THE STUDY ON ABRASIVE WEAR OF CARBON OF HIGH VANADIUM HIGH SPEED STEEL COMPARED WITH THAT OF HIGH CHROMIUM CAST IRON

WEI Shizhong\textsuperscript{a,b} ZHU Jinhua\textsuperscript{a} XU Liujie\textsuperscript{a} LONG Rui\textsuperscript{c}

\textsuperscript{a} School of Materials Science and Technology, Xi'an Jiaotong University, Xi'an, Shanxi, P.R. China\textsuperscript{b} School of Materials Science and Technology, Henan University of Science and Technology, Luoyang, Henan, P.R. China\textsuperscript{c} Henan Engineering Research Center for Wear of Material, Luoyang, Henan, P.R. China

ABSTRACT

It is studied the carbons abrasive wear property of high vanadium high speed steel compared with that of general high chromium cast iron (Cr20) in this paper. The vanadium content is 10\% in the high vanadium high speed steel, and it is a kind of new wear material that has been studied in the past ten years. In the experiment the three materials were used to resist the abrasive wear of Al\textsubscript{2}O\textsubscript{3}, the wear test was conducted on a ML-10 abrasive wear-testing machine. The abrasive surfaces, cross-section and sloping -section surfaces were scanned by means of a SEM (JSM-5160LV) device. The typical morphology photos of VC and Cr\textsubscript{7}C\textsubscript{3} were taken in course of abrasive wear, which not only describe the different abrasive wear property of the carbons in the two materials, but also make the cause of the excellent wear property of this HSS clear.

The research results have showed that the service lives (V10) are three times longer than that of high chromium cast iron (Cr20). The excellent wear resistance of high vanadium high-speed steel depends on the characters of high hardness, lumpy morphology of VC which are scattered in hard matrix of HSS.

1. INTRODUCTION

High vanadium high speed steel is a kind of new wear material that has been studied in the past ten years. Japan has firstly used this steel for steel rollers successfully, whose service lives are twice to four times as long as those of high chromium cast iron (Keun \textit{et al}, 1998. He \textit{et al}, 1996. Fu \textit{et al}, 1999. Liu \textit{et al}, 1999). Henan Engineering Research Center for Wear of Material has studied and exploited a new kind of high vanadium high speed steel by absorbing worldwide research results and making some innovations on this HSS’ chemical elements. The HSS has been successfully used into crush industry (Wei \textit{et al}, 2002).

The essay concentrates on the study on abrasive wear of carbon of High vanadium high speed steel compared with that of high chromium cast iron, which enlarge the application area of High vanadium high speed steel materials, provide some basic datum for research. It is important that some typical morphology photos of VC and Cr\textsubscript{7}C\textsubscript{3} were taken in course of abrasive wear besides these morphology photos can not only describe the different abrasive wear property of the three materials, but also make the cause of the excellent wear of this HSS clear.

2. METHODS

In the wear test, the specimens with the size of 4x4x5mm were conducted on a ML-10 abrasive wear-testing machine, using alumina sand paper. The test distance was 20x72mm with pressure of 250N. In the experiment there were three specimens in a group, the average wear amount of three specimens represented this material wear property. The mass of wear is measured by an analysis-balance whose degree of discrimination is 0.1mg. The relative wear property is specified by \( \bar{A}_m \), where \( M_0 \) expresses the wear lost in the standard specimens, and \( M \) expresses the wear lost of each tested specimen. In the experiment, the specimen made of steel with high chromium iron was considered a standard one.

3. RESULTS AND DISCUSSION

Table 1 show the wear extents and wear resistance of high vanadium high speed steel and high chromium cast iron. The table shows that the wear resistance of high vanadium high speed steel is 3.3 times much than high chromium cast iron in this study, respectively.

