Development of new burden for blast furnace operation with low carbon consumption

Kenichi Higuchi
Nippon Steel & Sumitomo Metal

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Outline

RCA, *Reactive Coke Agglomerate*

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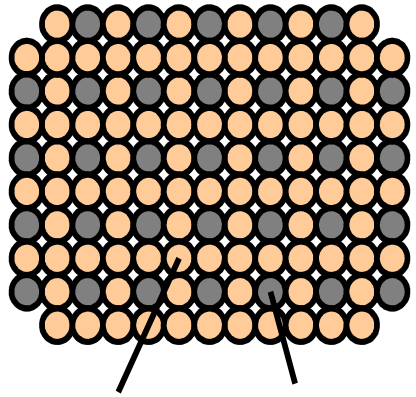
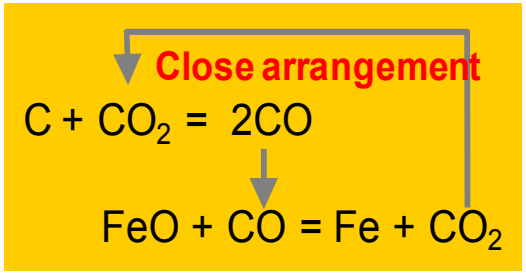
2. Laboratory tests
   1) Influence of carbon content of burden
   2) Estimation of reaction beginning temperature
3. Plant trial of RCA
4. Commercialization of RCA
5. Conclusion

RCA
Reactive Coke Agglomerate





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Purpose and background

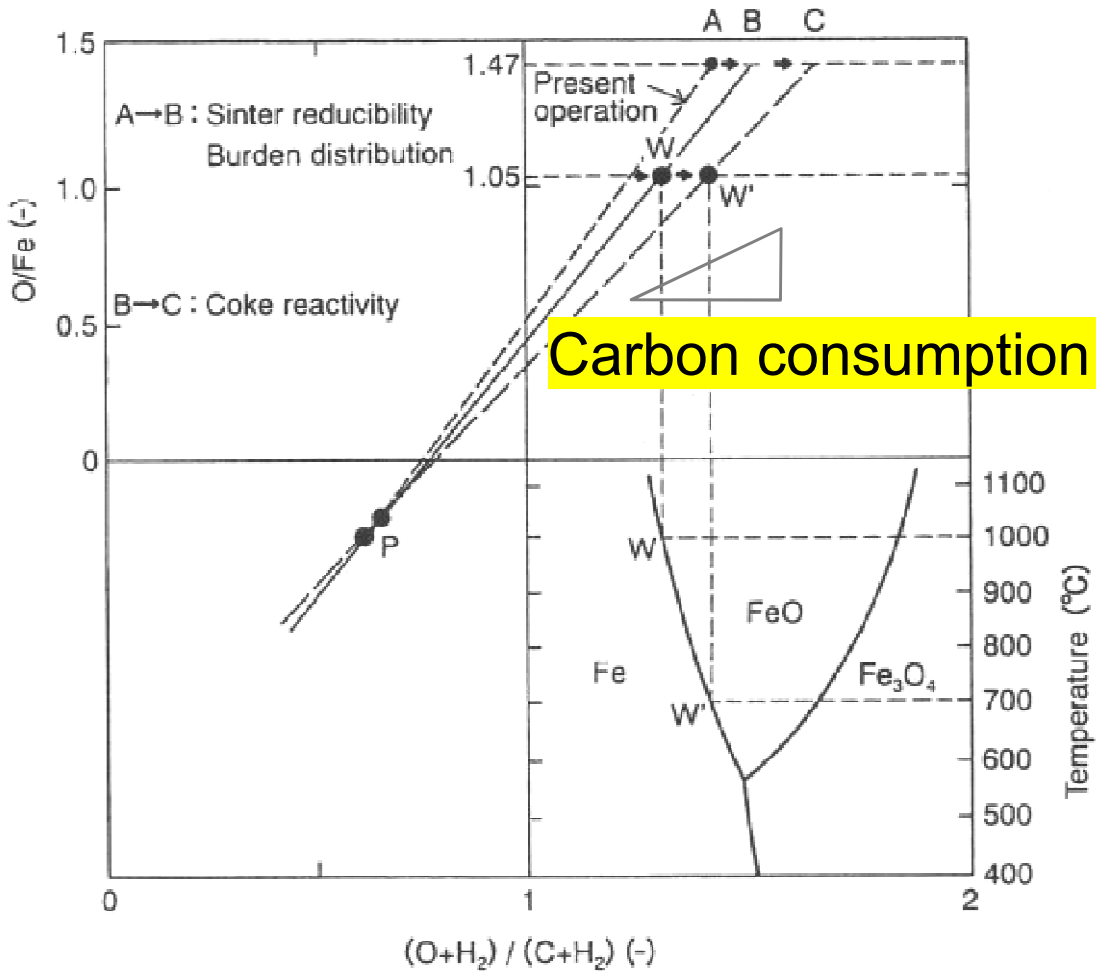

Fig. Explanation of approach for decreasing carbon consumption of blast furnace by using RIST diagram*.

