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「課程博士用」

学 位 論 文 の 要 旨

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学位論文題目	**Study on Carbothermal Reduction Process from Alumina to Aluminum** アルミナからアルミニウムへの炭素熱還元プロセスの研究		

学位論文要旨

Recently, the world consumption of metal aluminum knew a significant rise. This growth in the demand is mainly due to the world focus on using a stable and lightweight material for automobiles, infrastructures and sensors technology. However, the conventional process known as Hall-Héroult used for the production of aluminum expresses a high energy cost and loss of greenhouse emissions. To deal with the high-cost problem, a substitution method known as the carbothermal reduction of alumina based on reducing the alumina with carbon as reductant material in an induction heating furnace shows to be efficient and expressed low energy cost. In the other hand, the yield of produced aluminum via carbothermal reduction of alumina still quite low. To improve the reduction process yield, the knowledge and study of the different processes occurring during the reduction are necessary to improve the efficiency of the carbothermal method and increase the yield of the final aluminum product. In the following, I describe the main objective of my study:

- Simulation and analysis of the phase stability diagram of Al-O-C, to understand thermodynamically the different reactions occurred during the carbothermal reduction process.
- Evaluation of the optimum heating temperature condition to achieve a higher yield based on the relationship between the partial pressure of the by-product gas-form (Al_2O and CO).
- Investigation of the effect of adding aluminum carbide to the starting raw materials mixture of alumina and carbon to speed up the reactions and enhance the reduction yield.

In this study, I have attempted to optimize and enhance the yield of the produced aluminum following all the objectives cited above and success on determining the optimum thermodynamics conditions such as the mole fraction, the pressure and the temperature for the enhancements of the carbothermal reduction process yield. In addition, the positive effect of the additive on the improvement of the reduction process yield will be discussed in details..

The thesis is composed of four chapters. The first chapter is dedicated to discussing a brief

history of aluminum production, with the importance of aluminum in the automobile and current industries. Furthermore, the current aluminum world market and the conventional process will be discussed. While the in the second chapter the direct carbothermal reduction of alumina compared to the conventional Hall-Heroult process will be explained in details including the thermodynamics theoretical background on the presence and stability of alumina, aluminum, aluminum carbide and carbon under various conditions such as temperature and pressure which are the key for the understanding of the reduction process. While all the focus of this research work is about the necessity optimization and precise determination of the heating process temperature which has a significant impact on the by-product Al_2O gas generation. On the other hand, the investigation of the aluminum carbide additive effect will be discussed in details to determine precisely its impact on the enhancement of the reduction process yield.

The third chapter will present the experimental procedures used for the two main work of this research starting with the optimization of the heating temperature for the reduction process. A complete explanation of its relationship to the stability phase diagram of Al-O-C, the material used and the effect on the final yield of the reduction. A second part, the experimental procedure of the aluminum carbide additive optimization such as the used material and methods, and the impact of the additive on the different reaction inside the process will be discussed. As for both experimental parts, the same characterization techniques will be used including XRD for product quantification and mass balance calculation, while Quadrupole mass spectroscopy (Q-mass) will be used for real-time estimation of different gas phase during the reduction process.

Chapter four will present the experimental results and discussions following each experimental procure discussed in the third chapter. The optimization results or the heating process temperature will be discussed in details with their impact on the determination of the exact temperature allowing a higher aluminum yield. While for the optimization of the aluminum carbide additive effect by comparing nine different ratios will be compared in term of gas loss, product composition, aluminum carbide and aluminum yield.

Finally, the conclusion section will summarize the achievement and comments on the investigation and enhancement of the carbothermal reduction of alumina for production of aluminum.

注）和文 2,000 字以内又は英文 800 語以内　　続紙　有□　無□