SPRAY SYSTEM DEVELOPMENT FOR QUALITY IMPROVEMENT IN REPAIRING THE BLAST FURNACE

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ABSTRACT

This report is about spray system of blast furnace designed to improve furnace wall repair quality and life.

In general, there are several ways to repair furnace wall such as spraying, injection and pre-cast panel repair etc. Especially, Spraying is often used because it can repair wide range with high efficiency. But, due to enlargement of blast furnace size and distribution form of charging materials inside furnace, there are many difficulties to repair furnace wall. As a result, the need for repair quality development has been on the rise.

So, we developed brand new system which is available to evaluate repair materials, repair machine and repair quality to solve above situation. Repair materials are Silica sol bond based, and Al2O3-SiO2, Al2O3-SiC are for each part. Repair machine is developed to repair without interference of charging material but at the same time, repair ability and adhesion are enhanced. Quality evaluation facility can monitor repair state in real time. 3D Scanner evaluates rebound loss rate and repair state.

Here are results of real application. Rebound loss is under 10% with high adhesion so, reached normal operation in early stage. Especially, repairing life and repair cycle are improved by repair quality improvement. Consequently, we can guarantee stable furnace management and productivity improvement.

INTRODUCTION

Due to blast furnace operation technic improvement, demand for longer lifespan of refractories and repair method has increased over a decade.

There are BF wall spray repair, grouting repair(upper tuyere, taphole, lower BF wall), and pre-casr panel repair. (Table 1, Fig. 1) Among the three repair methods, wall spray method allows larger dimension repair and has high efficiency rate which is why it has become the most common repair method. However, introduction of larger blast furnace created unforeseen restraints which led to development of new wall repair material and method.

Recently, material base for wall material is moving towards colloidal silica bond from previous cement bond and positive results such as better adhesiveness and longer life are shown [1~4]. Therefore we evaluated abrasion resistance of which colloidal silica bond is applied to various materials.

Table 1. BF Wall Repair Method

	Characteristics
Stack Gunning	1) Large repair dimension 2) High repair efficiency 3) Hot repair possible 4) Needs long duration of work 5) Takes a long time to reach normal operation level
Stave Change	1) Selective repair possible 2) Short period of time needed 3) High repair efficiency 4) Weak panel joints 5) Takes a long time to reach normal operation level
Injection	1) Selective repair possible 2) Hot repair possible 3) Short period of time needed 4) Low repair efficiency 5) Takes a short time to reach normal operation level

Stack Gunning	
Stave Change	
Injection	

Fig. 1. Various furnace wall repair methods

Figure 2 shows Chosun Refractories'(hereinafter "CR") wall repair process.

CR uses Al_2O_3-SiO_2 due to abrasion resistance and insulation performance and also uses Al_2O_3-SiC for even higher abrasion resistance and enhanced thermal conductivity. Recently CR developed Al_2O_3-SiO_2-SiC material which combined two previous materials' strengths while colloidal silica bond is used as a binder.

POD connects the machine inside of furnace with pipes. Pipes and nozzle are used to transport and spray material by spinning 360 degrees to repair inner wall. Boom crane connected with a utility line and POD moving up and downwards. Mixing and pumping machine is used for material mixing and transporting.

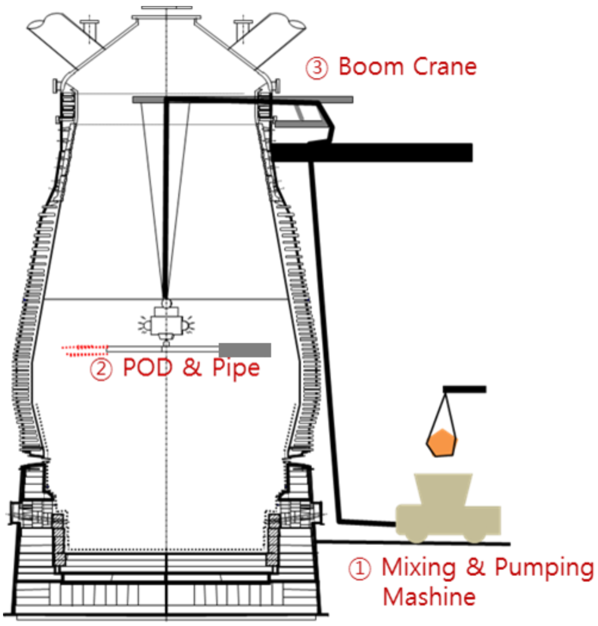

Fig. 2. Wall Repair Process Schematic Diagram

A repair machine consists of POD, Pipe, Boom Crane, and length and height is adjustable to accommodate various size of blast furnace. Adjustable length makes it easier to secure enough distance to minimize rebound loss. (Fig. 3.)

