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KYUSHU UNIVERSITY 2011
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Reduction Behavior of Iron Oxide Using Woody Biomass

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Contents

1. Background

CO_2 emissions in Japan

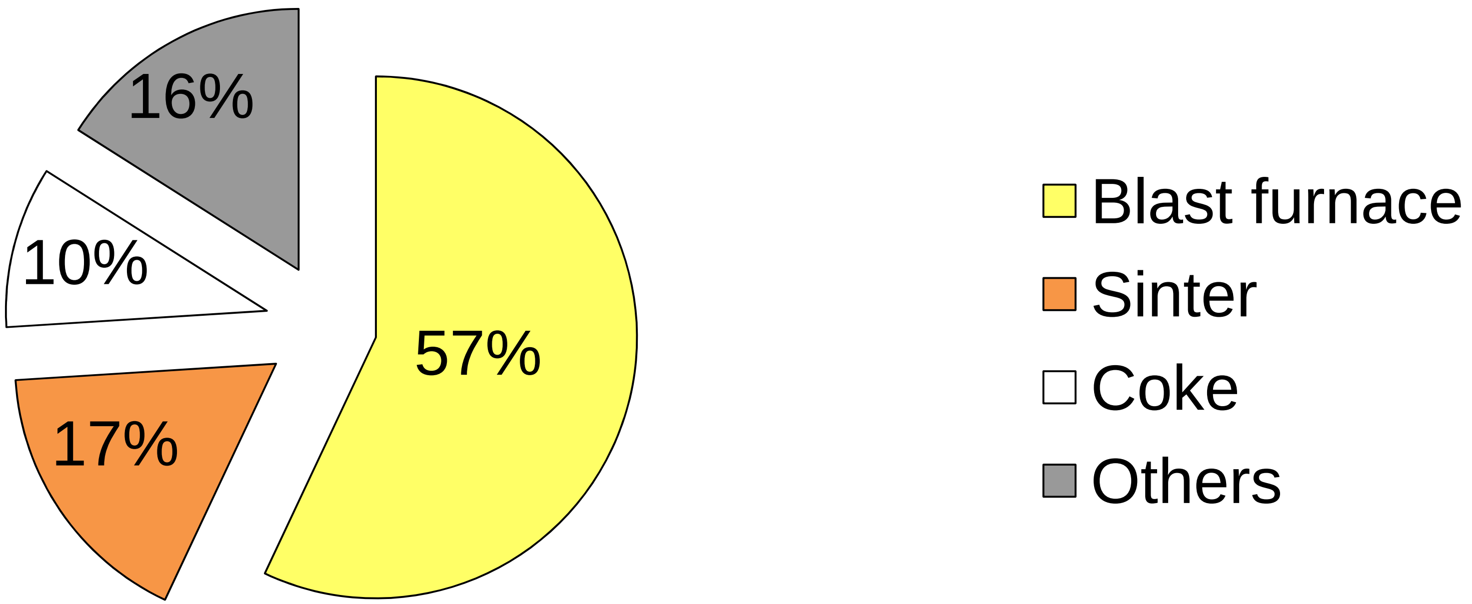


Fig.3 CO_2 emission of each process in steelworks.

It is important

to reduce CO_2 emissions from blast furnace

to reduce the consumption of fossil fuel

2. Objective

- to reduce CO_2 emissions from blast furnace
- to lower reducing agent rate of the fossil fuel origin.

Utilization of charcoal in blast furnace process

Charcoal is not used / is not produced for blast furnace in Japan

If it is useful, charcoal may be imported for blast furnace from foreign countries

3-1. Composition analysis

Table. 1 Chemical composition of sinter, charcoal and coke.

Sample	Composition (mass%)					
	T.Fe	FeO	CaO	SiO_2	Al_2O_3	MgO
Sinter	58.18	6.61	9.16	5.63	1.62	0.79

Sample	Proximate analysis		Ultimate analysis			
	Ash wt.%, dry	VM wt.%, dry	C wt.%, dry	H wt.%, dry	N wt.%, dry	O wt.%, dry
Charcoal	2.0	14.6	82.9	2.65	0.26	12.3
Coke	11.8	0.8	85.6	-	-	-

The characteristic differences between coke and charcoal are ash content and volatile matter content

3-2. Strength test

1.Rotational intensity

Rotational intensity was evaluated by ratio of sample whose diameter was 3mm or less after rotation

<Conditions>
・Sample size：9～13mm
・Weight：100g
・Rotational speed：30rpm

2.Crushing Strength

Crushing strength was evaluated by average value of 30 pieces

<Conditions>
・Sample size：9～13mm
・30 pieces

3-2. Strength test

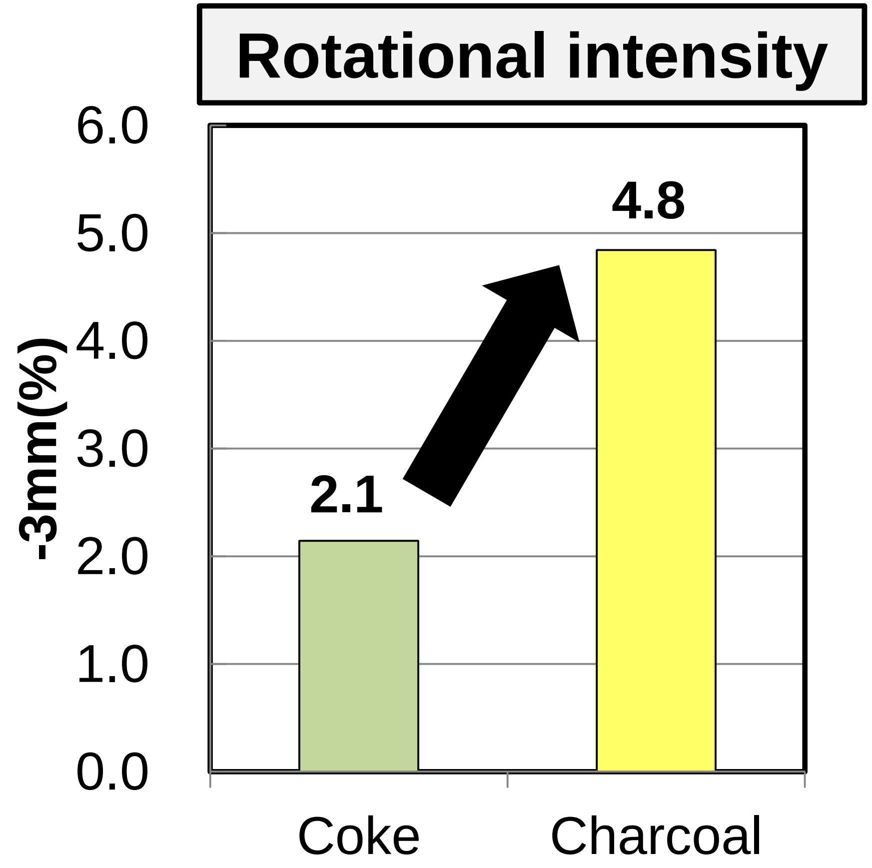


Fig.4 Rotational intensity of coke and charcoal.

