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Analysis of Laser Sintered Materials Using Finite Element Method

(Analisis Terhadap Bahan Kerja Sinteran Laser Menggunakan Teknik Unsur Terhingga)

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ABSTRACT

Invention of milling combined laser sintering system (MLSS) is able to reduce the mould manufacturing time and improve the mould accuracy. Thus, more study is needed to increase the understanding for the laser sintered material machining characteristic to gain benefit from the invention of MLSS. This paper clarified the analysis of laser sintered material machinability with the application of Finite Element Method (FEM). Mild steel AISI1055 was applied in developing the Finite Element model in this study due to its popularity in machinability test and adequate level of data availability. 2D orthogonal cutting was employed on edge design tools with updated Lagrangian coupled thermo mechanical plane strain model. Adaptive meshing, tool edge radius and various types of friction models were assigned to obtain efficient simulations and precise cutting results. Cutting force and cutting-edge temperature estimated by Finite Element Method are validated against corresponding experimental values by previous researchers. In the study, cutting force increases when radial depth increases and lowest error acquired when the shear friction factor of 0.8 was applied. Machining simulation for laser sintered materials estimated lower cutting force compared with mild steel AISI1055 due to lower Young modulus. Higher cutting temperature estimated for machining simulation laser sintered material compared with machining simulation mild steel AISI1055 due to its low thermal conductivity.

Keywords: Cutting force prediction; cutting temperature prediction; Finite Element Method (FEM); friction model; 2D orthogonal end milling

ABSTRAK

Reka cipta sistem sinteran laser berpemotong (MLSS) mampu mengurangkan tempoh penghasilan acuan dan meningkatkan kejituan acuan. Oleh kerana itu, kajian yang lebih mendalam adalah perlu bagi mengukuhkan pemahaman terhadap ciri pemesinan bahan kerja sinteran laser untuk mendapatkan manfaat daripada reka cipta MLSS. Kertas ini menjelaskan tentang analisis terhadap kebolehmesinan bahan kerja sinteran laser dengan meramalkan daya, suhu pemotongan dan perbandingan bersama kebolehmesinan keluli lembut AISI1055 menggunakan teknik unsur terhingga (FEM). Keluli lembut AISI1055 diguna pakai dalam pembikinan model unsur terhingga kerana kepopularannya dalam ujian kebolehmesinan dan kuantiti data yang diperoleh agak memuaskan. Model simulasi untuk reka bentuk mata alat pemotong dihasilkan menggunakan model pemotong ortogon 2D dengan aplikasi formulasi Lagrangian terhadap model satah terikan termo mekanikal. Siratan beradaptif, radius mata pemotong dan pelbagai jenis model geseren digunakan untuk memperoleh simulasi yang efisien dan keputusan yang tepat. Nilai daya potongan dan suhu mata pemotong yang diramalkan akan dibandingkan dengan nilai uji kaji daripada kajian terdahulu. Dalam kajian ini, daya mata pemotong menunjukkan pertambahan nilai apabila kedalaman radial mata pemotong meningkat dan nilai ralat terendah diperoleh ketika faktor geseren ricih, m 0.8 digunakan. Simulasi pemesinan bahan kerja sinteran laser meramalkan daya potongan yang rendah apabila dibandingkan dengan keluli lembut AISI1055 disebabkan pemalar Young yang lebih rendah. Suhu pemotong untuk pemesinan bahan kerja sinteran laser diramalkan lebih tinggi berbanding keluli lembut AISI1055 kerana kekonduksian haba yang rendah.

Kata kunci: Jangkaan daya pemotongan; jangkaan suhu pemotongan; model geseran; pemotong ortogon 2D; teknik unsur terhingga (FEM)

INTRODUCTION

Injection moulding is one of the most flexible and prominent operations for mass manufacture of complicated plastic parts with excellent dimensional tolerance. In the conventional mould manufacturing, mould is prepared from the hardened steel using subtractive processes such as high speed machining (HSM) (Dewes & Aspinwall 1997) and electro discharge machining (EDM) (King & Tansy 2003). These processes are time consuming; therefore, the conventional mould manufacturing is not economic. Additionally, in making a precise mould having a deep rib, tool deflection could cause various negative effects such as chatter, wobble and impact. This issue will result in poor dimensional accuracy. Reducing the tool length is one of the ways to control the tool deflection but capability to produce deep rib on the mould reduces.