

Process Simulation of Hot Embossing on Polymeric Microstructure

蔡昭源、吳政憲

E-mail: 9511518@mail.dyu.edu.tw

ABSTRACT

This thesis discuss the simulation and process results difference. Make use of the Pro-E and ANSYS-APDL(ANSYS Parametric Design Language) parametric design as the Pre-Processor and the convergence of the element number analysis. At the same time, take the Finite element model describing by ASCII word file to edit the DEFORM executive Keyfile to carry out the simulation. The simulation of the phenomenon is the micro-structure forming by the hot-embossing. By the way that is a multi-body contact problem, stress-strain and heat transfer effect is dynamic change with the time and the process conditions. Besides, PMMA belongs to the polymer the forming viscosity change with the process temperature and shear force. In the thesis we will take the consideration of the heat transfer or not in 3-D model to discuss and compare the forming difference in the micro-structure number further in simplified the model as the 2-D cross section . The process make use of the Lab development in design and assembly hot-embossing machine including the structure and the Man Machine Interface to undergo the controlling and data derived as the hard and soft device. The material PMMA is directly purchased and the mold insert is produced by the semi-conductor process in the etching and electroplating reaching the micro scale .

Keywords : hot embossing simulation, DEFORM, LVDT

Table of Contents

封面內頁 簽名頁 授權書.....	iii	中文摘要.....	iv	英文摘要.....	v	誌謝.....	vi	目錄.....	vii	圖目錄.....	ix	表目錄.....	xii																																																																																																																																																																																
第一章 序論 1.1 前言.....	1	1.2 參考文獻.....	3	1.3 文獻總結.....	7	第二章 軟體及熱壓設備簡介 2.1 DEFORM 的使用情形.....	8	2.2 DEFORM 的組成架構.....	9	2.3 熱壓設備.....	12	第三章 熱壓製程及模擬 3.1 製程簡介.....	16	3.2 熱壓材料的特性.....	17	3.3 模擬的架構.....	24	3.4 模擬所需熱壓參數的量測與取得.....	25	第四章 光柵元件的熱壓與模擬比較 4.1 成型高度的量測.....	45	4.2 模型的建立.....	46	4.3 熱膨脹的模擬與比較.....	51	4.4 光柵熱壓成品與光功率量測.....	58	第五章 結論.....	64	參考文獻.....	66	圖目錄 圖1.1模穴填充示意圖 4		圖1.2 Lagrange、Euler座標網格 6		圖2.1 Jacobian Ratio三角形的比例 11		圖2.2 Jacobian Ratio矩形的比例 12		圖2.3熱壓結構本體 13		圖2.4光柵模仁 13		圖2.5個人電腦、LabVIEW軟體 14		圖2.6資料擷取卡 14		圖2.7加熱控制模組 15		圖2.8模溫機 15		圖3.1 ANSYS 元素的節點分佈 22		圖3.2模擬的架構圖 24		圖3.3熱電偶在模具的量測點 27		圖3.4下模的3-D實體等角視圖 28		圖3.5 ANSYS網格加密的選取區域 28		圖3.6網格化後的等角視圖 29		圖3.7網格化後的三視圖 29		圖3.8加熱的節點分佈 30		圖3.9加熱階段溫度的量測與模擬 31		圖3.10冷卻階段動態的量測 31		圖3.11位移變化量的量測點 32		圖3.12熱壓時上模的位置變化 33		圖3.13熱壓時上模的位移量 34		圖3.14熱壓的速度變化 34		圖3.15開模的位置變化 35		圖3.16熱壓壓力變化 37		圖3.17摩擦力對成形影響的示意圖 39		圖3.18四邊形網格 39		圖3.19 Section 3 40		圖3.20 Section 2 40		圖3.21 Section 1 40		圖3.22行程80 μ m 41		圖3.23行程90 μ m 42		圖3.24微結構的位置 42		圖3.25接觸的節點分佈及微結構尺寸(單位mm) 43		圖3.26行程90 μ m壓出的形狀 43		圖3.27摩擦係數對成形高度的影響 44		圖4.1模型等角視圖 46		圖4.2側視圖 47		圖4.3前視圖 47		圖4.4光柵模仁 48		圖4.5陣列長條形及圓形面積 49		圖4.6陣列長條形及圓形面積相減 49		圖4.7光柵模型 50		圖4.8光柵模仁的模型局部放大圖 50		圖4.9光學顯微鏡下的模仁局部放大圖 51		圖4.10 PMMA板材及模具的加熱膨脹高度 52		圖4.11 PMMA板材及模具的冷卻收縮總高度 52		圖4.12 PMMA板材膨脹高度模擬(單位：mm) 53		圖4.13模具膨脹高度模擬(單位：mm) 53		圖4.14 130 熱膨脹變形量模擬 54		圖4.15 140 熱膨脹變形量模擬 54		圖4.16 150 熱膨脹變形量模擬 55		圖4.17熱膨脹模擬與量測比較 55		圖4.18熱壓壓力模擬的變化曲線 56		圖4.19 PMMA板材和模具熱壓變形模擬與量測比較 57		圖4.20下模受熱膨脹後熱壓壓力Z方向變化高度分佈模擬 57		圖4.21光功率計 58		圖4.22光學平台、氬-氬離子雷射光 58		圖4.23熱壓成型之S/N比因子回應圖 61		圖4.24模擬熱壓成形PMMA的光柵成形圖 62		圖4.25熱壓成形最佳參數PMMA的光柵成形圖 62		圖4.26微射出實驗最佳參數組合之繞射現象 63		圖4.27微射壓實驗最佳參數組合之繞射現象 63		圖4.28熱壓實驗最佳參數組合之繞射現象 63		表目錄 表3.1 DEFORM 內部所使用的單位 18		表3.2 PMMA板材物理性質 19		表3.3 PMMA板材在DEFORM內的數值 20		表3.4 DEFORM-3D及ANSYS 四面體元素編號 21		表3.5 ANSYS 的網格狀態 23		表3.6 JIS S50 C鋼的性質 26		表3.7 JIS S50 C鋼換算後輸入DEFORM數據 26		表3.8 Smart Size 3、4、5、6元素及節點數目 38		表4.1預壓加熱的高度變化 45		表4.2下壓時高度變化 45		表4.3壓力釋放高度變化 46		表4.4田口L9水準表 59		表4.5 PMMA板材熱壓的直交表 60		表4.6最佳化熱壓製程參數 61	

