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Powder Assisted Sheet Forming to Fabricate Ti Capsule Magnetic Hyperthermia Implant

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Abstract : To establish mass production process of Ti capsule which has Fe powder inside as magnetic hyperthermia implant, we assumed that Ti thin sheet can be drawn into a φ1.0 mm die hole through the medium of Fe Powder and becomes outer shell of capsule. This study discusses mechanism of powder assisted deep drawing process by both of numerical simulation and experiment. Ti thin sheet blank was placed on die, and was covered by Fe powder layer without pressurizing. Then upper punch was indented on the Fe powder layer, and the blank can be drawn into die cavity as pressurized powder particles were extruded into die cavity from behind of the drawn blank. Distinct Element Method (DEM) has been used to demonstrate the process. To identify bonding parameters on Fe particles which are cohesion, tensile bond stress and inter particle friction angle, axial and diametrical compression failure test of Fe powder compact was conducted. Several density ratios of powder compacts in range of 0.70 - 0.85 were investigated and relationship between mean stress and equivalent stress was calculated with consideration of critical state line which rules failure criterion in consolidation of Fe powder. Since variation of bonding parameters with density ratio has been experimentally identified, and good agreement has been recognized between several failure tests and its simulation, demonstration of powder assisted sheet forming by using DEM becomes applicable. Results of simulation indicated that indent/drawing length of Ti thin sheet is promoted by smaller Fe particle size, larger indent punch diameter, lower friction coefficient between die surface and Ti sheet and certain degrees of die inlet taper angle. In the deep drawing test, we have made die-set with φ2.4 mm punch and φ1.0 mm die bore diameter. Pure Ti sheet with 100 μm thickness, annealed at 650 deg. C has been tested. After indentation, indented/drawn capsule has been observed by microscope, and its length was measured to discuss the feasibility of this capsulation process. Longer drawing length exists on progressive loading pass comparing with the case of single stroke loading. It is expected that progressive loading has an advantage of which extrusion of powder particle into die cavity with Ti sheet is promoted since powder particle layer can be rebuilt while the punch is withdrawn from the layer in each loading steps. This capsulation phenomenon is qualitatively demonstrated by DEM simulation. Finally, we have fabricated Ti capsule which has Fe powder inside for magnetic hyperthermia cancer care treatment. It is concluded that suggested method is possible to use the manufacturing of Ti capsule implant for magnetic hyperthermia cancer care.

Keywords : metal powder compaction, metal forming, distinct element method, cancer care, magnetic hyperthermia
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