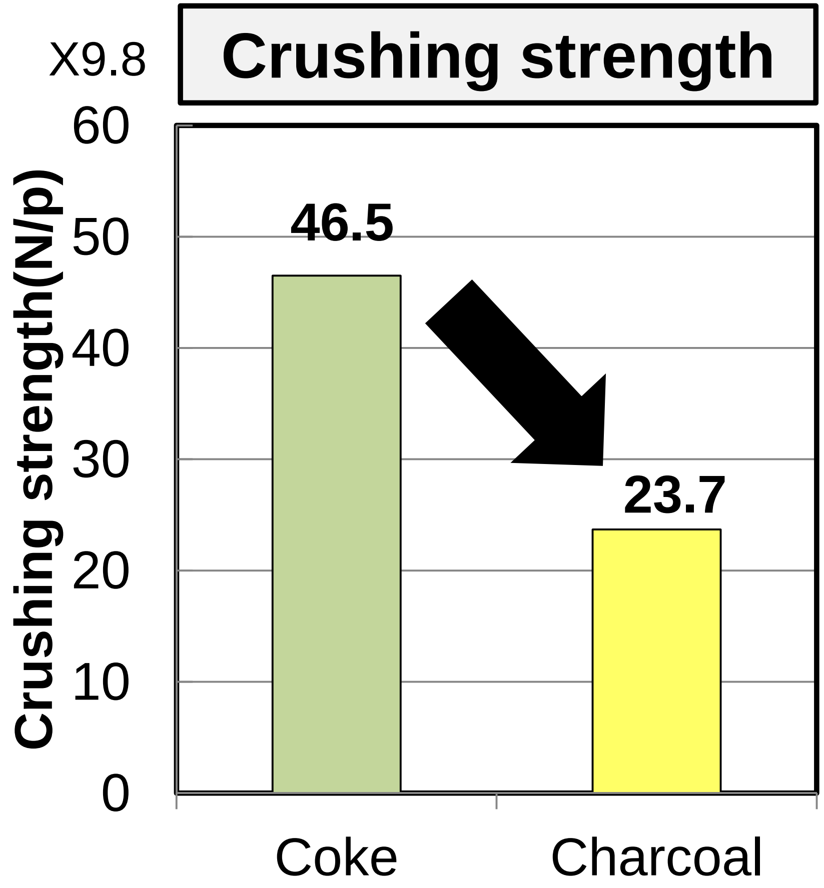


Fig.5 Crushing strength of coke and charcoal.

Charcoal has less strength than coke

3-3. Evaluation of physical property

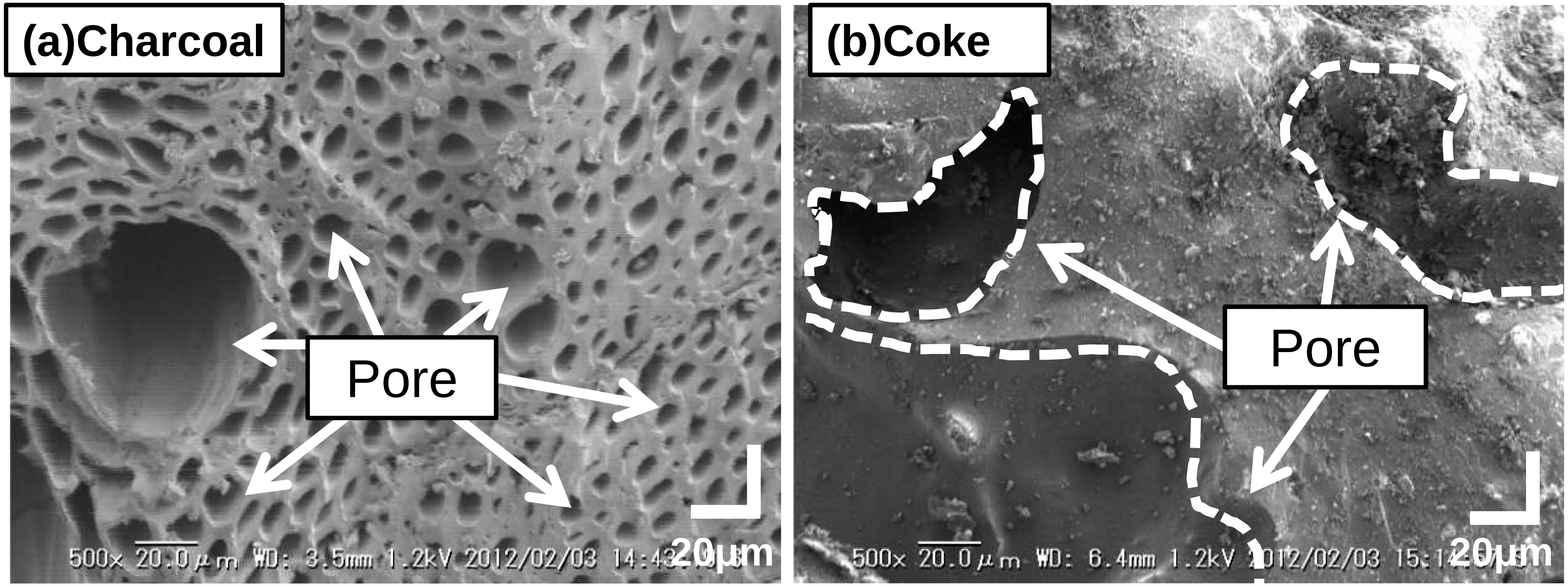
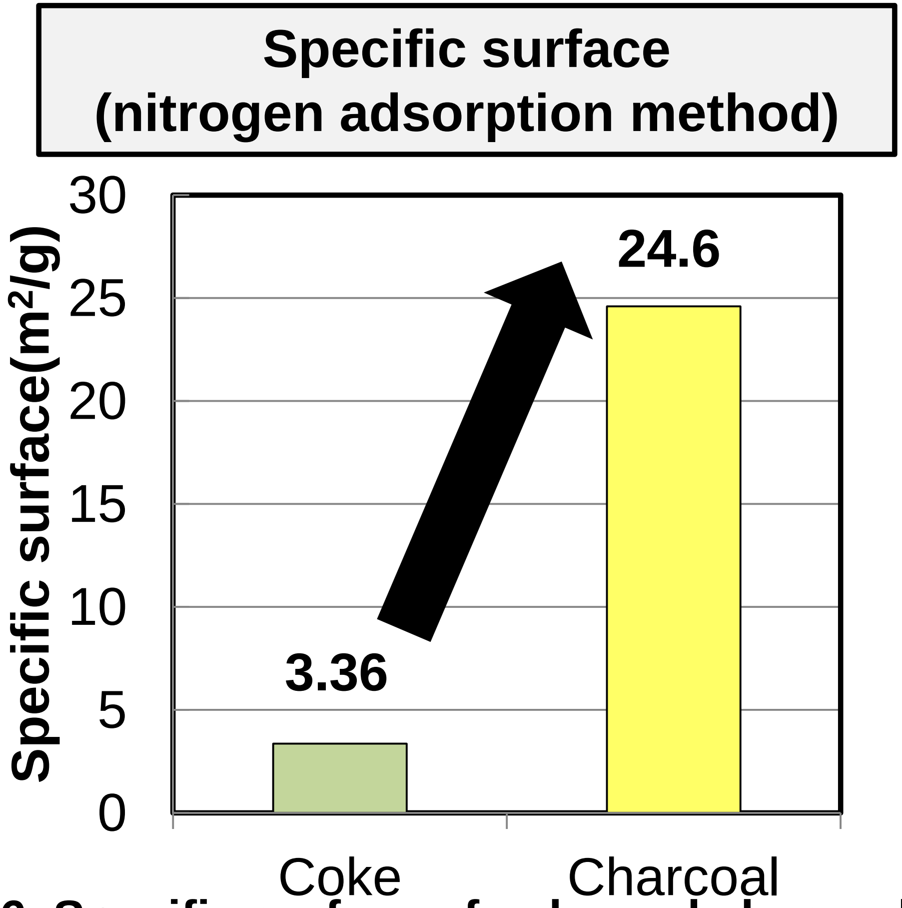