Two possible approaches to reduce carbon consumption of blast furnace.

- A to B; Increasing shaft efficiency. → Limitation
- B to C; Lowering the temperature of thermal reserve zone (Fe/FeO equilibrium).

⇩

Temperature of thermal reserve zone is controlled namely by gasification rate of carbon.

⇩

New agglomerates both with high reducibility and with high gasification of carbon have been designed.

* M. Naito et al. : Proc. of 3rd ICSTI, Düsseldorf, VDEh, (2003), 539.

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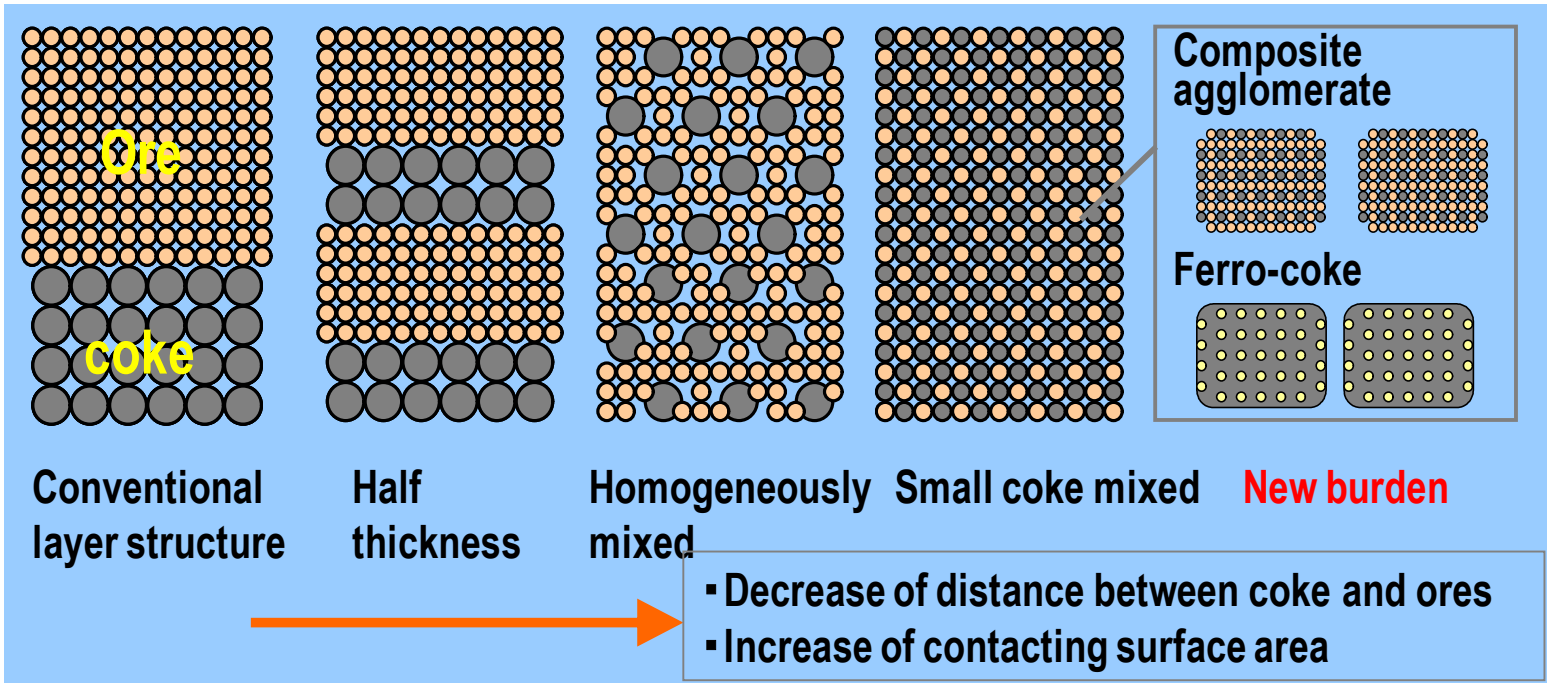
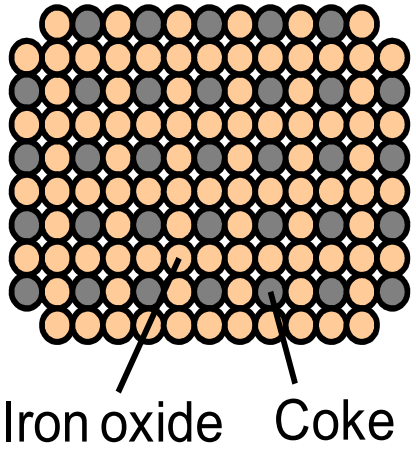
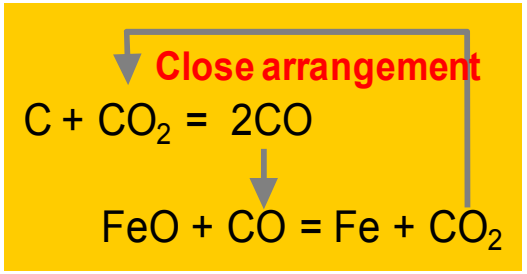
Principle of designing new burden

