O-19

Evaluation of Anti-sticking Effect of Microstructure Components in Cast Iron by Friction Thermal Shock Test

Nozomu Oda[1], Yasunori Nozaki[1], Hiroshi Yamamoto[2], Tatsuya Tokunaga[2] and Hidenori Era[2]
[1] Hitachi Metals Wakamatsu Ltd., 1-9-1 Kitahama, Wakamatsu-ku, Kitakyusyu, 808-8558 Japan
[2] Kyushu Institute of Technology, 1-1 Sensui-cho, Tobata-ku, Kitakyusyu, 804-8550 Japan

Anti-sticking resistance is an important property to avoid deep cracks for hot strip mill work roll materials, especially in the later stands where mill incidents like cobble are likely to occur.

Effect of microstructure components on anti-sticking property was investigated with cast steel and iron samples using friction thermal shock test. Graphite was found to show higher effect than carbides, although they also show preferable effect, depending on its carbide type.

Keywords: *casting roll, cobble incident sticking property, microstructure*

1. Introduction

HSS rolls were started to be applied to HSM work roll in the end of 1980's. They have much higher wear resistance than high chrome steel, high chrome iron and ICDP based rolls. In the past, many trials have been made to use HSS rolls in later stands, however they were not successful due to their inferior sticking resistance which lead to rapid crack propagation. In the late 1990's, enhanced ICDP rolls which contain MC carbides (vanadium carbide, niobium carbide), have been introduced in HSM finishing trains. Although they show higher wear resistance than conventional ICDP rolls, still much less compared with HSS rolls[1]. Lower wear resistance roll leads to reducing HSM production efficiency by frequent roll changes. Accordingly there is still high demand for new roll materials having both high wear resistance and anti-sticking property.

HSS contains several types of carbide such as MC, M_2C, M_7C_3 (M: Metal) and so on, but no graphite. Enhanced ICDP contains higher amount of carbide, mostly M_3C with smaller content of MC and graphite[1]. The research about the relationship between microstructure of rolls and sticking property is expected to be utilized for the development of new roll materials for HSM later stands.

2. Experimental Procedure

2.1 Sample preparation

Sample ingots containing three series of microstructure component variation were prepared. White pig iron, steel scrap, electrolytic nickel and ferrous-based compounds of alloys were used for raw materials. They were melted in high frequency induction furnace and cast into molds composed with iron chiller at the bottom and heat-insulated sleeve at side part in order to obtain directionally solidified 4kg ingots. Ingots were quenched and then tempered at 623 to 823 K to adjust to hardness of 50-55HRC, however some samples could not be controlled within this hardness range.

Table 1 shows basic chemical composition of each series. C-series (Cs) has 0.8 to 3.0mass% range of carbon aiming to obtain various contents of cementite (M_3C). C-Si-series (CSis) has 1.5 to 3.4 mass% range of carbon and 1.7 to 2.0mass% of silicon range to obtain various contents of M_3C and graphite. Cr-series (CCrs) has 9.2 to 23.4 mass% chromium range and 1.2 –to 3.7 mass% carbon range to obtain various contents of chromium carbide.

The microstructure observation by optical microscopy and sticking property evaluation were made at the distance of 30mm from the chilled surface of each ingot. The microstructures were quantitatively measured as area ratio of each structural component using image processing software.

Table1 Basic chemical composition (mass%).

C	Si	Mn	Ni	Cr	Mo	V
*[1]	0.75*[2]	0.75	1.0	0.9*[3]	*[4]	0.5

*[1]:0.8 – 3.4, *[2]:Cs and CCrs, *[3]:Cs and CSis, *[4]: Cs and CS-s <0.15, CCrs 1.0

2.2 Sticking property evaluation

The sticking property of samples were evaluated using friction thermal shock test (FTS test) [2] which simulates cobble incident phenomenon[3]. Mild steel rod is forced into a narrow gap between the specimen and a steel cylinder connected with pinion gear by dropping of a weight. The steel rod is pressed strongly on specimen surface and friction heat is generated. The specimen surface is heated up by the friction and the steel rod stick to it. Sticking property was evaluated as "sticking surface ratio", the area ratio of the stuck area against the outline of steel rod contact on the specimen .

3. Results

Figure1 shows the relationship between carbide content "carbide area ratio" and sticking property "Sticking surface ratio". Sticking surface ratio decrease as carbide area ratio increase in both Cs and CCrs. Especially Cs show larger decrease rate and reaching to same level as CSis at 20% of carbide area ratio. In case of CSis, no clear correlation between the sticking surface and carbide area ratio is found and sticking surface ratio shows stably low level around 20%.

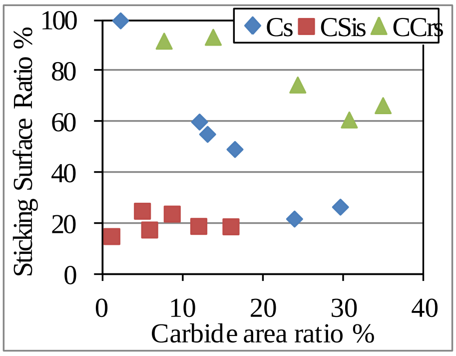

Fig.1 Relationship between carbide amount and sticking property.

Graphite amounts and distributions of all CSis group samples were observed with non-etched samples by optical microscopy. There were various shapes of graphite found in the samples like grain type or flake type. The range of graphite area of CSis was measured as from 0.5 to 6.7%. Their hardness were within 50-53HRC, except the sample containing 6.7% graphite area ratio with 35HRC.

In both of Cs and CCrs samples, no obvious graphite has been recognized by microscopy, only 10 - 20 μm - sized very small dark points were observed with non-etched polished state, which could be graphite but also inclusions or shrinkages. The area ratio of this dark point part in Cs samples were less than 0.3%. Electron micro scope analysis has been conducted to check the dark points and found that those in the samples showing lower sticking surface ratio were around 10μm - sized small graphite.

4. Discussion

It is well known that graphite is a excellent solid lubricant. In this study, it was confirmed that graphite is more effective to prevent steel from sticking to cast iron than carbides under FTS test condition. And 0.5% area ratio of graphite can be concluded to be enough to get the anti-sticking effect, considering the experiment results of no further reduction of sticking surface ratio above this amount.

In case of two of Cs samples, which show the same level of sticking surface ratio as CSis samples in spite of containing less than 0.3% area ratio of graphite, rather high carbide area ratio may have some effect for anti-sticking resistance.

Carbides in Cs and CSis samples are mainly M_3C and those in CCrs are M_7C_3. CCrs samples show higher sticking surface ratio than Cs, compared at same carbide areas. From this result, we can conclude that M_3C is more effective for anti-sticking component than M_7C_3. Further study is necessary to locate the reason of this difference effect of them.

5. Conclusions

Effect of anti-sticking property of each component in cast steel and iron samples was investigated and the following results were obtained ;

(1) Graphite is the most effective component for anti-sticking property even very small amount like 0.5% of area ratio.

(2) Carbide is also effective component for anti-sticking property, and its effectiveness depends on carbide type.

References

[1] N. Oda: *ISIJ Nishiyama Kinen Kouza No221&222*, (2015) pp. 47-66.

[2] S. Ohhashi,T. Ishiguro and H. Gotoh: *Tetsu - to - Hagane* 77 (1991) 652-659.

[3] A. Noda, E. Matsunaga, T. Hattori and Y. Sano: Hitachi Metals Technical Review 13 (1997) 89-92.