig. 2 Calculated changes in in-flow heat of ladle.

thickness of the wall impact area, fluctuation of wear rate according to changes in operating condition should be taken into consideration. Thus, combined application of troweling repair was assumed. The target repair pattern for this test is shown in Table 5.

4. 2 Adherence of molten steel skull to bottom

As a trial, ALTIMA bricks were used for the full lining. As a result, serious steel skull adhesion to the bottom surface took place so that it became necessary to remove it by oxygen flushing during the slag discharging-maintenance stage after casting completion. This is considered attributable to the difference in in-flow heat. Although the in-flow heat of the ALTIMA brick-installed ladle is almost equivalent to that of the zircon brick-installed ladle, it is smaller than that of the high alumina brick-installed ladle. Therefore, excessive temperature drop of molten steel occurs for the ALTIMA full-installed ladle at the final stage of casting when the amount of retained molten steel becomes smaller, resulting in an increase

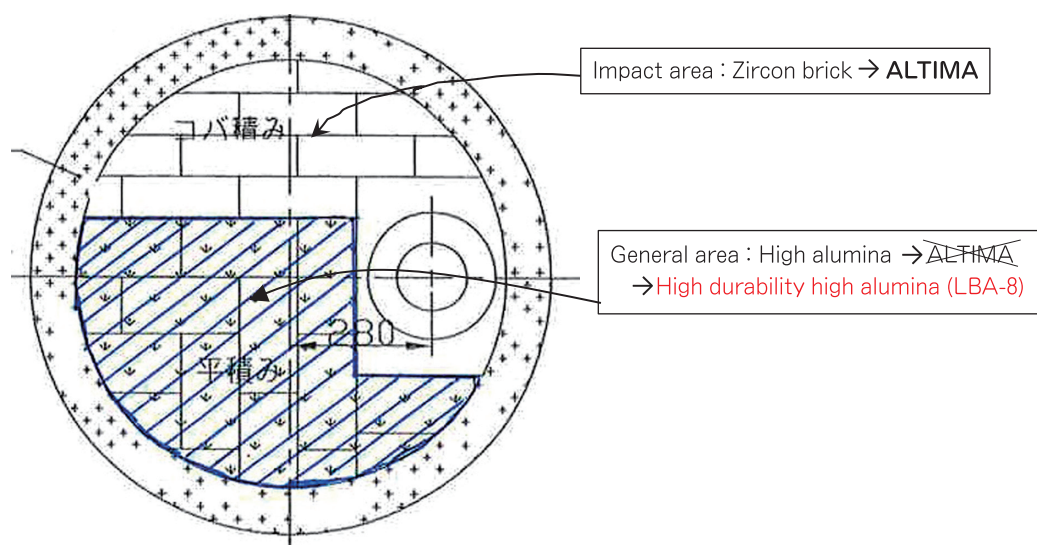
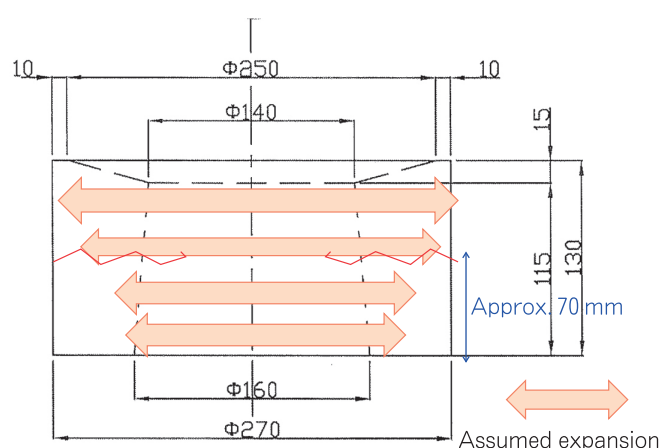


Fig. 3 Bottom brick lining.

