New Gray Cast Iron with Eutectic Graphite Structure "S-H Cast Iron" and its Mechanical Properties

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At present the following methods are well known to produce gray cast iron castings with eutectic graphite structure.

(1) To melt cast iron in vacuo.[1]

(2) To superheat cast iron melt.[2]

(3) To have cast iron solidified rapidly.[3]

(4) To bubble carbon dioxide gas through cast iron melt for a short time, immediately after dissolving 0.1 to 0.2 pct of titanium in the melt.[4]

The present writer found a fact that cast iron of the same kind could be produced when cast iron melt was treated with the molten slag containing a suitable amount of titanium oxide.

1 kg. charges of metallic raw materials were first melted in graphite crucibles in a cryptol furnace, and then the melts were covered with slag forming materials. The compositions of these materials are given in Tables I and II. The melting temperature was 1400°C. to 1470°C., and the amount of the charged slag forming materials was 20 pct of the cast iron melt. After molten slags were formed, they were covered with charcoal powder. The melts were vertically cast into green sand moulds, 25 mm. in diameter, at 1300°C. The melting of the slag forming

Table I. Compositions of Slag forming Raw Materials

	CaO (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)
Portland Cement	64.2	21.4	7.72	3.56
Silica	SiO_2=61.8%, Ignition Loss=38.2%			
Calcium Carbonate	CO_3Ca=99.2%			
Alumina	Al_2O_3=98%			
Titanium Oxide	TiO_2=98%			

Table II. Compositions of Metallic Raw Materials

	C (%)	Si (%)	Mn (%)	P (%)	S (%)
Cast Iron	3.84	1.41	0.51	0.313	0.062
Soft Steel	0.24	0.27	0.44	0.025	0.021
Ferrosilicon		71.0			

materials took about 3 to 4 minutes, and the contact time between the cast iron melts and the molten slags was 20 minutes. One charge was melted without slag for comparison. The resulting castings were fractured in four different positions along their longitudinal axes, the coarseness of the fracture was noted, and microscopic examination was made.

From the results summarized in Table III, a fact is confirmed that when cast iron melts are treated with the slags containing titanium oxide, the eutectic graphite structure, as shown in Photo. 1, appears in the castings. Under the present experimental conditions, the eutectic graphite structure forms throughout the castings when the treatment is carried out with the slags containing over about 9 pct of titanium oxide.

Table III. Results of Slag Treatment

Specimens No.		0—1	0—2	0—3	0—4	0—5	0—6	0—7
Composition of Specimens (%)	C	3.42	3.57	3.76	3.67	3.54	3.47	2.97(?)
	Si	1.51	1.33	1.29	1.27	1.36	1.11	1.53
	S	0.036	0.030	0.032	0.033	0.040	0.042	0.042
	Ti	60.060	0.117	0.200	0.210	0.175	0.322	—
	Soluble N_2	0.0022	0.0033	0.0033	0.0026	0.0022	0.0026	—
	Insoluble N_2	0.0096	0.0107	0.0088	0.0100	0.0088	—	—
	Total N_2	0.0188	0.0140	0.0121	0.0126	0.0110	—	—
Composition of Slags (%)	CaO	45.56	42.70	42.84	42.55	40.46	38.73	—
	SiO_2	35.80	34.14	34.13	34.53	33.24	35.53	—
	Al_2O_3	12.34	15.74	13.40	13.57	13.24	9.75	—
	TiO_2	0	3.58	7.34	8.75	11.10	13.36	—
Maximum Heating Temperature (°C)		1420	1440	1450	1470	1420	1435	1400
Graphite Structure*		A	B	C	D	D	D	A

* A : All flaky graphite structure.
B : Flaky graphite structure mixed with a small area of eutectic graphite structure.
C : Eutectic graphite structure mixed with a small area of flaky graphite structure.
D : All eutectic graphite structure.

