Development of dual coating process for effective combination of sand mold process and 3D printing technique

Hyun-Hee Choi[1], Hye-Yeong Park[1], ErdenechuluunTumenbayar[1], Geun-Ho Cho[1], Eun-Hee Kim[1], Yeon-Gil Jung*[,1], Jing Zhang[2]

[1]School of Materials Science and Engineering, Changwon National University, Changwon, Gyeongnam 641-773, Republic of Korea

[2]Department of Mechanical Engineering, Indiana University-Purdue University Indianapolis, Indianapolis, IN 46202, USA

In a conventional sand casting, the mold is prepared by mixing silica-based starting powders with resin-based organic binders. Therefore, the mold collapses easily by the degradation of the organic binders during casting. Nevertheless, the sand mold has been widely used in the manufacturing industry due to its simplicity and low production cost. In this work, a dual coating process is developed to combine the sand mold process and 3D printing technique. Two types of polyvinyl alcohol (PVA) with the different boiling points were applied. In the dual coating process, the starting powder was coated with PVA with the lower boiling point, and then re-coated with PVA with the higher boiling point, followed by 3D printing process. The sample was heat-treated at 250°C for 4h in order to burn out the PVA with the lower boiling point. The heat-treated sample was dipped into an inorganic binder slurry, composed of tetraethyl orthosilicate (TEOS) and sodium methoxide (NaOMe), which are the silica (SiO_2) and sodium oxide (Na_2O) precursors, respectively. After dried at 80°C for 1h, the final heat-treatment was conducted at 1000°C for 1h for organic-inorganic conversion. The green and firing strengths were much enhanced compared with the conventional converting process, which are due to the increased amount of inorganic precursor causing a sol-gel reaction for the green strength, and the glass phase converted by the inorganic precursor filled in the spaces of the evaporated PVA and coated on the surfaces of particles for the firing strength. Relationship between the coating process and the strength was extensively discussed, including applicability of dual coating process into 3D printing technique.