UNIVERSAL TECHNOLOGY FOR THE PRODUCTION
OF CARBON-CONTAINING SOLID SOLUTIONS AND COMPOSITIONAL
MATERIALS ON THEIR BASIS

SHVEIKIN G.P., LUBIMOV V.D.
Institute of Chemistry, Ural Branch of the USSR Academy of Sciences, 91 Pervomaiskaya St., Sverdlovsk, USSR

SUMMARY

Some theoretical basis and the mechanism of carbothermal production of powder materials are discussed in the paper. The proposed method of carbothermal reduction of oxides in the controlled gaseous medium is the most simple, economical and technological one. This method allows to maintain the direct and reverse dependence between the substance and the material depending on the requirements to the materials based on this substance. The method enables to regulate the granulometric composition of the final product.

Among modern methods of powder material production the carbothermal method is considered to be most simple, economical and technological one. This method implies minimum of technological operations, cheap raw materials (oxides, carbon) and a possible organization of a continuous process with simple technological equipment.

In is one of the most ancient methods. The production of cast-iron, steel, ferrous alloys and other materials was based on it. Fundamental studies of Soviet scientists (Chufarov G.N., Esin O.A., Geld P.V. and others) on kinetics and mechanism of this process made great contribution into this method. It should be emphasized that the technology of carbothermal reduction does not require any special safety conditions, and the reaction products (CO) are well utilized and do not pollute the environment.

It can be said that in case of easily reducible oxides this process dominates on the other processes for the production of metals and alloys which do not form stable carbides. As regards hardly reducible oxides of IVa-Va subgroup carbide-forming metals,
the carbothermal production of metals and their different compounds with nonmetals has not been sufficiently investigated.

There are several viewpoints of view on oxide reduction mechanism related first of all with their physico-chemical properties, such as dissociation, evaporatio, etc. The variety and complication of the arising phenomena do not allow to create a universal theory irrespective of the oxide type and process conditions. The main constituents of the process - oxide interactions with reductants, gaseous atmosphere, solid phase transformations - turned out to be poorly studied for the reduction of hardly reducible oxides of IVa-Va subgroups. These oxides, however, show many analogous physico-chemical properties: they are refractory, stable, have defects in metalloid sublattice, etc. (1). This allows to consider their reduction mechanism from the common positions.

First of all, it was obtained by means of gravimetric, mass-spectrometric and complete thermodynamic methods that the steam content of the studied oxides and oxygen in gaseous medium was negligible at working temperatures (1100-1500°C). Evidently, the dissociation or evaporation of oxides are not the main reduction canals in this temperature rate.

Statistics and kinetics studies of the oxide reduction by gaseous reductants (H₂ and CO) showed (Nb₂O₅ as example) that the process of indirect reduction was due not to the mobility of structural elements of the condensed reagent lattices, but due to the interaction at the solid-gas interface and, perhaps, to crystallo-chemical transformations in solid phase (2-4). The second important conclusion from these studies is as follows. It turned out that carbon oxide, at least at its small pressures relative to the oxide group, has lower reducing potential than hydrogen. The question of the direct oxide reductants is complicated and arouses discussion. But it is clear that this reductant must be gaseous and genetically related with the introduced carbon. Recently, a hypothesis on gaseous or amorphous carbon with higher reducing potential than that of carbon oxide has been advanced (5).

Solid phase crystallochemical transformations in the reduction of 4d-5d metal oxides (unlike, for example, iron oxides (6)) are due to oxygen diffusion from deep areas of the