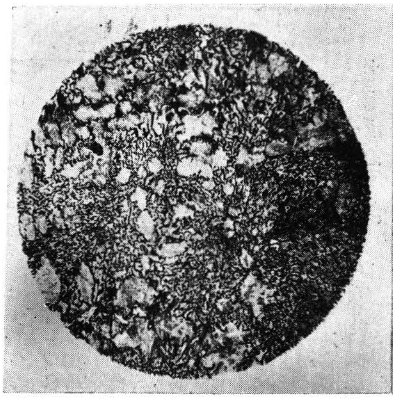

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Photo: 1

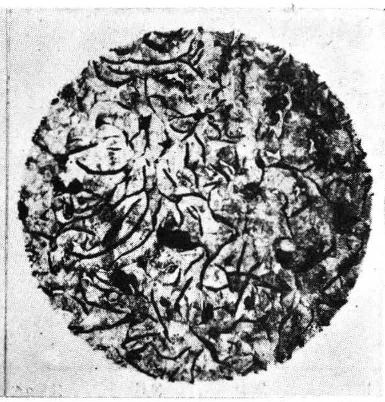

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Photo. 2

During the above-mentioned treatment, titanium is reduced in the slags and absorbed by the cast iron melts and the titanium content in the castings having all eutectic graphite structure is over about 0.2 pct. The contents of soluble nitrogen, insoluble nitrogen, and total nitrogen in the castings are almost independent of the content of titanium oxide in the slags with which the melts are treated.

The present writer calls the special cast iron with eutectic graphite structure made by the new special slag treatment "S-H cast iron".

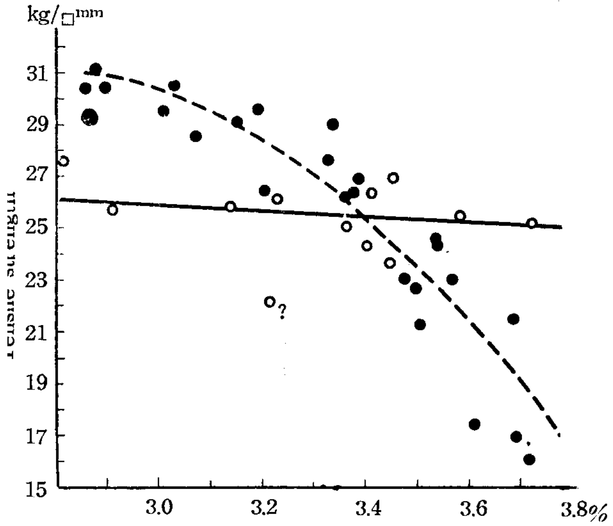
The detailed conditions necessary for the production of the S-H cast iron and the theory as to why the eutectic graphite structure forms in the new cast iron will be published in the nearest future.

The present writer, along with Y. Hotta, chief engineer of the Kobe Cast Iron Co. in Kobe, examined various mechanical properties of the S-H cast iron.

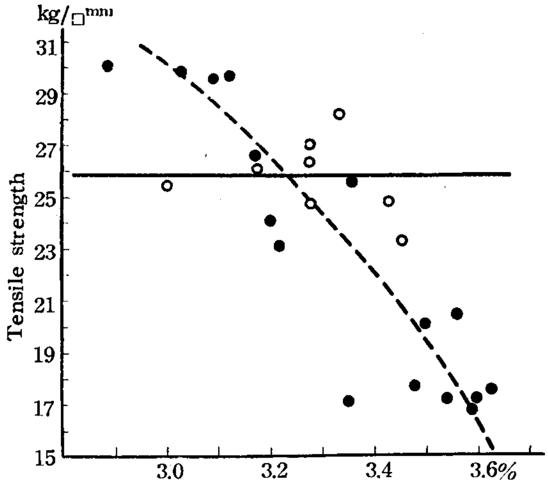
2 kgs. of the cast iron with varied carbon and silicon contents were melted in graphite crucibles in a cryptol furnace at 1400°C. to 1450°C. After the melts were treated with the slags containing about 9 pct of titanium oxide, they were cast vertically into the dry sand moulds, and thereby the round test bars, 25 mm. in diameter, were made. The contents of manganese, phosphorus and sulphur in the test bars were as follows:

$$Mn = \text{ca. } 0.6\% \quad P = \text{ca. } 0.3\% \quad S = \text{ca. } 0.06\%$$