Development of new burden for blast furnace operation with low carbon consumption → RCA



RCA
Reactive Coke Agglomerate





Close arrangement of coke and iron oxide results in high reactivity

↓

Decrease of temperature of thermal reserve zone

↓

Low carbon consumption of blast furnace

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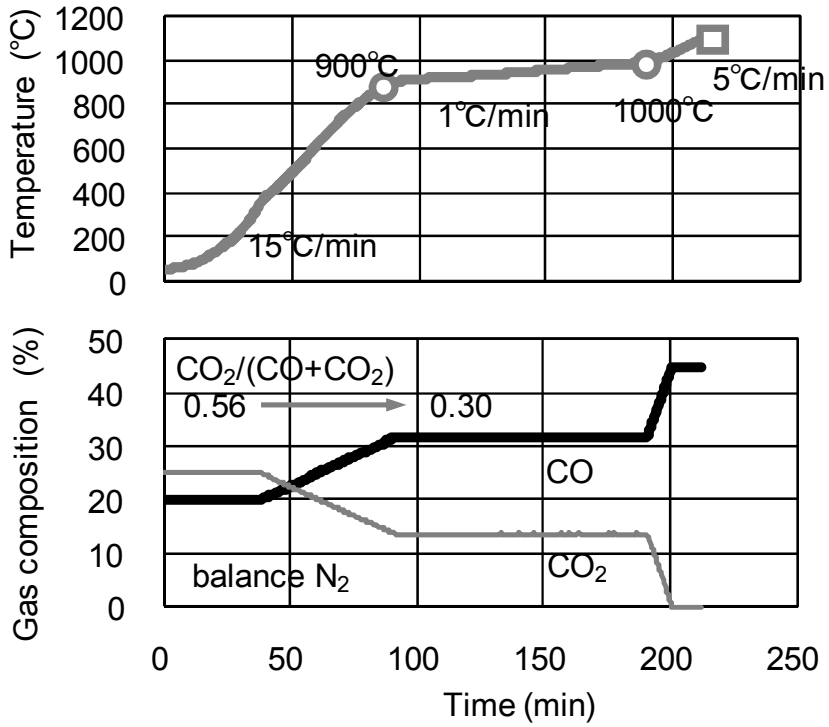
2. Laboratory tests

Influence of carbon content of burden

- ✓ Cement-bonded, carbon composite agglomerate (CCA), containing different carbon content (T.C =0～23%) were manufactured.
- ✓ Manufacturing condition of CCA's is , Cement 10%, curing time 2 days in 50℃, 12 days in room temperature.