Table 6 Typical properties of high alumina bricks

	LBA-8 Al ₂ O ₃ 81%	Conventional Al ₂ O ₃ 74%
Modulus of rupture / MPa	15.2	9.6
Cold crushing strength / MPa	97.0	57.8
Apparent porosity / %	20	23.3
Bulk density / -	2.75	2.56
Apparent density / -	3.43	3.33

Table 7 Corrosion resistance of high alumina brick for bottom



そこで、ハialミナノ範囲は、ALTIMAではなく低気孔率、高強度のハialミナLBA-8に置換することにした。図3に数部のライニング、表6にLBA-8と従来品の品質比較を、表7に耐食

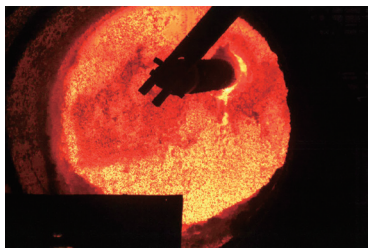
in molten steel viscosity. The drainage difficulty due to high viscosity caused the steel adhesion. Figures 1 and 2 show the hypothesized steel adhesion process and theoretical difference in in-flow heat of the ladle to which the materials were installed, respectively.

According to the hypothesis, high strength high alumina brick LBA-8 was used in the area of which traditional high alumina brick had been installed since its heat capacity is larger than that of ALTIMA. Figure 3, Tables 6 and 7 show schematic illustrations of the bottom brick arrangement, typical properties of two high alumina bricks and result of corrosion resistance evaluation, respectively. This brick arrangement reduced the steel skull adhesion to the acceptable level as shown in Table 8.

4. 3 Bottom wear

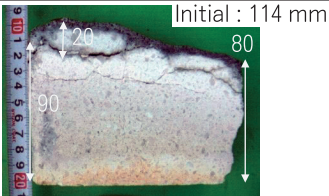
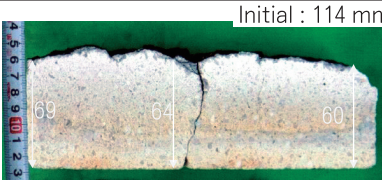
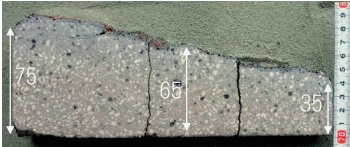
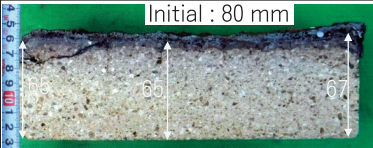
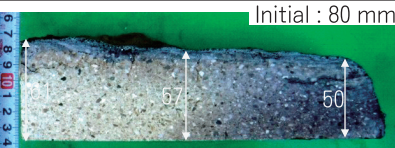
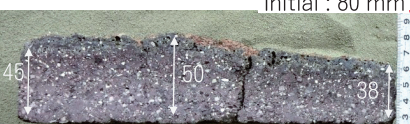
Table 9 shows the cut surface of a bottom brick after 25 heats. Both ALTIMA and LBA-8 showed sufficient residual thickness in comparison with conventional zircon brick and high alumina brick. In this application, the residual thickness of ALTIMA brick-installed area around the well block was insufficient. The wear of this area is attributable to rapid

Table 8 Steel skull adhesion configuration

Steel skull adhesion (Trial 1) (SiC-coated ALTIMA)	No adhesion (Conventional) (Zircon & High alumina brick)	Less adhesion (Trial 2) (ALTIMA & LBA-8)
		

Steel skull adhesion became smaller to acceptable level by application of ALTIMA & LBA-8 for ladle bottom.

Table 9 Residual thickness of bottom brick after 25 heats

	Trial 25 heats		Conventional 25 heats
	ALTIMA : Central area	ALTIMA : Peripheral area	Zircon brick
Impact area			
General area			

性比較を示す。

敷部がALTIMAとLBA-8のライニングでは、表 8 に示す通り従来と比べて溶鋼附着は許容できる程度になった。

4. 3 敷れんがの25回テスト結果

表 9 に25回使用後の敷れんがの切断面写真を示す。

従来のジルコンとハIALミナに比べて、ALTIMAとLBA-8は残厚が十分に大きく良好である。ただしノズル側の部分は、ノズル受けの損傷（25回で使用限界）に影響されて残厚が小さくなっており、ノズル受けが耐用アップすればその近傍のれんが残厚も大きくなると考えられた。

4. 4 ノズル受けのテスト結果（1）

従来のハIALミナ質ノズル受けは25回が使用限界であった。そこでアルミナ・マグネシア質

wear of well block, 25 heats maximum. Hence, it was considered that improvement of well block durability would reduce the wear rate of the ALTIMA brick-installed area around the well block.