Photo. 1 Microstructure at surface of (a) charcoal, (b) coke.

- **Charcoal has a lot of small pores**
- **Coke has a few large pores**

3-3. Evaluation of physical property



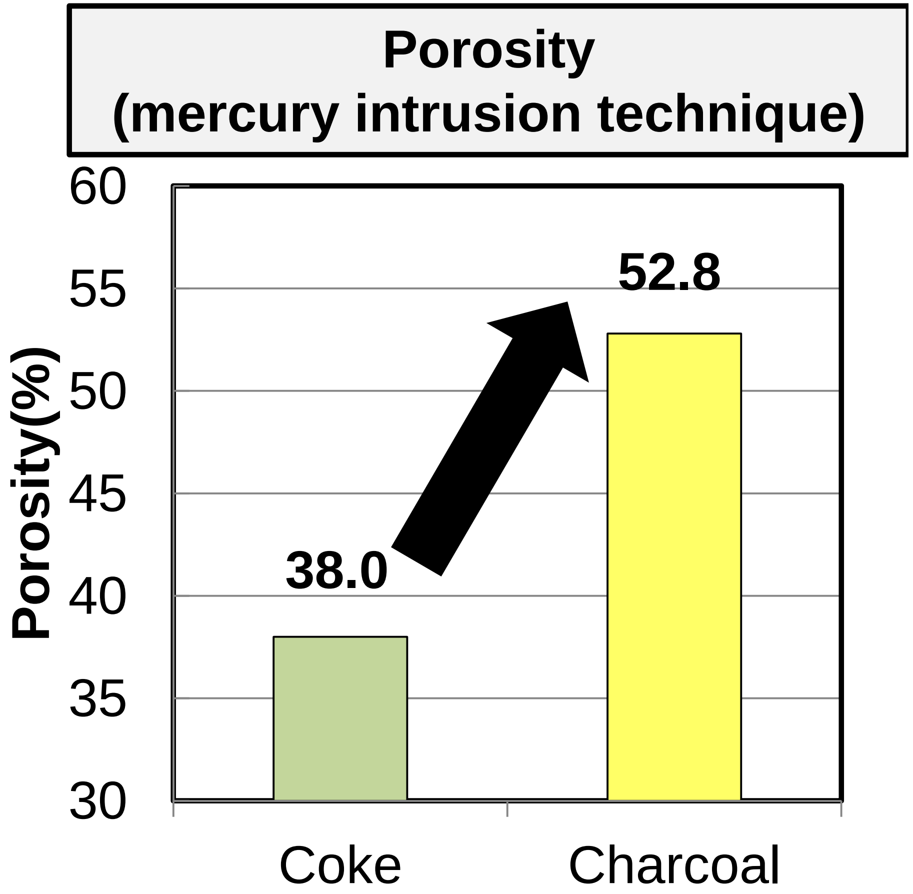


Fig.6 Specific surface of coke and charcoal. Fig.7 Porosity of coke and charcoal.

Difference of physical property between coke and charcoal is very large

3-4. Evaluation test of gasification reactivity

CRS(Coke reaction simulator)
This is a large thermobalance which can evaluate gasification reactivity of reducing agent such as coke or charcoal

Table. 2 Experimental condition of CRS test.