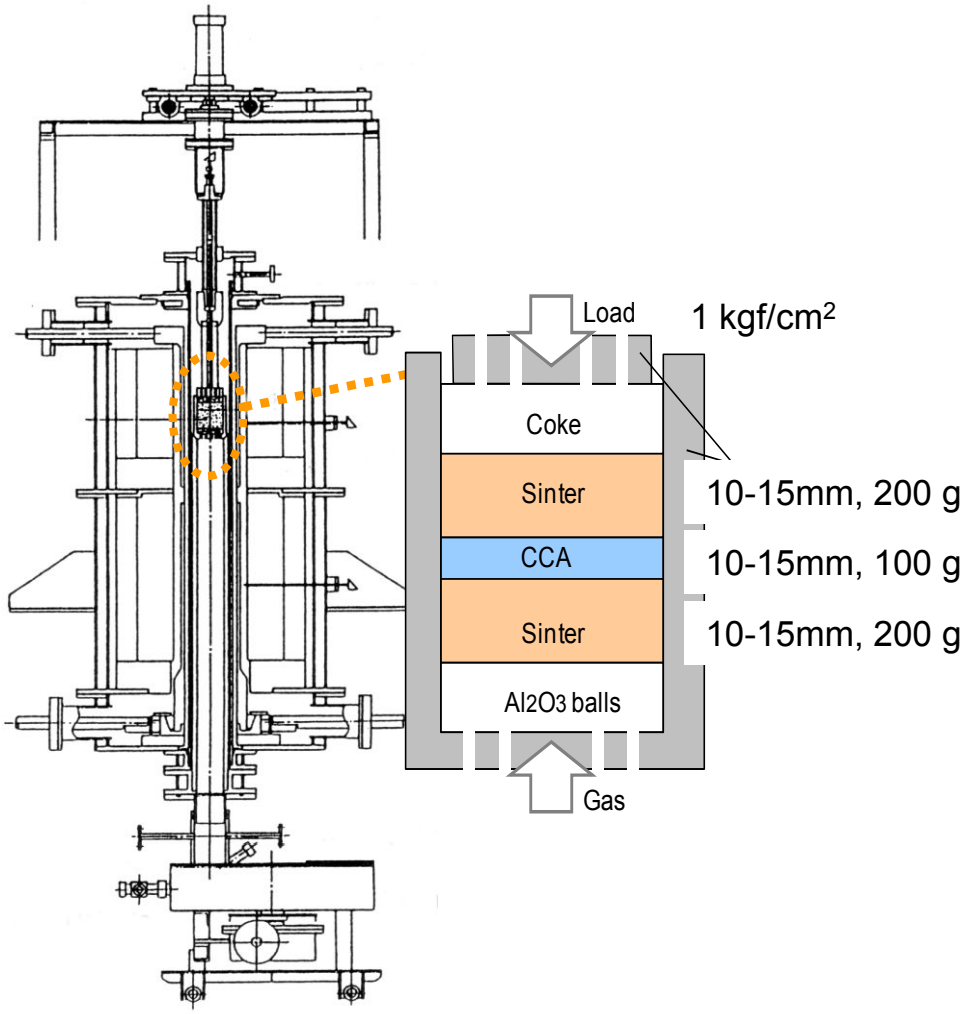


Fig. Test procedure of reduction test under load.