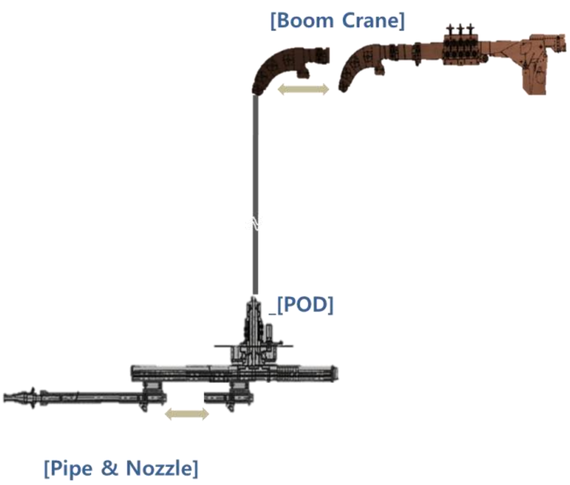

Fig. 3. Function of Each Repair Part

Various type of pipes are developed to accommodate all levels of coal and cokes pile inside of furnace. (Fig. 4.)

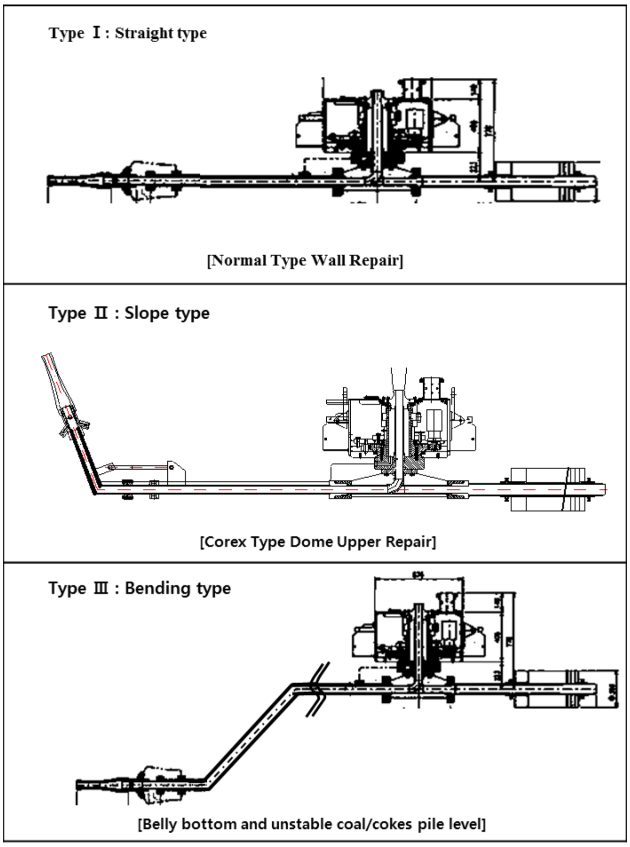

Fig. 4. Various Types of Pipe

Plus, we installed new suspension system on the BF steel plate to quality improvement and we checked improved life span from 6months to 12months.

This report is to show different ways to improve repair machine, repair material development and new development of 3D scanning process and effectiveness of each improvement.

EXPERIMENTAL

Table 2 indicates wall repair materials' quality specifications. Al2O3-SiO2(A)is used mainly on shaft area due to its anti-spallingness and good insulating performance with mullite as its raw material. Al2O3-SiC(B) is mainly used on bosh & belly area due to its heat-resistance, abrasion resistance, and high thermal conductivity. Al2O3-SiO2-SiC(C) can be applied on any areas of furnace and used mullite and SiC as its raw material for anti-spalling, abrasion resistance, and high thermal conductivity.

Table 2. Wall Repair Material Quality and Chemical Composition

		(A)	(B)	(C)
Chemical Composition (%)	Al_2O_3	62.5	66.4	48.9
	SiO_2	32.0	9.2	25.0
	SiC	-	20.0	20.0
B.D (g/cm^3)	110℃x24hrs	2.36	2.76	2.38
C.C.S (kg/cm^2)	110℃x24hrs	244	261	217
	1200℃x3hrs	630	1235	1080

Abrasion resistance is a key factor to longer life of refractory since furnace wall is mainly damaged by coal and cokes being dropped from the top. Generally, abrasion resistance is measure in room temperature, but considering the temperature inside of furnace, CR developed a measuring device which allows users to measure abrasion resistance under heated condition similar to actual condition inside of blast furnace.(Fig. 3)

Testing condition is as following.