Gas	**CO / CO_2 (50%/50%)**	
Flow rate	**20 l/min**	
Temp.	**RT – 1100℃ at 10 ℃/min**	
Sample	**mass**	**200g**
	size	**10 – 15 mm**

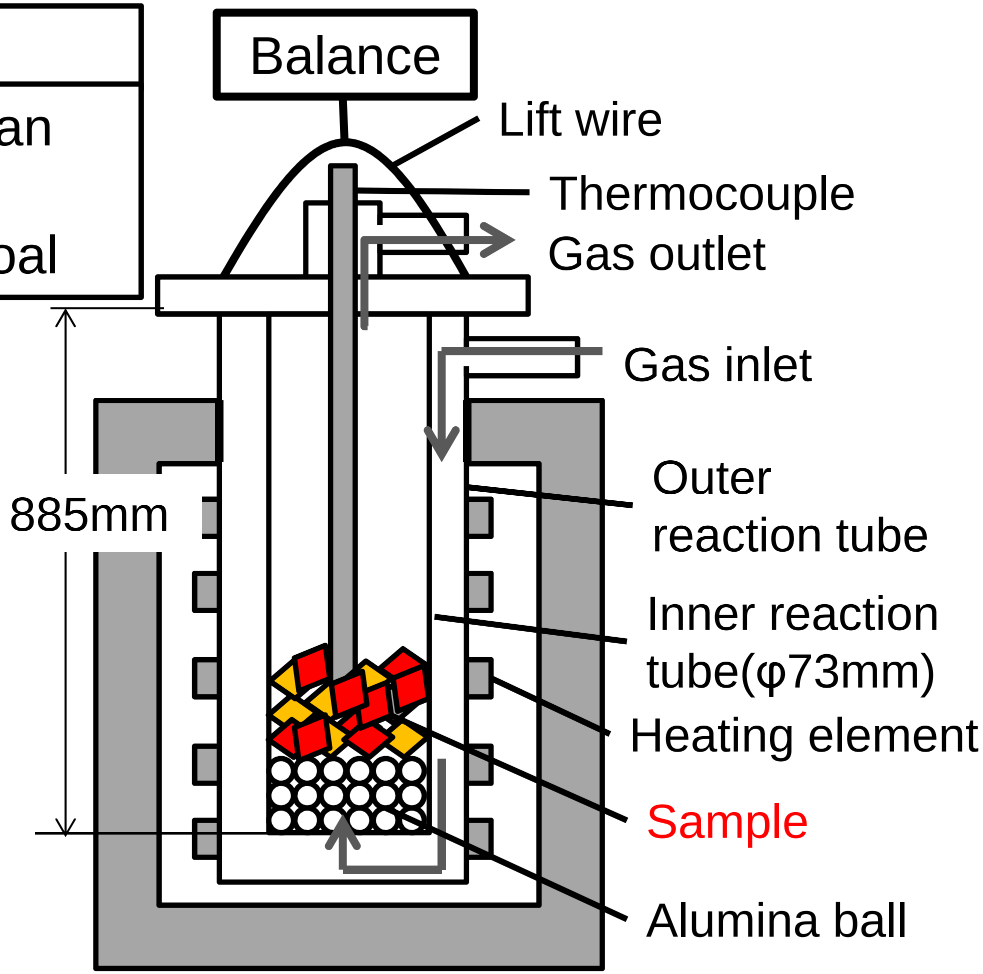


Fig.8 Schematic diagram of apparatus of CRS test.

3-4. Evaluation test of gasification reactivity

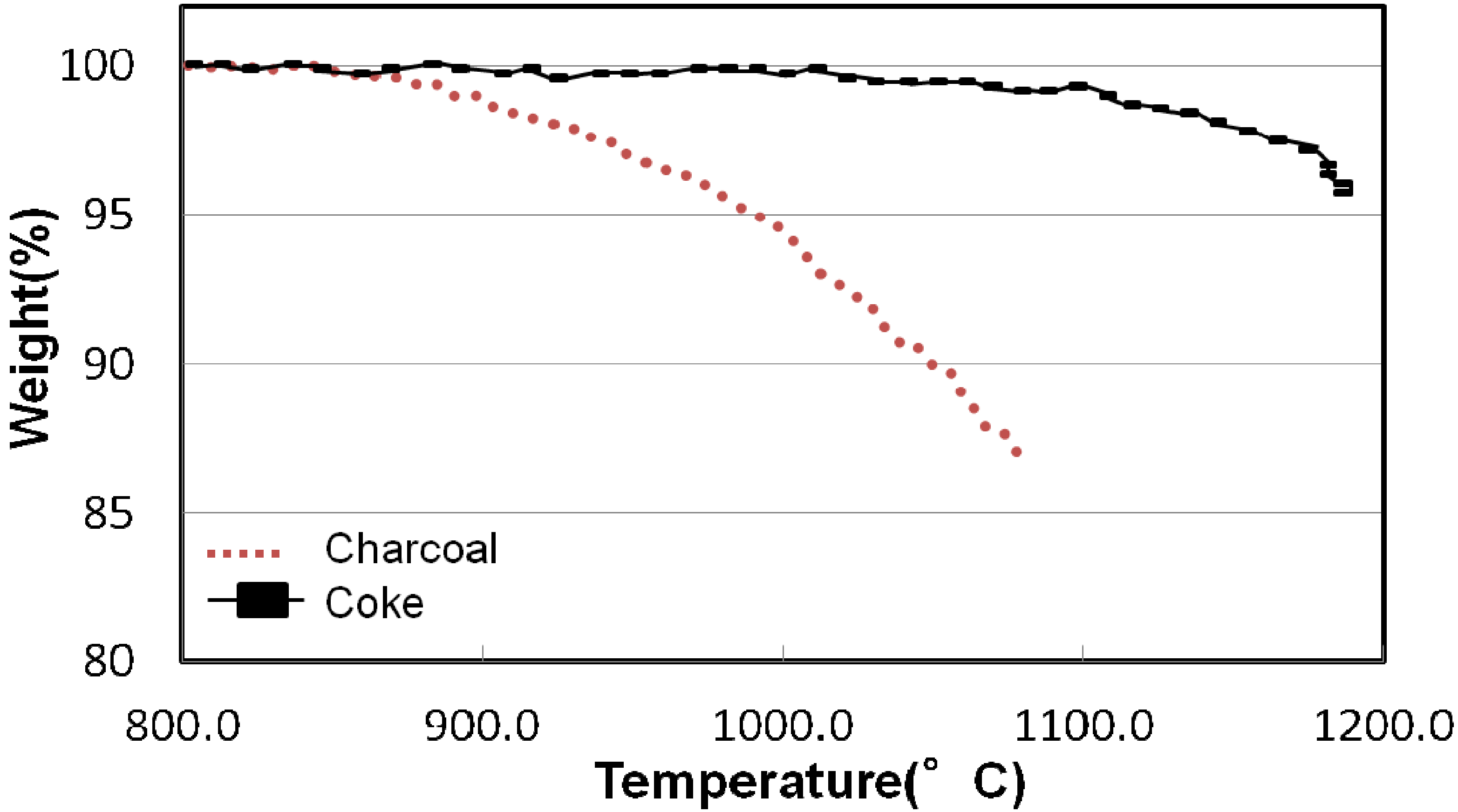
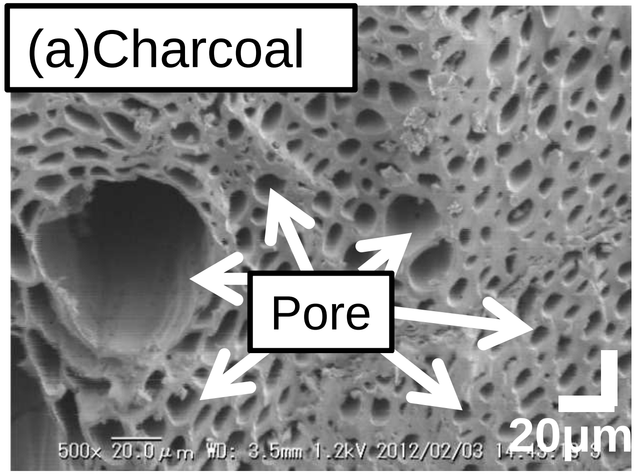
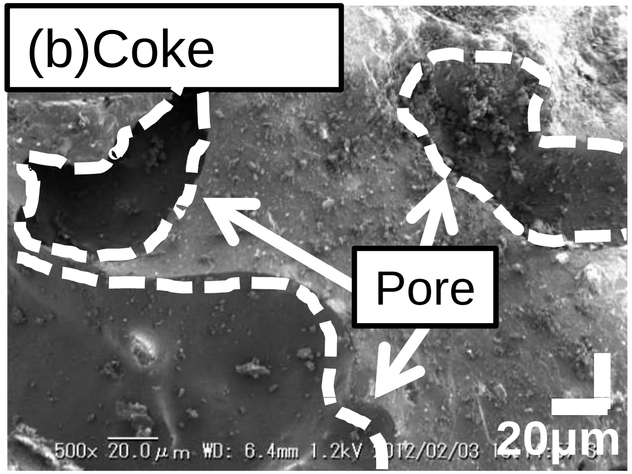