4. 4 Well block test results (1)

In order to extend the 25 heats service life of conventional high alumina well block, the effect of well block made of alumina-magnesia material AMP-8Y2 was evaluated. Tables 10 and 11 summarize the typical properties and corrosion resistance of well block, respectively.

As a result of commercial application, AMP-82Y showed horizontal cracking at a 70 mm height from the back end, which was at the

Table 10 Typical properties of well brocks

		Alumina-Magnesia	High alumina
		AMP-8Y2	Conventional
Chemical composition / mass%	Al ₂ O ₃	92	82.4
	MgO	6	
	SiO ₂		9.4
Apparent porosity / %		15.5	21.5
Bulk density / -		3.20	2.70
Cold crushing strength / MPa		60	41

Table 11 Corrosion resistance of well blocks

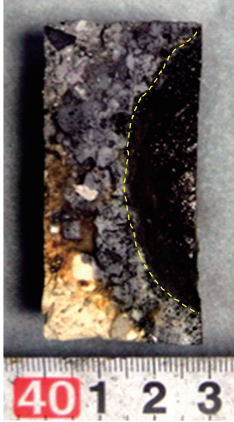
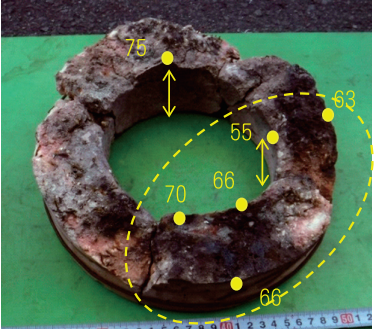
	Alumina-Magnesia	High alumina
	AMP-8Y2	Conventional
Cut section after corrosion test		
	Depth 5.4 mm Index 41	Depth 13.4 mm Index 100

Table 12 Situation of well block after 41 heats

	External view from shell	Upper side	Lower side
After 41 heats			

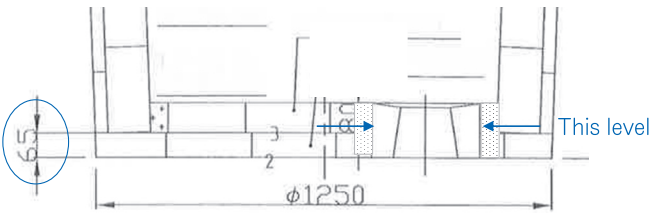


Fig. 4 Cracking position of well block.

AMP-8Y2をテストした。AMP-8Y2の品質表を表10に、従来のハイアルミナとの耐食性比較を表11に示す。

ノズル受けAMP-8Y2の実炉テスト結果は表12の様に高さ130mmの方向の中間付近(70mm付近)で割れてしまった。図4に示すようにこの割れた部分は鍋の施工位置ではALTIMAれんがとパーマれんがの境界付近になる。

middle range of its initial thickness of 130 mm as shown in Table 12. As shown in Fig. 4, the cracking occurred at the interface level of the ALTIMA brick and permanent lining.