1) Specimen Size: 114x114x65mm

2) SiC Grain Size : 0.85mm=trace, 0.6mm=20±2%, 0.3mm=80±3%, 0.212mm=max 2%

3) Pressure : 448kPa

4) Gas : N_2

5) Distance between nozzle and specimen : 200mm

6) Calculation : A = {(M1-M2)/B} = M/B

B = Bulk Density(g/cm^2)

M1 = Specimen Weight before test(g)

M2 = Specimen Weight before test (g)

M = Weight Loss (g)

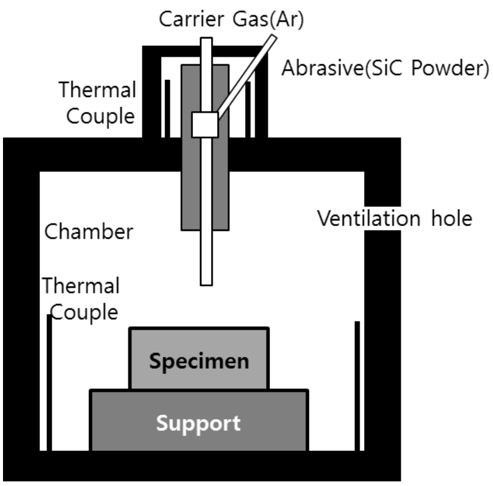

Fig. 3. Hot abrasion resistance measuring machine

RESULTS AND DISCUSSION

As a result of abrasion resistance test, strengths by bonding material is better than by refractory's sintering at 110℃~600℃, so that matrix of material B which has high density shows less abrasion resistance compared with matrix of material A and C.

At 1,200℃, due to high strengths from volumetric stability of material B which raw material is high alumina+SiC, the abrasion resistance of material B is highest between test materials. Following is material C from mullite+SiC, and the last one is material A from mullite. (Fig. 4, Fig. 5.)

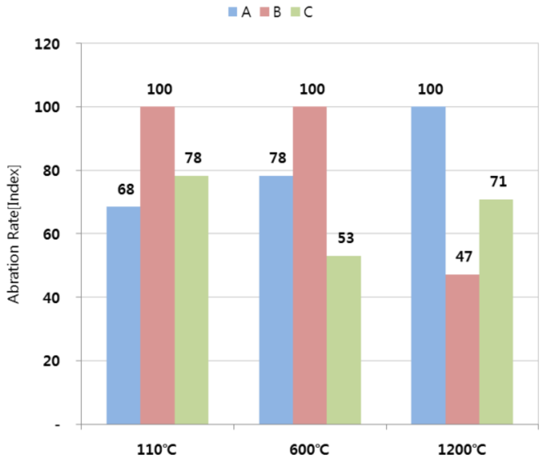

Fig. 4. Wall Repair Abrasion Resistance Test Result

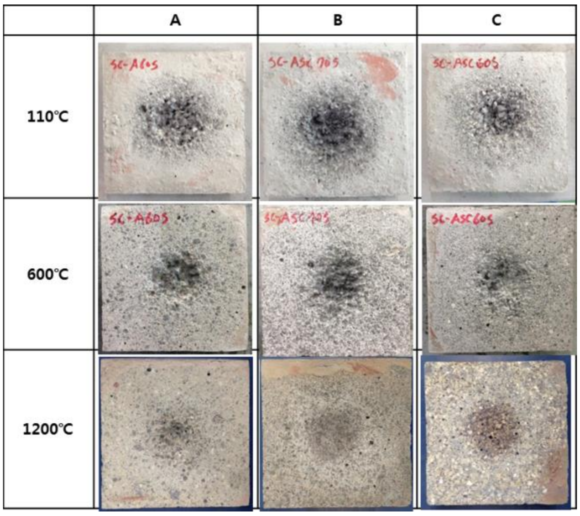

Fig.5. Picture of Specimen after Test at Each Temperature

We measured rebound loss rate by Nozzle-target distance (Fig.8.). If Nozzle-Target distance is short, spray materials could bounded off. If Nozzle-Target distance is long, spray materials couldn't reach the target. Optimal Nozzle-Target distance is on the Fig.9.

