CHAPTER I

INTRODUCTION

Electric steelmaking with direct reduced iron (DRI) has proved a possible substitution method for conventional steelmaking processes such as scrap-remelting or the blast furnace-BOF process. Although much has been written on the general performance of the electric arc bath as a medium for melting DRI, yet the practice of iron and steel manufacturing suffers from a lack of quantitative information on the behavior of the DRI melting system.

The purpose of this study is to determine the roles that various parameters play until the prereduced iron particles fed into the electric arc bath are totally melted and to analyze the operational conditions under which the rate of production of steel may be enhanced.

The question to be answeredis therefore: What are the optimum properties of materials and operational conditions under which the rate of melting of DRI may be maximized? Because of the technical difficulties in running experimental tests at relatively high temperatures corresponding with typical practical DRI melting systems and substantial differences in conditions and properties of various materials employed in such systems, it is desirable to develope a general model that can utilize the available information to reasonably predict the melting time of DRI particles charged into a steelmaking furnace. Simple experimental tests are designed to collect the information that is essential to building such a model. The tests are conducted at temperatures below the melting point of DRI materials. Simple assumptions are made to extrapolate the model predictions up to the complete melting of the charged particles.

The melting of inert metallic spheres in ferrous silicate slags has earlier been studied by Nauman[58] who has developed a computer model for prediction of the melting rate of cold spheres immersed in slags. He has, however, neglected the variations of the thermal properties of the materials involved as temperature rises. Such variations have a significant effect on the rate of heating and melting of particles in slags. The thermal conductivities of iron and nickel spheres used by Nauman[58] for heat transfer studies, for instance, drop to one and two third of their initial values when the temperature of the immersed object rises 1000°C, while that of the slag shell doubles for a similar temperature change (cf. Table 5-3 and Appendix D).

The chemical reactions that result in the final reduction of D-R pellets immersed in liquid slags result in further changes of the thermal properties of the pellets. The enthalpies of the reduction reactions will be added to the heat capacity of D-R pellets while the changes of the chemical composition and porosity affects the thermal conductivity of the pellets. The evolution of the gases formed in DRI pellets increases the porosity of the shell of slag that may freeze on the pellets and changes the thermal conductivity of the shell.

The conditions of the liquid slags used as media for heating and melting of DRI pellets and growth of the shell of solid slag on periphery of the immersed pellets are influeced by the evolution of gas from the pellets into the slag (chap. VI). As will be seen later, the formation of gas, the condition of the bath, the exchange of heat, and the solidification and melting of liquid and solid phases all are interrelated.

The gas evolution and heat transfer processes are analyzed separately to identify the appropriate interrelations. The results of these analyses are then synthesized to determine the nature of the overall system and the influence of various parameters on the behavior of the system. The focus of the studies has always been on the properties and behavior of materials involved in the DRI melting system, such as: (a) D-R particles that are utilized as the charge to the steelmaking furnace, (b) the solid and liquid phases that function as the medium for the transfer of heat, and (c) the gases that form in the particles and evolve into the liquid bath during the melting process.

The evolution of gas from pellets was studied by determining the volume and analysis of the gases evolved during heating of DRI particles. Changes in properties of the DRI particles such as chemical composition, thermal diffusivity, and melting temperature were evaluated from the above information. These results were incorporated into a dynamic model that simulates the behavior of direct reduced pellets immersed in a hot liquid environment such as a steelmaking slag. The model was tested against the experimental results and was used to determine the parameters that may be influential in optimization of the DRI-electric steelmaking practice.