After the trial, the well block was retrieved and mineralogical compositions of upper and lower part from the crack were evaluated by X-ray diffraction method. Figure 5 shows the result. Although magnesia, which is indicated as “M”, was detected in the lower part, it disappeared, and spinel, which is indicated as “SP”, was detected in the upper part. As a result of the spinel forming reaction, alumina-magnesia material showed rapid expansion above 1200 °C

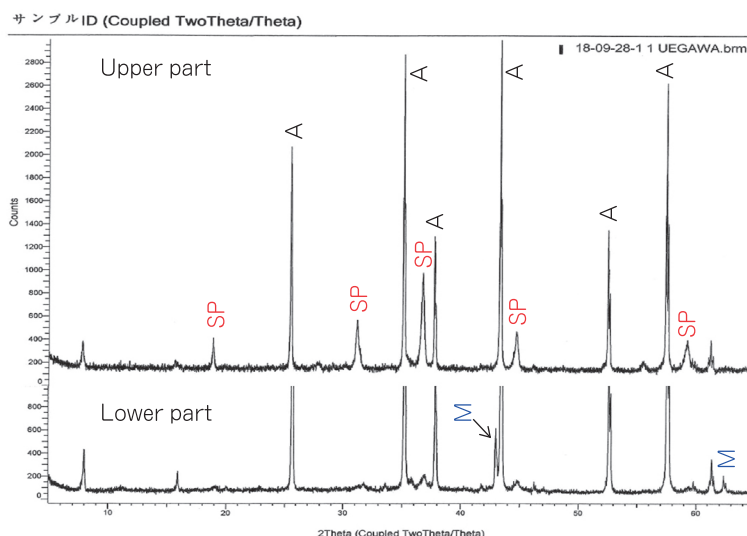


Fig. 5 XRD spectrum of well block after use.

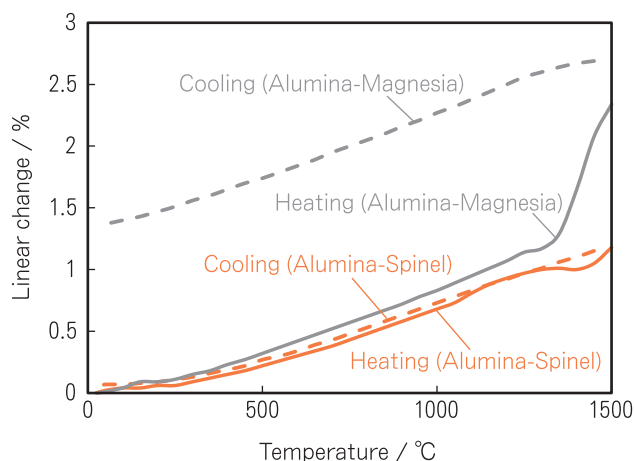


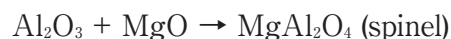
Fig. 6 Thermal expansion behaviors.

使用後ノズル受けを回収し、途中で割れた位置の上側と下側のサンプルをX線回折法により鉱物相を調査した。その結果を図5に示す。下側には“M”で示したマグネシアのピークが見られるが、上側には“M”はなくスピネル“SP”が検出される。アルミナ・マグネシア質は、1200℃以上で次に示すスピネル生成反応によって図6に示すように大きく膨張する。



これらのことからノズル受けは上側（鍋内側）は溶鋼の熱によりスピネルが生成して急激な体積膨張が起きるが、下側（鉄皮側）はスピネル化に

as shown in Fig. 6.



From these facts, the cause of cracking is inferred as follows. Although rapid expansion according to the spinel formation reaction occurs in the upper side at which sufficient heat is provided from molten steel, the expansion of the lower side is smaller since no spinel formation is expected due to the lower temperature. This situation creates a volume expansion mismatch, resulting in cracking at the middle range of its lining. This configuration is schematically illustrated in Fig. 7.

4. 5 Well block test results (2)

Therefore, in order to reduce the influence of expansion due to spinel forming reaction, a well block made of AMP-8Y2, which had been fired at over 1300℃ in advance, were tested. The result was that 44 heats were achieved without middle range cracking. Wall wear was the limiting factor at 44 heats. According to the investigation of the samples obtained from the well block after application, it was judged to be good and still usable. Hence, it was clarified that 45 heats was achievable.

