INVESTIGATION OF MODIFIER COMPOSITION TO IMPROVE WEAR RESISTANCE DURING THE MELTING OF WHITE CAST IRON

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Abstract

White cast iron is widely used in wear-intensive applications due to its high hardness, but its brittleness limits performance in many industrial settings. This research investigates the effect of various modifiers—such as titanium (Ti), vanadium (V), and rare-earth metals (REMs)—on the microstructure and wear resistance of white cast iron during the melting process. The study includes melting tests, microstructural analysis, and tribological testing to determine the effectiveness of each modifier composition. Results show that Ti and V act as effective carbide stabilizers and grain refiners, while REMs enhance the uniformity of carbide distribution, leading to a notable increase in wear resistance.

Keywords: White cast iron, wear resistance, modifiers, titanium, vanadium, rare-earth metals, carbide formation, microstructure

1. Introduction

White cast iron is a critical material in mining, construction, and crushing equipment due to its excellent wear resistance, which is primarily derived from its carbide-rich microstructure. However, its inherent brittleness and non-uniform carbide distribution often limit its operational life. Recent advancements in metallurgy suggest that the addition of specific modifiers during the melting process can significantly refine the structure and improve wear resistance.

The aim of this research is to explore the effectiveness of various modifier compositions in enhancing the wear resistance of white cast iron by analyzing the changes in microstructure and tribological behavior after the addition of Ti, V, and REMs.

2. Materials and Methods

2.1 Experimental Material

The base metal used was high-chromium white cast iron with the following chemical composition:

Element	C	Cr	i	n	Fe
wt.%	2.8–3.0	12–14	.0	.5	Balance

2.2 Modifiers and Melting Procedure

Three different modifier groups were used:

- Group A: 0.3% Titanium (Ti)
- Group B: 0.2% Vanadium (V)
- Group C: 0.15% Rare-earth metals (REMs)

The castings were melted in an induction furnace at 1450°C and poured into standard sand molds.

2.3 Microstructure Analysis

Samples were polished and etched with 4% nital solution for optical microscopy and SEM analysis. The volume fraction and morphology of carbides were observed and quantified.

2.4 Wear Testing

Pin-on-disk tests were conducted under a 20 N load and 600 rpm speed for 30 minutes. Wear rate was calculated by weight loss measurements.

3. Results

3.1 Microstructural Observations

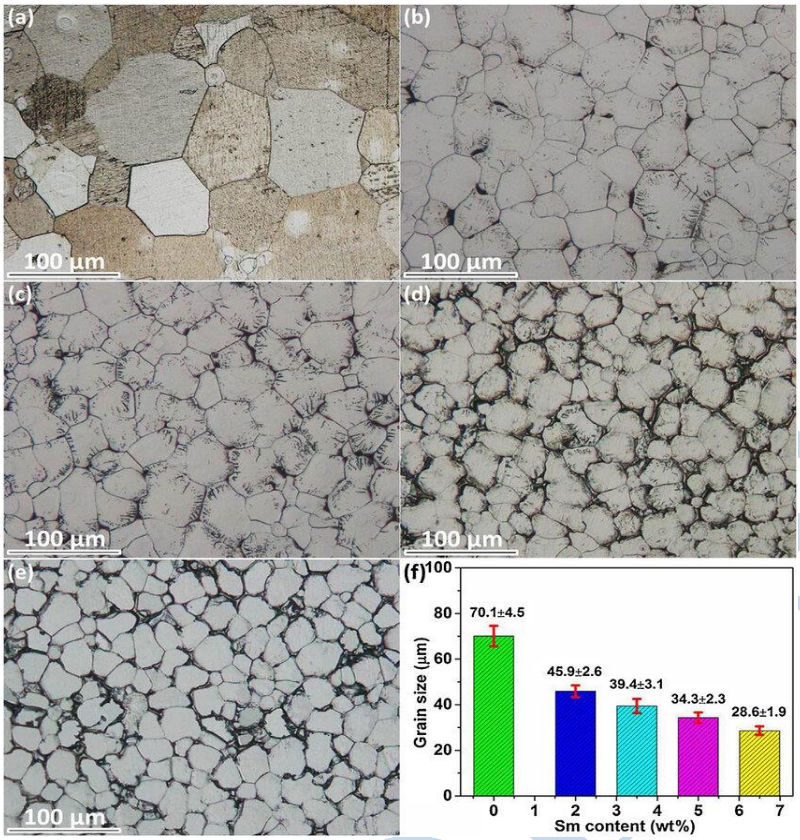

Figure 1 shows comparative micrographs of the base alloy and each modified sample.

- Unmodified sample: Coarse, irregular eutectic carbides with uneven distribution.
- Ti-modified: Finer, more evenly distributed primary carbides and reduced graphite flakes.
- V-modified: Higher volume of fine secondary carbides (VC), enhancing hardness.
- REM-modified: Refined eutectic structure and reduced microsegregation.

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