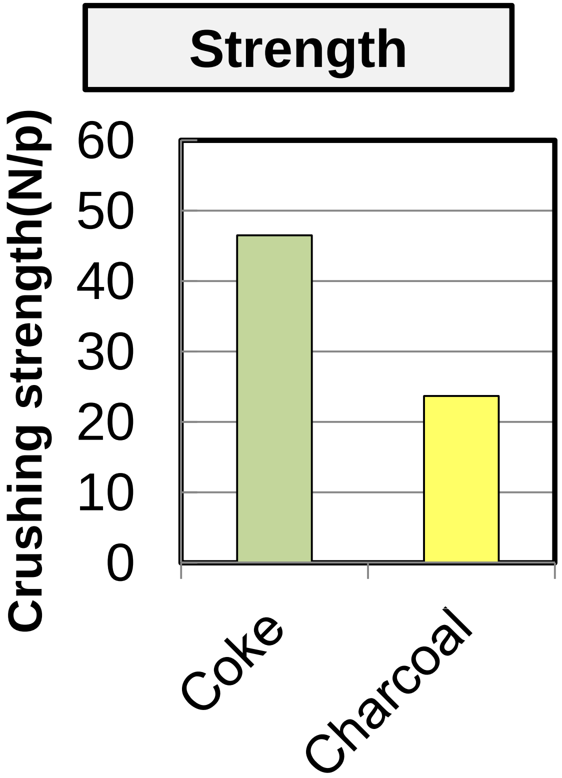
Fig. 9 Result of CRS test.

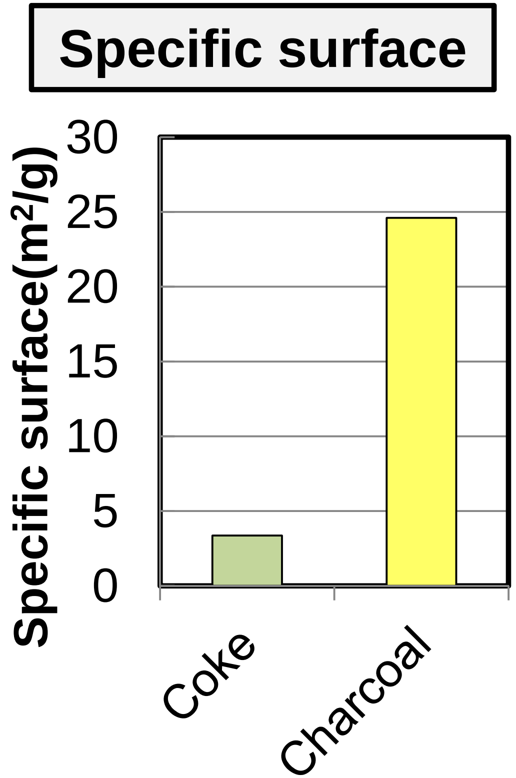
- Charcoal started to lose weight at less than 900 C
  Coke loses their weight at the temperature over 1000 C
- Difference of weight expanded further at high temperature

How to use charcoal ?