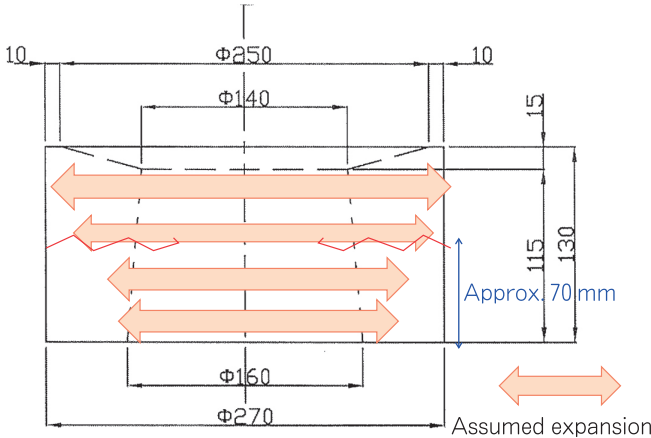


Fig. 7 Schematic illustration of expansion mismatch.

は至らない小さな膨張であったため膨張ギャップが生じて中間付近で割れたと推察される。筆者らはこの膨張ギャップを図7のようにイメージした。

4. 5 ノズル受けの実炉テスト結果 (2)

そこでスピネル化膨張の影響を低減することを狙い、予め1300℃以上で焼成したアルミナ・マグネシア質AMP-8Y2を取鍋でテストした。その結果、中間付近での割れの発生はなく44回を問題なく耐用して、壁要因で使用終了となった。ノズル受けの使用後の状態は良好でまだ使用可能な状態で45回は十分に耐用可能と判断した。

4. 6 コテ塗り補修材のテスト結果

壁湯当り部の局所的な損耗に対してアルミナ・マグネシア質のコテ塗り材による修理間 (途中) での補修テストを行った。テストの結果を表13に

4. 6 Troweling repair material test results

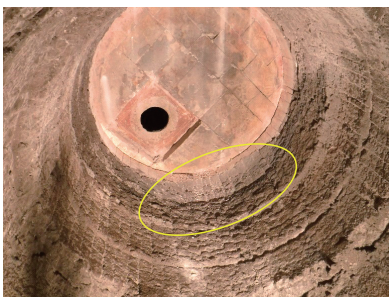
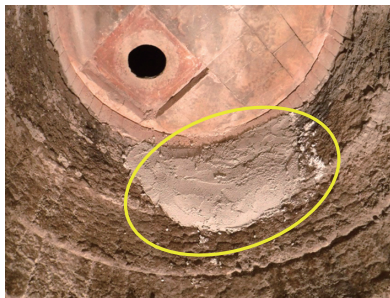
In order to repair local corrosion of the impact area, alumina-magnesia troweling material was evaluated as the material for intermediate repair, which is carried out between brick replacing repairs. Table 13 summarizes the test results. Troweling repair material SSC-AM340T is used as paste kneaded with water. As a result of the trial, good workability for installation, which resulted from easy adjustability of the paste softness by controlling the amount of water, as well as sufficient durability, that is, 7 to 8 heats without peeling-off. Accordingly, excellent adhesion during operation was confirmed.

4. 7 Results of trials for 45 heat cycle-repairs

Table 14 summarizes condition of the bricks after use. ALTIMA was used for the side wall and both ALTIMA and LBA-8 were used for bottom. They were 91 heats and 41 heats, respectively. According to the investigations of these samples, sufficient durability of these bricks was confirmed.

The fired well block made of alumina-magnesia AMP-8Y2 was used as trial for 45 heat cycle-repairs. For the well block, a small troweling repairs were applied. The results are shown in Table 15. While the repair had been carried

Table 13 Trial result of troweling repair material

Impact area wear (50 heats)	Troweling repair	2 heats after repair (89 to 90 heats)
		
Local wear of impact side at course 1 to 2	20 kg of troweling repair	Troweling repair material sticks to ALTIMA firmly

示す。コテ塗り材SSC-AM340Tは水分調整により容易にコテで塗り付けしやすい軟らかさにできて、使用中のれんがによく接着して剥がれることはなく7～8回の耐用を確認できた。

out every 25 heats or less conventionally, the trial results showed that 45 heat cycle-repairs became possible.