Result of laboratory test

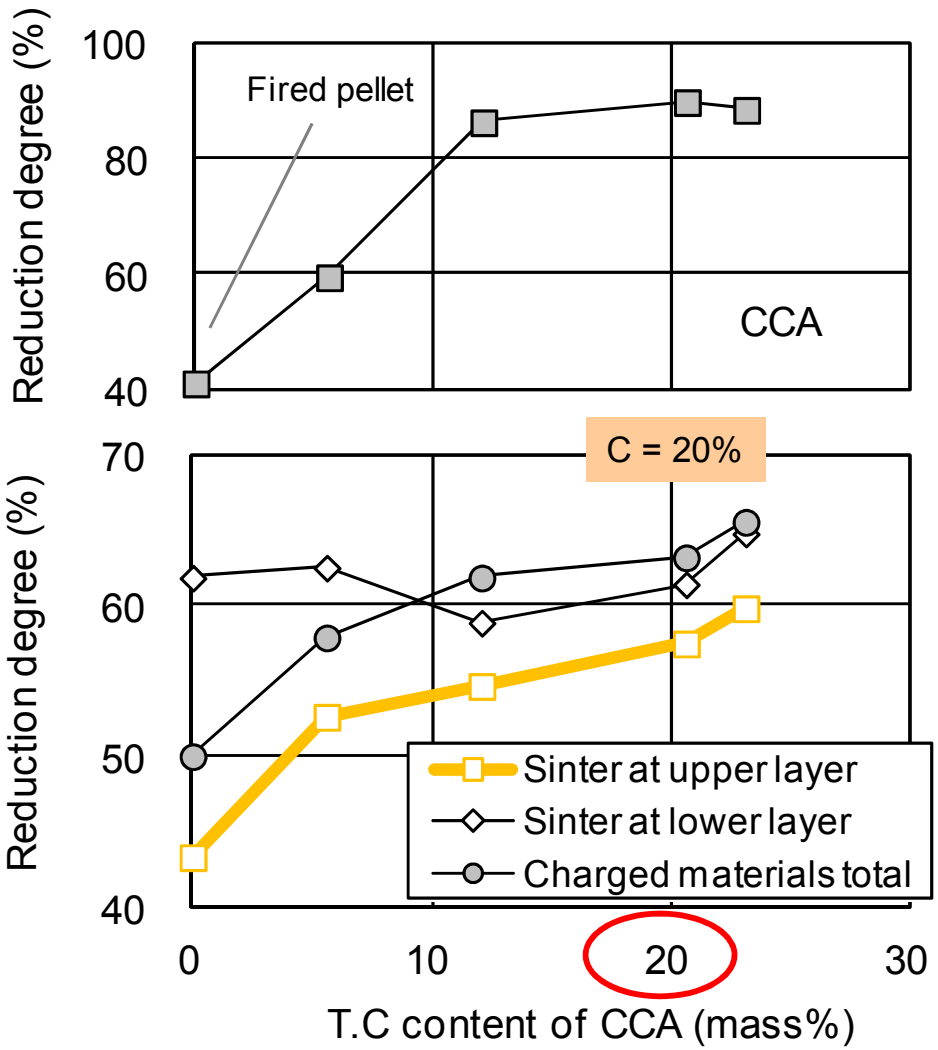


Fig. Influence of carbon content of CCA on reduction degree of materials at 1100℃.

- ✓ CCA had higher reduction degree than fired pellet.
- ✓ High carbon content of CCA resulted in higher reduction degree. 90% of reduction degree was attained by CCA with carbon content above 10%.
- ✓ Further high carbon content of CCA resulted in higher reduction degree of mixed sinter due to higher reduction gas potential formed by carbon in CCA.

Carbon composite agglomerate containing high carbon content, C=20%

→ RCA, *Reactive Coke Agglomerate*

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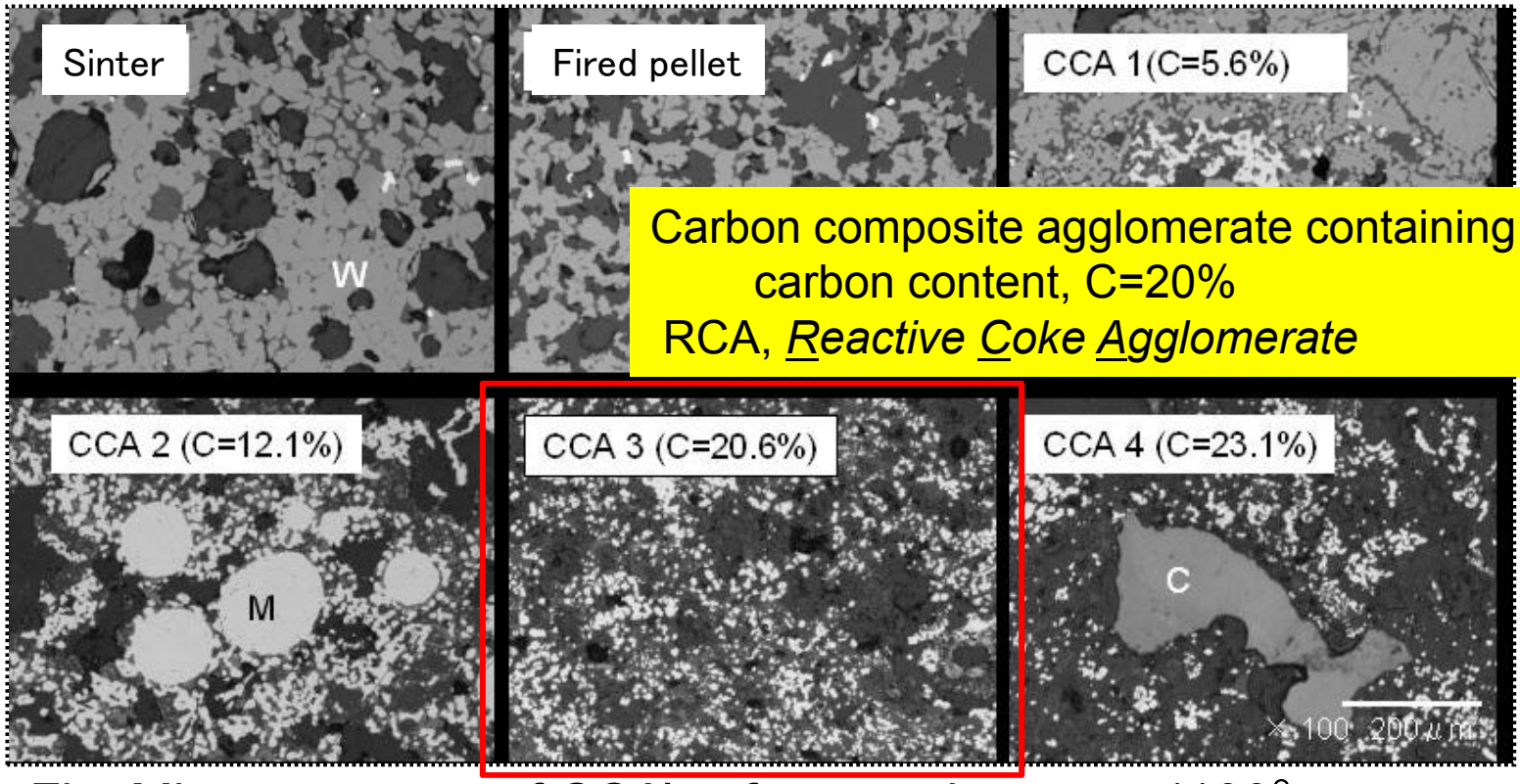
Microstructure of CCA's after reaction



