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An Investigation on $MgAl_2O_4$ Based Mould System in Investment Casting Titanium Alloy

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Abstract : The investment casting process offers a great freedom of design combined with the economic advantage of near net shape manufacturing. It is widely used for the production of high value precision cast parts in particularly in the aerospace sector. Various combinations of materials have been used to produce the ceramic moulds, but most investment foundries use a silica based binder system in conjunction with fused silica, zircon, and alumino-silicate refractories as both filler and coarse stucco materials. However, in the context of advancing alloy technologies, silica based systems are struggling to keep pace, especially when net-shape casting titanium alloys. Study has shown that the casting of titanium based alloys presents considerable problems, including the extensive interactions between the metal and refractory, and the majority of metal-mould interaction is due to reduction of silica, present as binder and filler phases, by titanium in the molten state. Cleaner, more refractory systems are being devised to accommodate these changes. Although yttria has excellent chemical inertness to titanium alloy, it is not very practical in a production environment combining high material cost, short slurry life, and poor sintering properties. There needs to be a cost effective solution to these issues. With limited options for using pure oxides, in this work, a silica-free magnesia spinel $MgAl_2O_4$ was used as a primary coat filler and alumina as a binder material to produce facecoat in the investment casting mould. A comparison system was also studied with a fraction of the rare earth oxide Y_2O_3 adding into the filler to increase the inertness. The stability of the $MgAl_2O_4/Al_2O_3$ and $MgAl_2O_4/Y_2O_3/Al_2O_3$ slurries was assessed by tests, including pH, viscosity, zeta-potential and plate weight measurement, and mould properties such as friability were also measured. The interaction between the face coat and titanium alloy was studied by both a flash re-melting technique and a centrifugal investment casting method. The interaction products between metal and mould were characterized using x-ray diffraction (XRD), scanning electron microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDS). The depth of the oxygen hardened layer was evaluated by micro hardness measurement. Results reveal that introducing a fraction of Y_2O_3 into magnesia spinel can significantly increase the slurry life and reduce the thickness of hardened layer during centrifugal casting.

Keywords : titanium alloy, mould, $MgAl_2O_4$, Y_2O_3, interaction, investment casting
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