Table 14 Investigation of the bricks after use

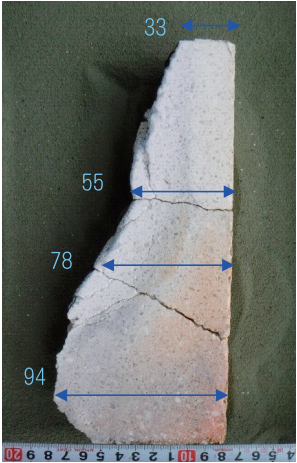
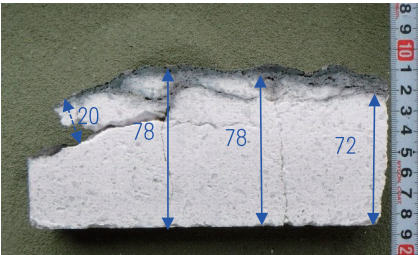
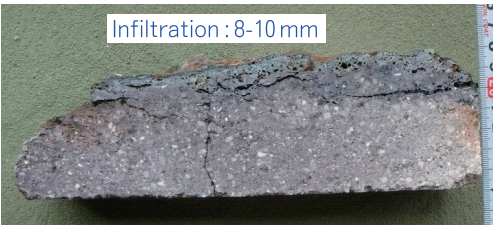
	ALTIMA for wall of impact area /course 1	ALTIMA for bottom (41 heats)	LBA-8 for bottom (41 heats)
External appearance	(91 heats) 		
Cut section	 Initial thickness: 114 mm, Target heats: 50 heats Peeling-off occurs. Residual thickness (more than 70 mm) predicts target heats (45) achievement.	 Initial thickness: 114 mm, Target heats: 90 heats The thinnest point (33 mm) covered by troweling material (30 to 40 mm). 3 troweling repairs after 50 heats.	 Initial thickness: 80 mm, Target heats: 50 heats Peeling-off occurs. Residual thickness (more than 60 mm) predicts target heats (45) achievement.

Table 15 Result of trial for 45 heats cycle-repair

Ladle #3

42 heats 43 heats 22 heats 44 heats

0 42 56 (14) 61 (19) 73 (31) 85 95 (10) 107 126 (19) 137 (30) 151

Troweling repairs Troweling Troweling

45 heats became possible

Lining	Wall	ALTIMA	ALTIMA	ALTIMA	ALTIMA
	Bottom	ALTIMA+LBA-8	ALTIMA+LBA-8	Zircon & High alumina (Conv.)	ALTIMA+LBA-8
	Well block	Alumina-Magnesia	Alumina-Magnesia	High alumina (Conv.)	Burnt Alumina-Magnesia

Repair	Heats	42(after repair) / 42(total)	43(after repair) / 85(total)	22(after repair) / 107(total)	55(after repair) / 151(total)
	Critical wear for repair	Damage of well block	Damage of well block	Damage of well block	Damage of brick around well block Optimization of replacement area enables 45 heats
	Repair methods	<Brick replacement> Bottom brick Well block	<Brick replacement> Bottom brick Well block	<Brick replacement> 4 courses of impact side Bottom brick Well block	Whole brick replacement after complete dismantling

Table 16 Summary for achievements of trials

Area	Materials	Target life	Trial result	Conventional	
Wall	Alumina-Magnesia (ALTIMA)	180 heats	Achieved	Zircon	90 – 100 heats
Wall Impact area	Alumina-Magnesia (ALTIMA)	90 heats × 2	Achieved with troweling repair	Zircon	45 – 50 heats × 2
Bottom	Impact area; Alumina-Magnesia (ALTIMA) General area; High alumina (LBA-8)	45 heats × 4	Achieved	Impact area; Zircon General area; High alumina	20 – 25 heats × 4
Well block	Burnt Alumina-Magnesia (AMP-8Y2PBB)	45 heats × 4	Achieved	High alumina	25 heats × 2
Local wear Wall / Bottom	Troweling repair material (SSC-AM340T)	7 to 8 times	Applicable to local wear	-	-

4. 7 45回修理パターンでの各材料のテスト結果

側壁ALTIMAの91回、敷ALTIMA及びLBA-8の41回の使用後の状態及び残厚結果を表14に示す。壁は90回以上を、敷は45回を十分に耐用できることを確認した。

