STUDY ON APPLICATION OF ZIRCONIUM DIOXIDE FOR UPGRADING QUALITY OF POURING CUPS USED IN CONTINUOUS STEEL CASTING TECHNOLOGY

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ABSTRACT: This theme studies on technology of zirconium oxide powder stabilized by calcium and testing production of steel pouring cup made of the stabilized dioxide zirconium ceramic. As a product of the theme, the steel pouring cup has had the following main characteristics: heat resistance > 1700^{0}C, density of 4,7 g/cm^3, apparent sponge degree of 1,63%, compressibility of 3300 kg/cm^2. The quality of the cup has been tested and highly evaluated during the actual production.

INTRODUCTION

Refractory material based on zirconium dioxide is widely used in the metallurgical technology. Zirconium dioxide ceramic is able to resist high temperature more than 1700^{0}C, its thermal stretch and abrasion degree are very low; therefore, the zirconium dioxide has usually been used for manufacturing pouring cups. However, it is impossible to use pure zirconium dioxide to produce the ceramic while it is possible for the stabilized zirconium dioxide. Cups made of zirconium silicate have been used in the continuous steel casting technology but their durability is shorter many times than that of the cup made of stabilized zirconium dioxide.

The task of this theme is to study on the procedure of preparing stabilized zirconium dioxide ceramic powder and trial production of steel pouring cups.

EXPERIMENT

1. Preparation of Stabilized Calcium Zirconium Dioxide by Co-precipitation Method

Tetragonal phase zirconium dioxide stabilized by calcium is produced by co-precipitation. Zirconium and calcium chloride solutions are precipitated by caustic soda 20% in continuous stirring reactors of Amfield company, England. Technological factors mainly affecting physio-chemical characteristics of the powder are also calculated and determined similarly with the system of ZrO_2-14%Mol CeO_2[4].

2. Trial Production of the Poured Cup

To determine heating condition for sintering of the zirconium ceramic and volume shrinkage of the material powder, ZrO_2-CaO powder are sintered twice, followed by grinding to certain particle sizes based on the suitable ratio between fine and crude particles, then thoroughly mixed with adhesive agent, creating moisture and being cured over 24 hours to get equal moisture in the material mixture. Consequently, the products are compressed by using hydrocompressor with the pressure of 800 kg/cm^2. Before sintering the cup at 1700^{0}C, the green cup is naturally dried for 48 hours and then dried at 200^{0}C for 24 hours. The diagram of material manufacture and pouring cup production is shown in the Figure 1.