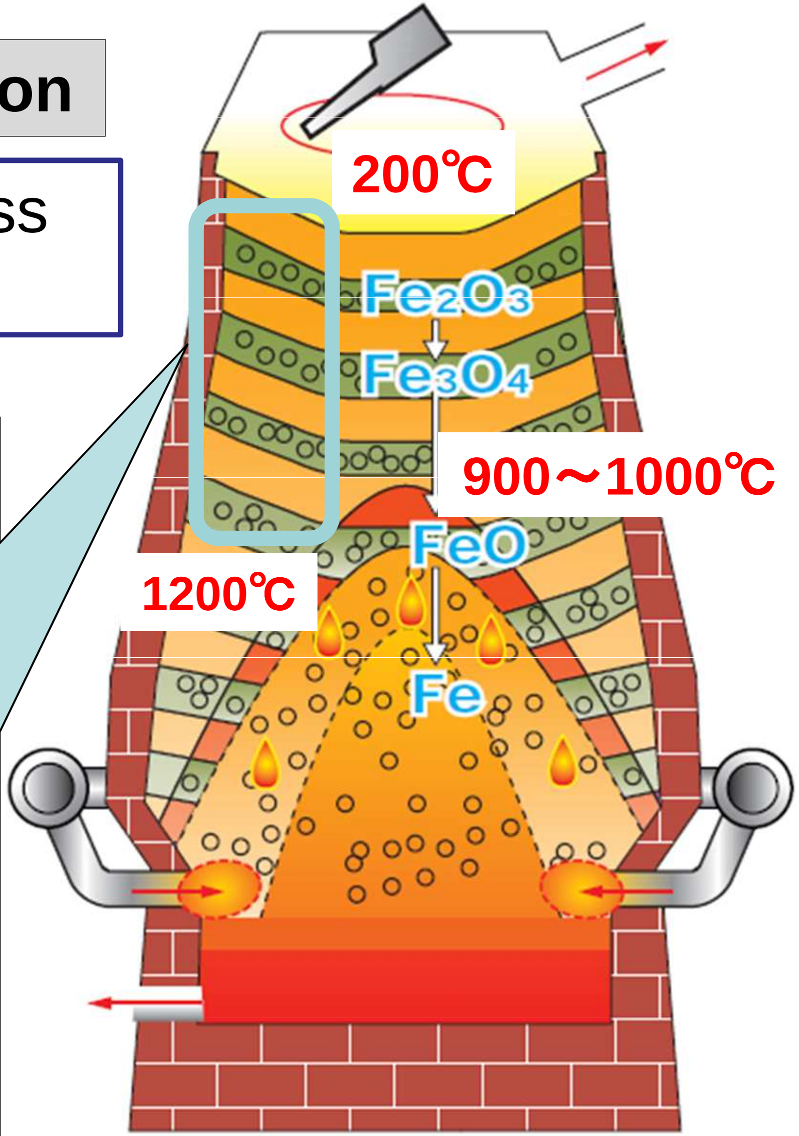
The possibility to use charcoal as substitution for nut coke which is mixed in the ore layer ??

4.Evaluation of blast furnace reaction using charcoal

Change of blast furnace reaction

Temperature at which solution loss reaction starts is lowered.

To evaluate change of blast furnace reaction by charcoal from top of furnace to top of cohesive zone using a special experimental apparatus.



4-1. Evaluation test of blast furnace reaction with BIS

- Sample：sinter, coke and charcoal
- Size：sinter 10～15mm, coke・charcoal 9～13mm
- RAR : 481kg/t
- CR : 349kg/t (Charcoal or Nut coke：73kg/t)
- Bosh gas : CO 36.0% H_2 7.0% N_2 57.0%, 1343Nm^3/t

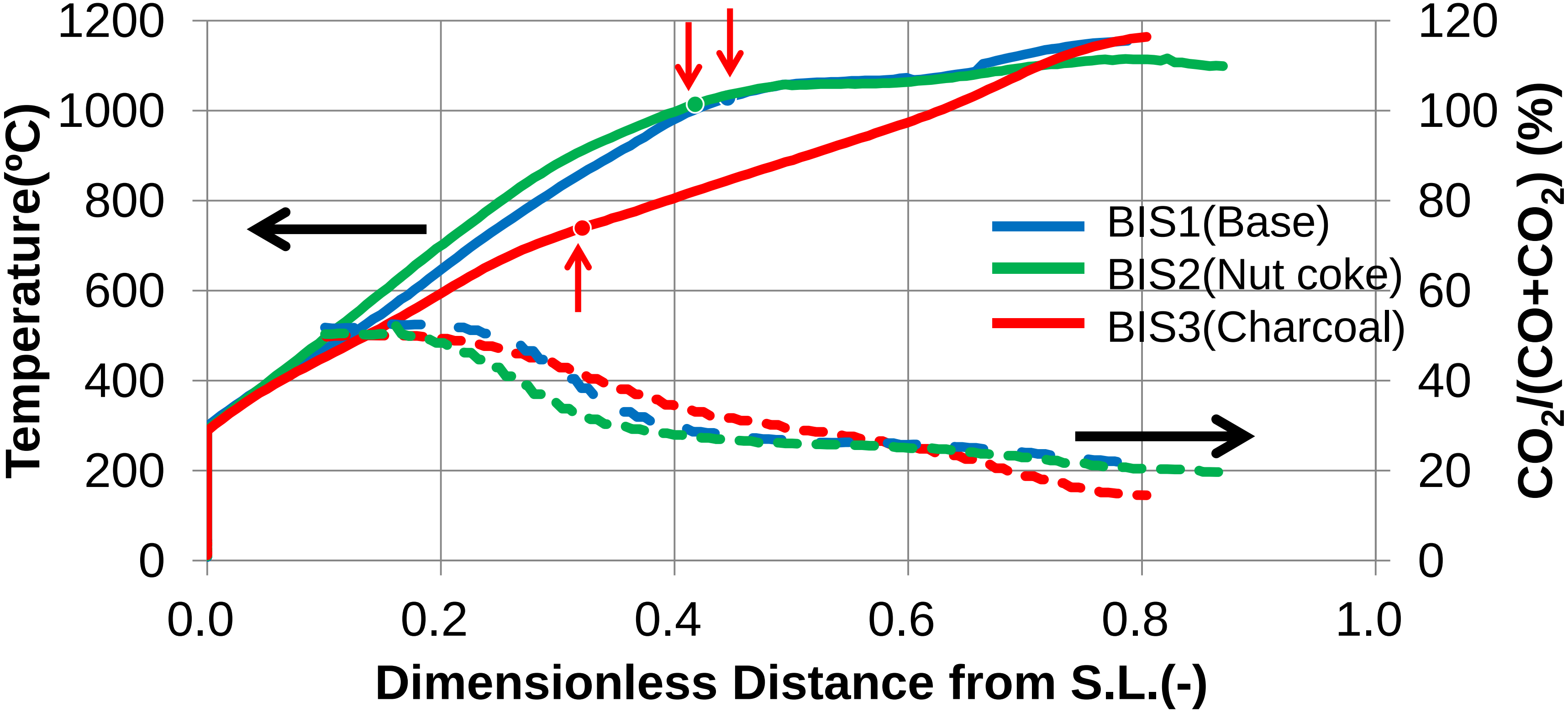
Table.3 Test condition of BIS test.

			BIS1	BIS2	BIS3
Mass of charged material	Sinter	g/ch	463	463	463
	Coke	g/ch	100	79.2	79.3
	Nut coke	g/ch	0	20.8	0
	Charcoal	g/ch	0	0	20.8
	Charged T.Fe	g/ch	269	269	269

- BIS1 : Basic condition
- BIS2 : Nut coke is mixed in ore layer
- BIS3 : Charcoal is used as substitution for nut coke

4-1. Evaluation test of blast furnace reaction with BIS

Result-1 Temperature and gas composition



Temperature was lowered on BIS3(Charcoal)

Thermal reserve zone temperature was defined based on the lowest rate of temperature increase.