Carbon composite agglomerate containing high carbon content, C=20%
RCA, *Reactive Coke Agglomerate*

Fig. Microstructures of CCA's after reaction up to 1100℃.
White: Metal (M) , pale gray :Wustite (W), dark gray: residual carbonaceous materials(C), black : void

- ✓ Many small white particles, representing metal, were observed in CCA with high carbon content (see CCA 2, 3, 4).
- ✓ CCA 4 contained residual carbonaceous materials. Less metal formation would lead loss of strength after reaction.

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Plant trial

- ✓Plant trials of manufacturing and using in blast furnace were performed at Oita works in 2007.
- ✓RCA was manufactured in dust treatment factory equipped by pan-pelletizer and cured for 2 weeks in yard-piling.
- ✓Quality and quantity of RCA were enough as blast furnace burden.

Table. Result of RCA production.

Total production	t	21000
Crushing strength (average)	kg/piece	114.8
Crushing strength (minimum)	kg/piece	100.2
Total carbon	%	21.3
Total Fe	%	36.6
Mean size	mm	13.6

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Result of plant trial ; manufacturing

Table. Comparison of basic properties of plant manufactured RCA with those of other conventional burden materials.

	RCA	Fired Pellet A	Fired Pellet B	Lump ore A	Lump ore B	Sinter
MS (mm)	13.6	14.3	14.0	23.2	23.3	21.1
TI (+10mm%)	97.4 (99.4)	94.1	95.6	87.4	82.5	70.2
AI (-0.5mm%)	2.0 (0.1)		1.8			4.4
JIS-RI (%)	97.6	73.3	71.2	43.9	70.3	63.0
RDI (%)	2.7	6.7	6.6	8.6	41.2	35.7
	(evaluated in wet state)					

✓Basic properties of RCA were enough as blast furnace burden and comparable with those of other conventional burden materials.