The high chrome cast iron can be thought as in situ compositions (the eutectic and over eutectic hard Cr\textsubscript{7}C\textsubscript{3} distributing in matrix) (Thomas \textit{et al}, 1999). In order to observe the behavior in the course of abrasive wear of the Cr\textsubscript{7}C\textsubscript{3} in the high chrome cast iron, especially to find the thick lathing Cr\textsubscript{7}C\textsubscript{3} of over eutectic in oblique cut (as C shows in fig 1-b). The hardness (HV1200-1800) of the Cr\textsubscript{7}C\textsubscript{3} is lower than that of the Al\textsubscript{2}O\textsubscript{3} (HV1800-2200). Under the condition of the hard Al\textsubscript{2}O\textsubscript{3} abrasive micro-cutting, the furrows in the thick lathing Cr\textsubscript{7}C\textsubscript{3} caused by the Al\textsubscript{2}O\textsubscript{3} abrasive micro- cutting are shallower than that in matrix, which shows that the Cr\textsubscript{7}C\textsubscript{3} can’t resist the Al\textsubscript{2}O\textsubscript{3} abrasive micro-cutting but can reduce it. In the hypo-surface, the crack can be seen in the thick lathing Cr\textsubscript{7}C\textsubscript{3} (as D shows in fig 1-b). This shows that the Cr\textsubscript{7}C\textsubscript{3} can crack and result crash and shelling in the abrasive surface and hypo-surface, under the double function of the hard Al\textsubscript{2}O\textsubscript{3} abrasive micro- cutting and direct stress.

The lumpy VC is mainly on the abrasive surface, which can resist the micro- cutting of the Al\textsubscript{2}O\textsubscript{3} abrasive. In some areas, there are concave holes caused by the shelling of lumpy VC.
In order to study the abrasive of VC in course of abrasive wear of high vanadium high speed steel, and find the bigger lumpy VC in size in cross-section and oblique cut surface especially, as V shows in fig1-a and 2-a. The broken VC can be seen clearly from thick big lumpy VC in the middle of fig1-a. The fig 2-a, b are morphology and energy spectrum of VC in photo of cross-section surface of high vanadium high speed steel. The top is abrasive surface and underside is metal phase surface in fig 1-a. the broken VC can be seen clearly from thick big lumpy VC in the middle of fig1-a.

The first, it can resist micro-cutting of the Al2O3 abrasive and reduce depth and thickness of the furrow. The second, under the double function of the micro-cutting of the hard Al2O3 abrasive and the direct stress, the lumpy VC crashes and shells in abrasive surface and hypo-surface according to the information from fig 1-2, VC has two behaviours in the course of abrasive wear as follows:

1. In condition that abrasive wear that Al2O3 was abrasive, the service lives (V10) are three times than that of cast iron (Cr20) respectively.
2. If Al2O3 was abrasive material, the degree of micro-cutting of high vanadium high-speed steel is lighter than that of high chromium cast iron. the failure form of Cr7C3 mainly is microcosmic cutting, crack, shelling. and the failure form of VC mainly is crack and shelling.
3. The carbon (VC) has higher hardness, good morphology and dispersed in hard matrix of high vanadium high-speed steel, which is the main reason that it has fine wear resistance.
4. The wear resistance of high vanadium high-speed steel is excellent. The hardness and assault toughness are higher than high chromium. There will be wide application prospects and becomes the safe and reliable update material of high chromium cast iron.

**REFERENCES**


He X F translated, 1996, Development of high speed steel rolls for hot strip rolling mills: Steel Rolling.


**TABLE**

<table>
<thead>
<tr>
<th>Samples</th>
<th>wear extents(mg)</th>
<th>Relative wear resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>High vanadium high speed steel</td>
<td>31.5</td>
<td>33.3</td>
</tr>
<tr>
<td>High chromium cast iron</td>
<td>102.5</td>
<td>112.1</td>
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**FIGURES**

(a) VC morphologies x1,000 (b) VC energy spectrum

Fig.1 Surface morphologies incline to grinding surface

Fig.2 VC morphologies and energy spectrum

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