The results shows that optimal Nozzle-Target distance is 0.4+α, and its rebound loss rate is 6.1%. Results can be different as test condition such as material's workability, Air pressure etc. So, test condition need to match with usage condition.

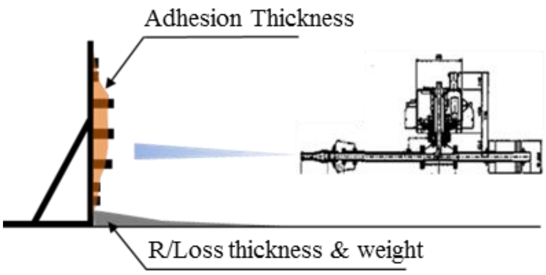

Fig.8. Repair simulation test by distance

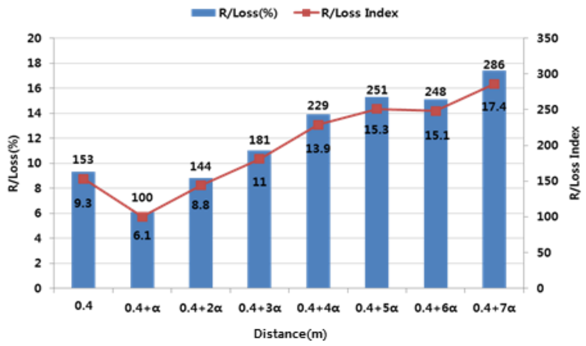

Fig.9. Rebound loss rate by distance

To check actual rebound loss rate and condition, we installed high-resolution camera and monitored repair condition in real-time after operation. Through this, we can achieve uniform thickness and improved adhesion.

Fig.10. Real-time monitoring system

Also, with 3D scanning, we can check overall operating situation such as before/after operating situation and actual rebound loss rate etc. (Fig.11.)

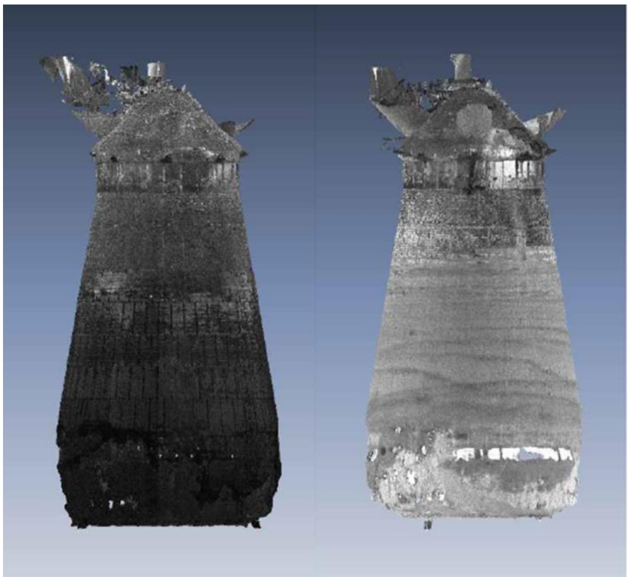

Fig.11. Inside of BF – 3D Scanned

Lately life span of BF wall repair increased from 6months to 12months by new system of repair quality improvement (Material, repair and evaluation method). Usage results are listed in the table 3 below.

Table3. Usage results for BF

Working Volume(m^3)	Avg. usage (Ton)	Life span (Month)
3,000≥	50~100	6~12
3,000~4,000	100~200	
4,000~5,000	150~250	
5,000≤	200~300	

CONCLUSION

We considered repair method (Spraying, Casting, Pre-casting panel repair etc.) for strengthen and long life of BF body and especially, developed comprehensive system to quality improvement of spraying which has high repair efficiency. First, developed new materials for each part of BF, Second, conducted improvement activities for POD, Pipe and Boom crane etc. which available for wide-range spraying as BF volume diversification. Also, we have real-time monitoring and 3D scanning system which available for quality evaluation, real-time adhesive condition check and rebound loss check.

We checked superior adhesive property (Rebound loss under 10%) through quality/repair method improvement, and achieved early normal operation rate. Life of repair mass and repair period also increased. These lead to stabilized BF maintenance and productivity improvement.

Recently, We are developing new materials which has rebound Loss 5%≥, and various facilities to quality improvement. Through this, we anticipate stabilized operating condition with strengthen BF and increased BF repair period.

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