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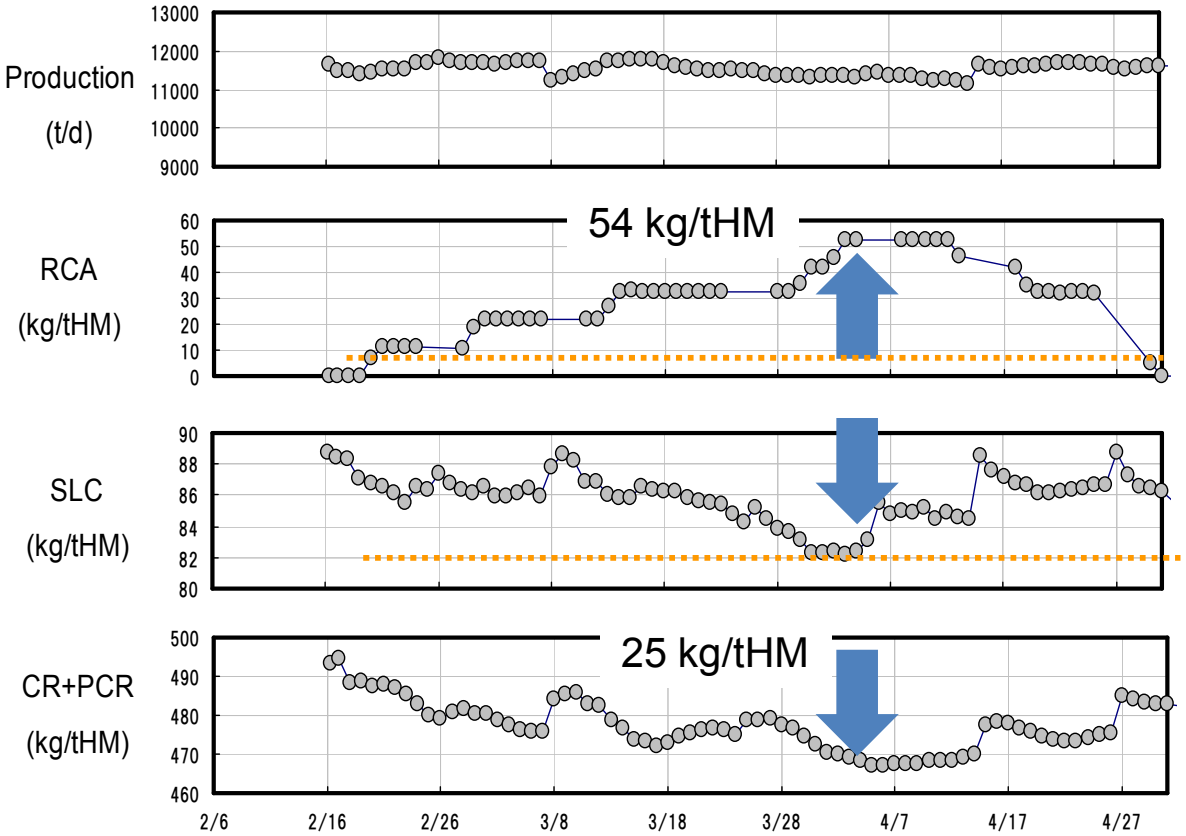
Result of plant trial ; Oita No.2 BF

BF volume	5775 m^3
Charging device	Bell
The number of tuyere	42
Period of RCA use	80 days



- ✓Using ratio of RCA was increased in stepwise up to 54 kg/tHM.
- ✓As RCA using ratio was increased, gas utilization was improved. Solution loss carbon was decreased accordingly.
- ✓Raw value of reducing agent rate (CR+PCR) was deceased by 25 kg/tHM.

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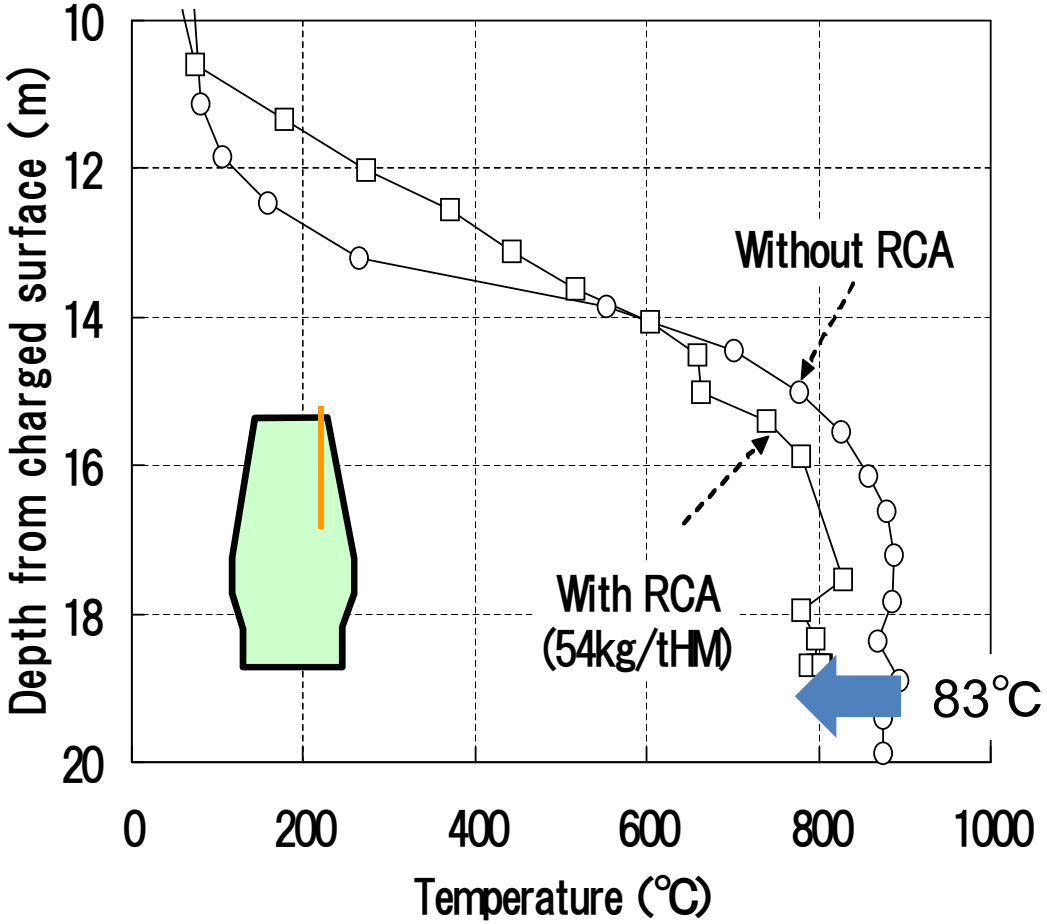
Result of plant trial ; Oita No.2 BF