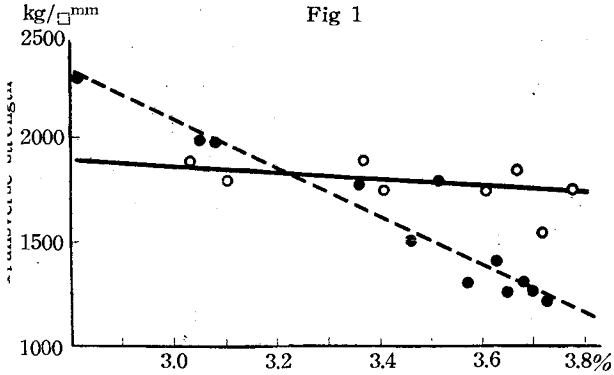
The tensile tests, the transverse tests were carried out on the test pieces having dimensions of the JES specification. The Brinell hardness was measured at the centre of the bars. The tests were also carried out on the test bars which were cast in the same manner as above mentioned except that they were melted without slag. They all had the flaky graphite structure as shown in Photo. 2.



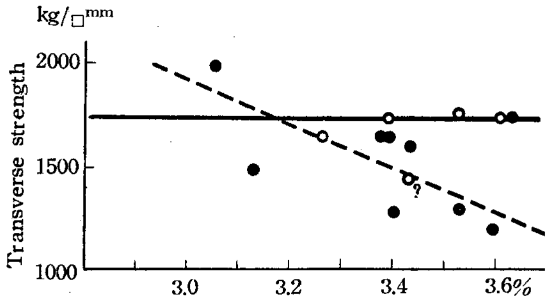
T. C
Si ≅ 1.5%
—○—○— S-H cast iron
—•—•— common cast iron
Fig 1



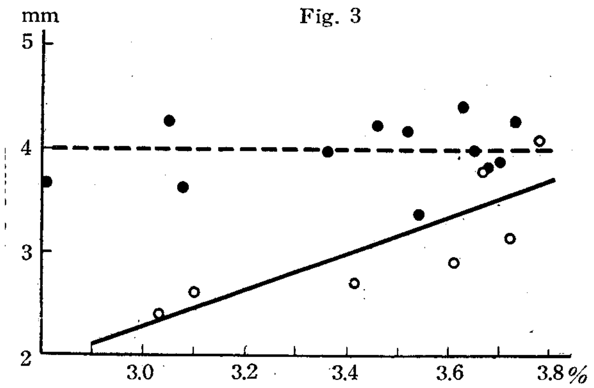
T. C
Si ≅ 2.0%
—○—○— S-H cast iron
—•—•— common cast iron
Fig 2



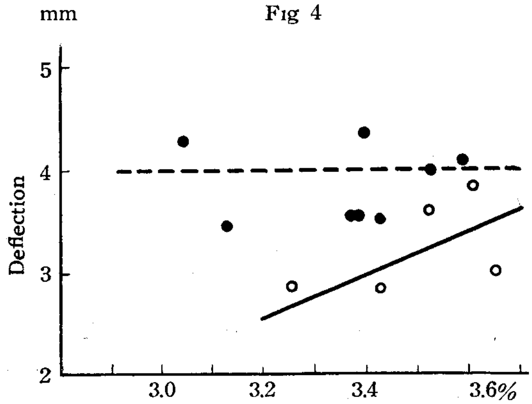
T. C
Si ≅ 1.5%
—○—○— S-H Cast iron
—•—•— common cast iron
Fig. 3



