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REACTION MECHANISM STUDY ON CARBOTHERMAL REDUCTION OF CHROMITE

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Objective

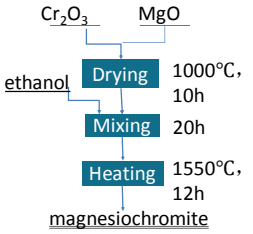
To investigate the carbothermal reduction mechanism of chromite
To provide a fundamental understanding of recovering Cr from chromite-containing stainless steel slag.

Introduction

Chromium is the most important element in manufacturing of stainless steels. A certain amount of chromium remains in the slag in the form of chromite, resulting in considerable chromium losses. This work studied on the reduction of chromite and chromium oxide either through direct interaction between solid carbon and chromite particles or through gas/solid reaction.

Experimental

Preparation of starting material:



Carbon black was used as reductant due to its large surface area.

Experimental procedure:

The reduction experiments were carried out in a vertical furnace in the temperature range from 1100 ℃ to 1500 ℃, at an argon flow rate of 400 mL/min. Chromite and carbon were thoroughly mixed and placed in an alumina crucible. The heating rate and cooling rate were both 5 ℃/min and the dwell time at the temperature of interest was 60 min.

Results & discussion

XRD Semi-quantitative analysis of the samples (wt%)

Temperature (°C)	$MgCrO_4$	Cr_3C_2	Cr_7C_3	$Cr_{23}C_6$	Cr	MgO
1100	86.6	13.4	-	-	-	-
1200	33.1	19.2	18.9	-	-	28.8
1300	24.5	-	46.4	-	-	29.1
1400	20.4	-	30.6	2.8	19.3	27.0
1500	-	-	-	36.4	6.7	56.9

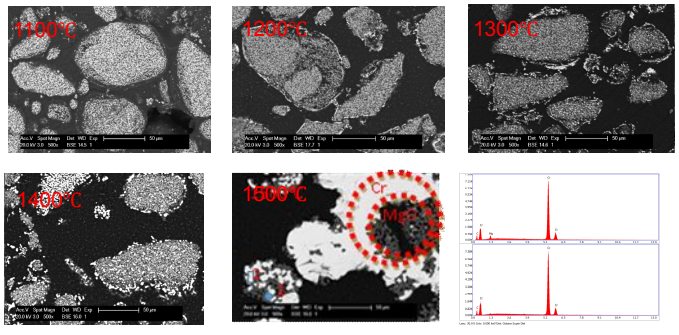


Fig.1 SEM images of reduced sample at different temperature

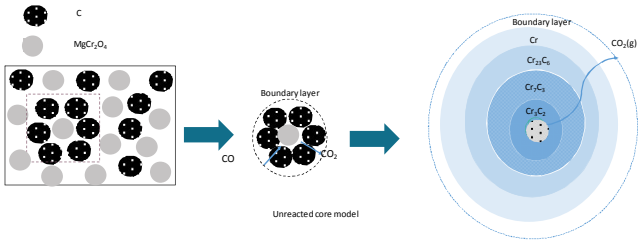


Fig.2 Schematic representation of the carbothermal reaction mechanism of $MgCr_2O_4$

Reduction Mechanism:

(1) Reaction between chromite and carbon at the chromite/carbon interface, leading to formation of CO and chromium carbides.

(2) Reduction of chromite by generating CO to form CO_2 with the transfer of CO from the carbon surface to proximate chromite via voids based on higher ratio of p_{co}/p_{co2}.

(3) Diffusion of the gaseous product (CO_2) through the porous product layer of the particle to the outer reaction interface through voids.

(4) Conversion from the carbide with lower Cr content to the carbide with higher Cr content to form pure metallic chromium by CO_2 transfer from the reaction surface to the boundary layer.

Conclusions

Carbothermal reduction of synthetic chromite was carried out under argon atmosphere. Chromite is gradually reduced by carbon through the consecutive formation of low chromium content carbides as intermediate phase, which then react with CO_2 to form carbides with higher Cr content, which are then finally reduced to metallic chromium. The reaction mechanism is proposed based on the experimental results and thermodynamic calculation.

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