4-1. Evaluation test of blast furnace reaction with BIS

Result-2 Thermal reserve zone temperature

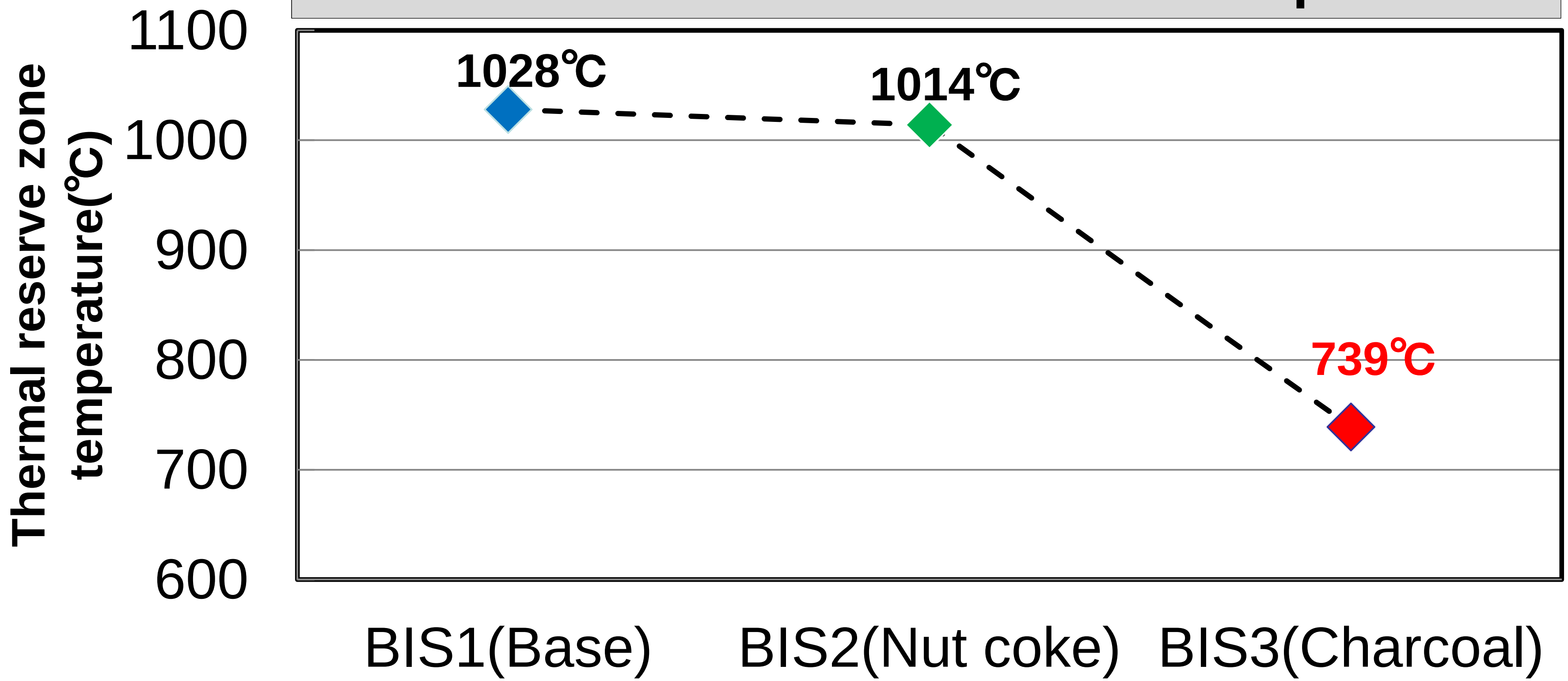


Fig.12 Thermal reserve zone temperature of BIS1, 2 and 3.

Thermal reserve zone temperature was lowered from 1028℃ to 739℃ with the utilization of charcoal