T. C
Si ≅ 2.0%
—○—○— S-H cast iron
—•—•— common cast iron
Fig 4



T. C
Si ≅ 1.5%
—○—○— S-H Cast iron
—•—•— common cast iron
Fig 5



T. C
Si ≅ 2.0%
—○—○— S-H cast iron
—•—•— common cast iron
Fig. 6

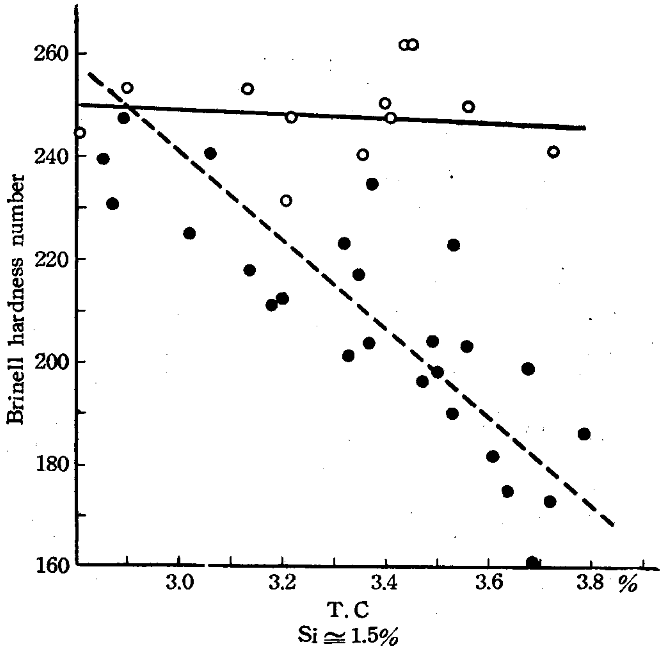


Fig. 7

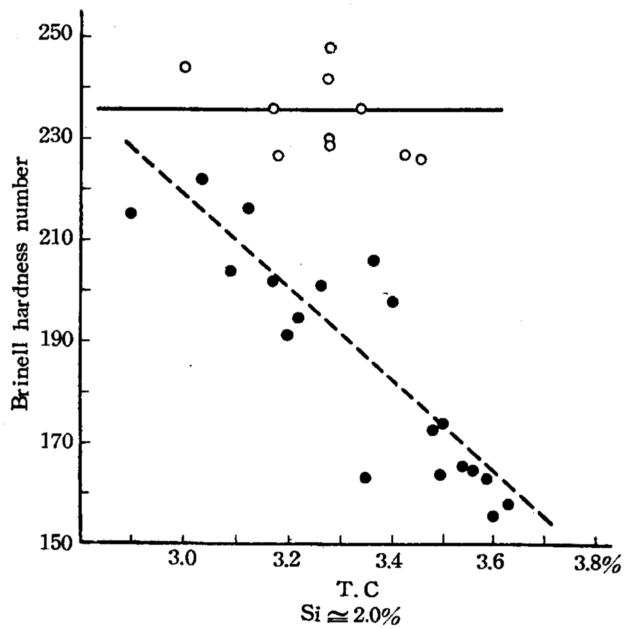


Fig. 8

The results are shown in Figs. 1 to 8. The tensile strength of the S-H cast iron is almost independent of the carbon content, and is about 25 to 27 Kg/□ mm within the limits of the compositions of the test bars. The property of the S-H cast iron containing over about 3.2 to 3.4 pct of carbon is higher than the same property of the common cast iron, and the difference in this property becomes greater as the carbon content increases. With the test specimens having less than 3.2 to 3.4 pct of carbon, the reverse relation is observed.

The difference in the transverse strength of the S-H cast iron and the common cast iron has almost the same tendency as in the tensile strength. The deflection of the former is somewhat smaller than that of the latter. The former is far harder than the latter.

The production of the S-H cast iron is very easy and economical, not only because titanium oxide is abundant and can be cheaply supplied in our country, but because the loss of titanium oxide in the slags during the treatment is negligible.

Acknowledgement

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References

1) P. Bardenheuer-K. L. Zeyen: Mitt. Kais.-Wilhelm Inst. Eisenforschg., 10 (1928) 23.
H. Sawamura: Suiyo-Kaishi, 6 (1929) 212.
S. Tanaka: Tetsu-to-Hagane, 18 (1932) 690; 22 (1936) 487.
T. Sato-S. Nishigori: Ditto, 21 (1935) 887.
A. Boyles: T. A. I. M. E. (Iron Steel Div.), (1937) 141.
2) E. Piwowarsky: Hochwertiger Grauguss (1929) 279 Abb. 248.
3) E. Schüz: Stahl Eisen, 45 (1925) 144.
4) A. L. Norbury-E. Morgan: J. Iron Steel Inst., (1936) II 327.