ELSEVIER

Journal of Materials Processing Technology 162–163 (2005) 127–130

Journal of Materials Processing Technology

www.elsevier.com/locate/jmatprotec

The structure and properties of sinters produced from composite powders Al–Al_2O_3–Al_3Fe–Al_3Ti

Józef Śleziona *, Maciej Dyzia, Jerzy Myalski, Jakub Wieczorek

Silesian University of Technology, ul. Krasinskiego 8, PL40-019 Katowice, Poland

Abstract

The paper presents some results of the research in scope of received composite powders by using liquid metal method. Controlled condition of reaction between ilmenite and liquid aluminium provide to obtained the composite powder consist of intermetallics (Al–Ti, Al–Fe system) and alumina.
© 2005 Elsevier B.V. All rights reserved.

Keywords: Aluminothermal reaction; Ilmenite; Composite powder

1. Introduction

More and more important in the range of heterophase composites production technologies are the powder metallurgy technologies. Mixtures of powders for compression are prepared by different methods which ensure a homogeneous structure with a ceramic particle reinforced intermetallic phase matrix. One of powders production method is SHS followed by grinding and hot compression. There is a variety of technological solutions which lead to obtaining a composite of predefined properties. One of them is hot compression in a vacuum, another - impulse compression [1].

The current great interest in the possibility of using the aluminothermal reaction in the production of composite powders is related to the use of ilmenite. The product of the reaction between ilmenite and aluminium are intermetallic phases from the Al–Ti and Al–Fe systems, and alumina particles. In the classical metallurgical technology, this reaction is used for the production of ferrotitanium containing up to 30% of Al [2]. One of the solutions developed when conducting the research on composites based on an intermetallic phase from the Al–Fe–Ti [3] system was obtaining a composite powder, from which, after treatment (soaking, grinding, separation), sinters were produced. The present paper presents some results of the research in this scope.

2. Materials for the research and method of composite powder production

$FeO{\cdot}TiO_2$ ilmenite of Norwegian production, grain size below 70 μm, and technically pure, A0 grade aluminium produced by ZM Skawina (Poland), were used for the fabrication of composites. The chemical composition of the ilmenite, according to Titania Company (Norway), is as follows: 44.35% TiO_2, 2.81% SiO_2, 3.80% MgO and 0.2% V_2O_5; the rest: 35.94% Fe and total: 0.167% (P,S) – impurities.

The technological concept of the production of a composite powder of a predefined phase composition consisted in making use of the aluminothermal reaction which takes place between aluminium and ilmenite. The reaction can be written down in the following way:

$$FeO \cdot TiO_2 + (8 + x)Al \rightarrow Al_2O_3 + Al_3Fe + Al_3Ti + xAl \quad (1)$$

Reaction (1) is thermally activated; it starts at a temperature of 680 °C [4] and proceeds very rapidly. Excess of aluminium is supposed to ensure that ilmenite is completely reacted and to slow down the reaction. The product of this reaction are intermetallic phases from the Al–Fe and Al–Ti systems and

* Corresponding author.
E-mail address: sleziona@pols.katowice.pl (J. Śleziona).

0924-0136/$ – see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.jmatprotec.2005.02.183