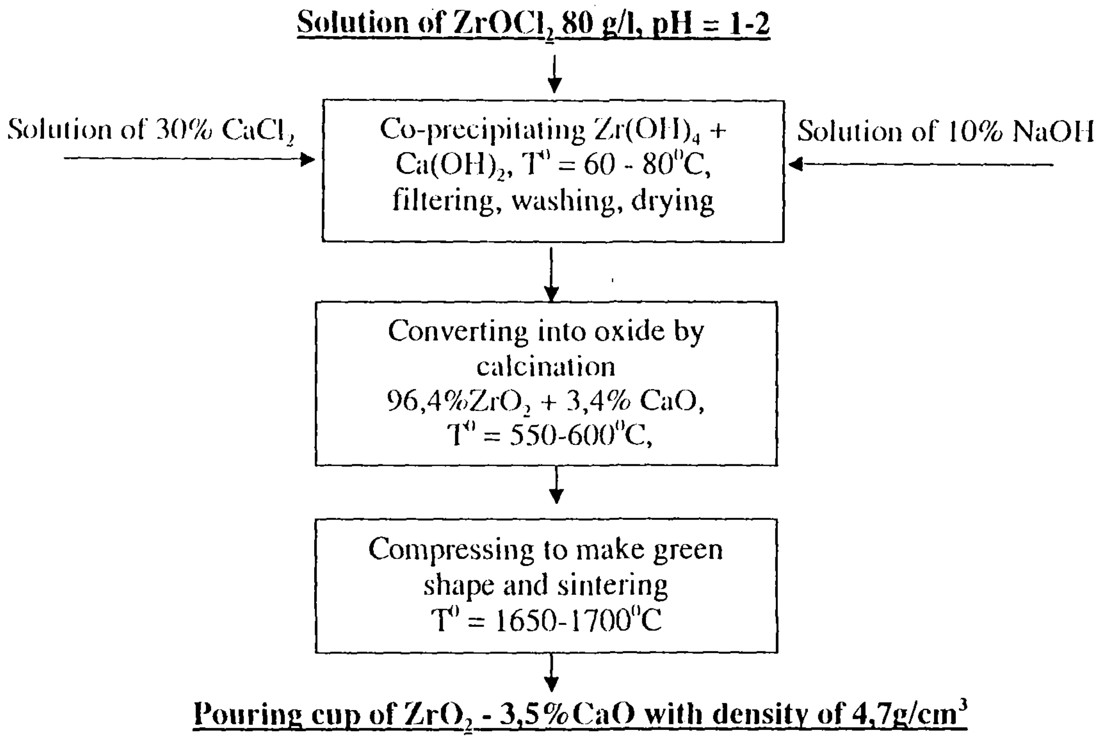

Figure 1: Diagram of preparation of stabilized calcium zirconium oxide ceramic powder by co-precipitation and testing production of pouring cup by stabilized zirconium dioxide.

3. Quality Control

Quality of the final product is evaluated by measuring main parameters such as density g/cm3, compressibility KG/cm2, moisture W% and apparent sponge degree γ%.

RESULTS AND DISCUSSION

The ceramic powder of ZrO_2-CaO has to satisfy two general requirements:

- Chemical property: ensure the correct chemical composition of the final product ceramic.
- Physical property: Fine, soft, sameness powder and free from hard agglomerates.

Based on phase transfer diagram of ZrO_2-CaO system, it is possible to choose the ceramic system of tetragonal geometry containing 96,4%ZrO_2 - 3,6%CaO at sintering temperature in the range of 1600-1700^{0}C. Mixing grinding and co-precipitation methods are usually used to prepare mixture of CaO+ZrO_2 oxides. However, the first method is not good enough and the second one has been successfully applied to ceramic powder of ZrO_2-14%Mol CeO_2[4]. Therefore, the co-precipitation method is also applied to make mixture oxide of ZrO_2-3,6% CaO. Selection of major technological conditions affected physico-chemical properties of the oxide has been similarly carried out with the system of ZrO_2-14%Mol CeO_2[4]. Table 1 notes some characteristics of the precipitate and the powder. The stabilized ceramic powder is then pressed for making green ceramic pellets with density of 1.2-1.3 gr/cm^{3}and sintered at temperature of 1700^{0}C to form the ceramic pouring cup. Figure 2 represents mould and the cups.

Table 1: Physico-chemical characteristics of the precipitate and the powder of ZrO_2+CaO

Characteristics	Hydroxide precipitate	Powder of ZrO_2+CeO_2
Chemical components,%	ZrO_2: 96-97 CaO: 3-4	ZrO_2: 96-97 CaO: 3-4
Particle size distributions	Monomodal	Monomodal
APS, µm	26.7	10.48
SSA, m^2/gr	6-7	12-14
Bulk density, gr/cc	0.4 – 0.5	0.66 – 0.7

The ceramic cup has a density of 4.7 gr/cm^3, soak degree of 0.35%, apparent sponge degree of 1,63% and compressibility of 3300 kg/cm^2. The characteristics of the cup have proved that the cup has had much higher durability than that of the cup made of silicate zirconium and equal to the imported one.

CONCLUSION

Study on the application of zirconium dioxide is conducted for testing production of pouring cup with satisfied technical parameters such as heat resistance higher than 1700^{0}C, density of 4,7 g/cm^3, apparent sponge degree of 1,63%, compressibility of 3300 kg/cm^2. Research results of this theme show that it is possible to implement successfully this technique in a larger production scale.

REFERENCES

1. Pham Xuan Yen, Huynh Đuc Minh. Technique of Ceramic Production, Hanoi University of Technology 2001.
2. Nguyen Van Đ similarly oan, Nguyen The Khanh and Others, Study on Manufacture of Ceramic of Aluminium-Zirconium Oxide, Science Report, 1998.
3. Nguyen Đuc Kim and Others, Study on Testing Production of Ceramic based on Zirconium oxide, Science Report, 1998.
4. Vu Thanh Quang, Pham Ba Kien, Preparation of 14Ce-TZP ceramic powders by co-precipitation method coded CS/02/03-09, Theme Report, Library of The Institute for Technology of Radioactive and Rare Elements.

1.10 - Computation and Other Related Topics