Temperature of thermal reserve zone was lowered.

Fig. Changes in temperature profile with using RCA measured by vertical probe during test.

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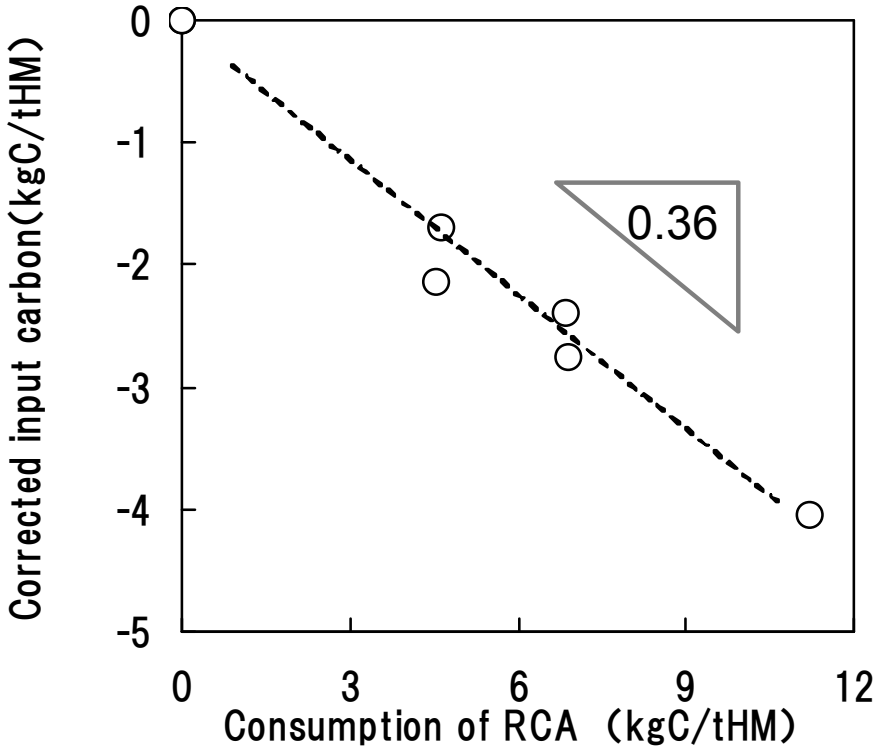
Changes in input carbon of blast furnace



Decrease of temperature of thermal reserve zone (℃)	83
Decrease of input carbon (kgC/tHM)	4.0
(kgC/tHM／▲10℃TRZ)	0.5
(kgC/tHM／ + 1 kgC /tHM)	**0.36**

Fig. Relationship between consumption of RCA and corrected input carbon* .

* calculated by heat and mass balance based on the Rist model.

✓Input carbon was decreased with using RCA in a linear fashion.
✓It was estimated that corrected input carbon was decreased by 0.36 kgC / tHM if we input 1 kgC / tHM from RCA.

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5. Conclusion

1) RCA, Reactive Coke Agglomerate, containing 20 % carbon has been developed as a new burden for blast furnace. Beside its high reactivity, RCA promotes reduction of mixed sinter.
2) Reaction beginning temperature of carbon in RCA was lower than that of conventional coke and along the theoretical lower limit. Thus, RCA is effective burden to lower the temperature of thermal reserve zone.
3) Facility of manufacturing RCA has been installed at Oita works in 2011. Since then, smooth production of RCA has been established. RCA has contributed low RAR, low input carbon, operation of blast furnace at Oita works.