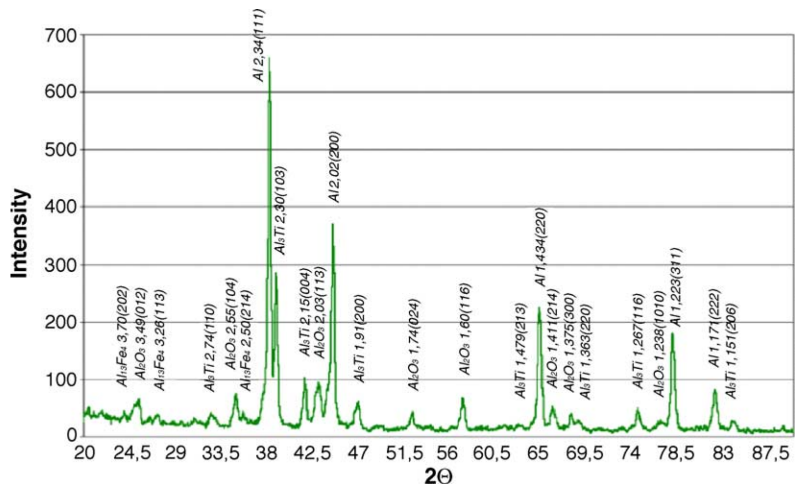

Fig. 1. Phase composition of composite powders after producing at 720 °C and size reduction in ball mill.

alumina. The composite powders were fabricated in an in situ reaction of liquid aluminium with ilmenite powder of particle size 40–80 μm incorporated into it using stir casting. To ensure control over the aluminothermal reaction, the minimum temperature of molten aluminium during the incorporation of the ilmenite powder did not exceed 720 °C. The ilmenite powder incorporated into liquid aluminium was priorly dried and heated to a temperature of 500 °C. The rate of stirring the liquid metal amounted to 280 rpm. The process temperature was predefined based on a differential thermal analysis (DTA) [4]. The reaction led to the production of powder of a phase composition (Al_2O_3, Al_3Fe and Al_3Ti) and size below 1 mm. The powder's phase composition was determined by X-ray radiography (Fig. 1).

Predominating components of this powder are aluminium, alumina and intermetallic phases Al_3Ti and $Al_{13}Fe_4$. The powder production process was conducted until the liquid aluminium ran low, however, the quantity of the ilmenite incorporated into it was always constant and amounted 20-wt.% in relation to the aluminium applied. The obtained composite powder was subjected to separation at further stages in order to separate large aluminium particles which had not been completely reacted. The large particles' share in relation to the primary aluminium volume did not exceed 5%. Next, the so prepared powder was subjected to grinding in a crusher and ball mill, after which screening took place and fractions below 40 or 40–80 μm and above 80 μm were obtained. The maximum size of the composite powder particles used for the fabrication of the specimens did not exceed 120 μm. The powder grain composition after grinding is shown in Table 1.

3. Technological process and structure of composite sinters

Two methods were applied for the production of specimens (sinters) from composite powder:

- cold compaction followed by sintering,
- hot compaction and sintering in a Degussa press.

Powders 25–45 μm and 45–80 μm in size were used for the investigation. Cold pressing was conducted by means of a two-sided Żywiec press of a maximum load equal 600 MN. Roll-shaped compacts, 30 mm in diameter and 15 mm high, were obtained. Changeable compaction pressure was applied: 150, 300 or 500 MPa. The sintering process proceeded in an argon atmosphere, at a temperature of 1000 °C/2 h. The sintering method applied turned out to be unsatisfactory. Not only did oxidation of the specimens occurred, but also deformation with partial foaming. This method of composites production should be considered inappropriate. It is sintering of composites at a temperature below 1000 °C that allows obtaining a good quality material. The composite hardness, however, is comparable to cast composites and it does not exceed 200 HB. The structure of the composites produced after cold compaction and sintering at 800 °C is shown in Fig. 2.

In the composite structure, fragments of not completely reacted ilmenite particles are visible. In order to avoid the oxidation of compacts during sintering, a reducing atmosphere is necessary, whereas in order to avoid the foaming of compacts, sintering must be conducted under pressure. Such conditions are met when compacting and sintering in a Degussa press. Hot compacting and sintering using the Degussa press was carried out in graphite moulds coated with boron carbide. Lack of such coating led to an additional reaction of the composite powder with carbon. A few variants of com-

Table 1
Grain composition of composite powder

Particle size (μm)	Particle weight fraction (%)
<20	1.5
25–45	8.5
45–80	20.5
80–125	17.5
125–200	23.5
>200	28.5

Download English Version:

https://daneshyari.com/en/article/9709054

Download Persian Version:

https://daneshyari.com/article/9709054

Daneshyari.com