4-1. Evaluation test of blast furnace reaction with BIS

Result-3 Reduction degree of sinter

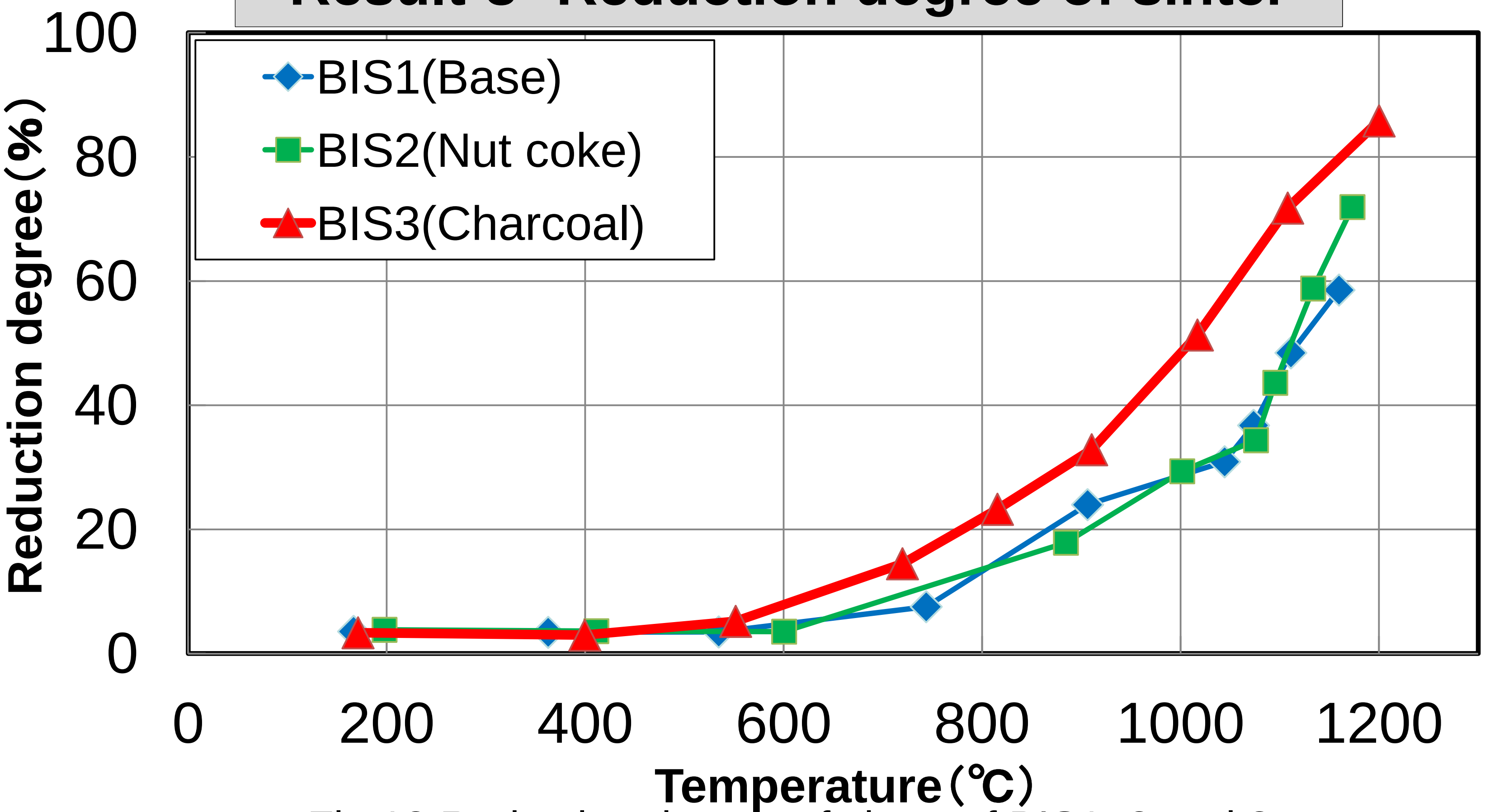


Fig.13 Reduction degree of sinter of BIS1, 2 and 3.

With the utilization of charcoal
- **reduction of sinter started at lower temperature**
- **sinter is high reduction degree at high temperature**

4-2. Effect of charcoal on reducing CO_2 emissions with heat and mass analysis by RIST diagram

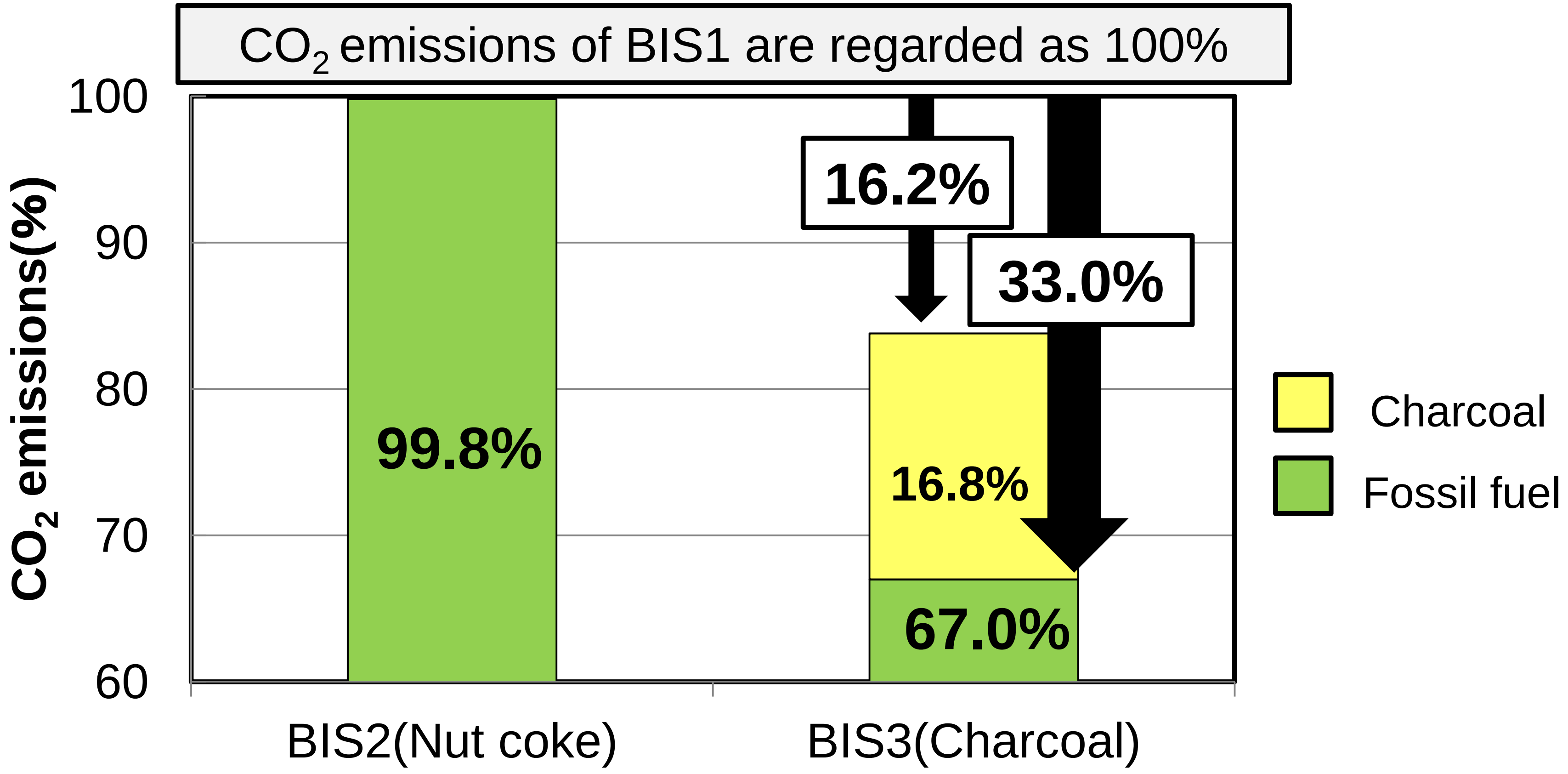


Fig.14 Effect to reduce CO_2 emissions.

5. Conclusion

1. Characteristics of charcoal

Charcoal has higher reactivity and less strength than coke → Utilization of charcoal as substitution for nut coke is effective and realistic

2.Evaluation of blast furnace reaction using charcoal

2-1. Evaluation test of blast furnace reaction simulator

→ Thermal reserve zone temperature was lowered from 1028℃ to 739℃ with the utilization of charcoal

2-2. Effect of charcoal on reducing CO_2 emissions with heat and mass analysis

→ Utilization of charcoal is expected to reduce CO_2 emissions from fossil fuel by 33%

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