アルミナ・マグネシア質AMP-8Y2の焼成ノズル受け、コテ塗り補修材を適用し45回修理パターンでテストした結果を表15に示す。従来は修理間隔が25回以下であったが今回のテストにより45回修理パターンでの運用が可能になった。

5. 寿命延長テストのまとめ

寿命延長テストの結果を表16に示す。従来のジルコンライニング鍋では25回修理パターンで計100回であったが、今回のテストの結果、側壁及び敷湯当り部にALTIMA、敷一般部にハイアルミナ質LBA-8、アルミナ・マグネシア質焼成ノズル受

5. Summary of Service Life Extension Trials

The results of the life extension tests are shown in Table 16. As described in section 2.1, the service life of conventional zircon lining ladle was 100 heats with 25 heat cycle-minor repairs. As a result of the trials, a service life of 180 heats with 45 heat cycle-minor repair became possible with the new lining, which consists of ALTIMA for the side wall and bottom impact area, and LBA-8 for the general zone of bottom and fired well block made of alumina-magnesia composition. This improvement reduced the specific cost of ladle refractories 47 % as shown in Fig. 8.

6. Conclusion

In order to extend the life of the steel ladle and to achieve stable durability, ALTIMA brick, which is an unfired alumina-magnesia brick, was tested as an alternative to conventional zircon brick. In addition, alumina-magnesia troweling material was also applied as a repair material used for local damage of the well block and the hot impact area.

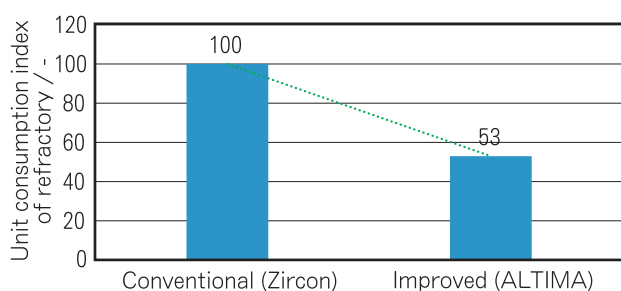


Fig. 8 Comparison of overall unit consumption of refractory.

けを適用したライニングでは45回修理パターンで計180回の耐用が可能となった。

この寿命延長により図8に示すように取鍋耐火物総合単価を47%低減できる目処を得た。

6. 結言

取鍋の寿命延長、安定耐用を目的にれんが材質を従来のジルコンから不焼成アルミナ・マグネシア質のALTIMAれんがを適用してテストした。またノズル受け及び湯当り部の局所的な損傷に対して活用するコテ塗り材にもアルミナ・マグネシア質を適用して安定耐用を図った。

その結果、

- 1) 従来は25回修理パターンで計100回の耐用であったが、45回修理パターンで計180回の耐用を達成することが可能となった。
- 2) 取鍋耐火物総合原単価指数が100から53に47%低減できた。
- 3) 取鍋の修理、解体・施工の頻度低減と、修理計画が立てやすくなり作業性、生産性の向上にも貢献した。

今後はさらに寿命200回に向けて改善を図っていく。

7. 謝辞

本報告の取鍋の寿命延長は、昭和電炉興業(株)、品川リフラクトリーズ(株)と共に、取組み実現した成果であることをご報告し、ここに改めてまして両社に謝意を表します。

As a result, the following conclusions were obtained.

- 1) Service life was improved from 100 heats with 25 heat cycle-minor repairs to 180 heats with 45 heat cycle-minor repairs.
- 2) The overall specific cost index of the steel ladle reduced by 47 %.
- 3) The frequency of repair, dismantling and construction of the ladle was reduced, which enabled easier repair planning. This contributed to improvement of workability as well as productivity.

For the future, we will continue to improve ladle refractories to extend service life to 200 heats.

7. Acknowledgment

The improvement described in this report was achieved by working together with Showa Denro Kogyo Co., Ltd. and Shinagawa Refractories Co., Ltd. We extend our appreciation to those two companies.