REFERENCES

- [1] M. Worgull, M. Hecke, J.-F. Hetu, K.K. Kabanemi, " Modeling and Optimization of the Hot Embossing Process for Micro- and Nanocomponent Fabrication ", The Journal of Microfabrication, Microlithography, and Micromachining, Special Issue Announcement NanoPatterning, 2005.
- [2] J. Richeton, S. Ahzi, K.S. Vecchio, F.C. Jiang, R.R. Adharapurapu, " Influence of temperature and strain rate on the mechanical behavior of three amorphous polymers: Characterization and modeling of the compressive yield stress ", International Journal of Solids and Structures 43, 2006.
- [3] Michael Adam Kaiser, " Advancements in the Split Hopkinson Bar Test ", Virginia Tech Dept. of Mechanical Engineering, p44, 1998.
- [4] J. H. Song, H. Huh, S. H. Kim and H. T. Hahn, " Finite Element Analysis of Room Temperature Nanoimprint Lithography Process with Rate Dependent Plasticity ", International Conference on Advanced Manufacture(ICAM),2005.
- [5] Harry D Rowland and William P King, " Polymer deformation and filling modes during microembossing ", JOURNAL OF MICROMECHANICS AND MICROENGINEERING , 2004.
- [6] 吳政達, 二元合金微、奈米成形之實驗與理論研究, 國立高雄 應用科大機械與精密工程研究所碩士論文, 2004。
- [7] Yi-JE JUANG, L.JAMES LEE, and KURT W.KOELLING, " Hot Embossing in Microfabrication ", ProQuest Science Journal, 2002.
- [8] 王冠曇, 鋅鋁合金微壓印成形之研究, 國立成功大學機械工程 研究所碩士論文, 2003。
- [9] Kwang Hwan Cho, Kyunghwan Yoon, Sung Jin Park¹ and Chul Park, " Direct surface forming: New polymer processing technology for large light guide of TFT-LCD module ", Korea-Australia Rheology Journal Vol. 15, No. 4, December 2003 pp. 167-171.
- [10] X.-J. Shen, Li-Wei Pan, and Liwei Lin, " Microplastic embossing process:experimental and theoretical characterizations ", Sensors and Actuators A, 2002.
- [11] Toshihiko Okano & Masataka Koishi, " Hydroplaning Simulation using MSC.Dytran " The 19th Annual Meeting and Conference on Tire Science and Technology, 2000.
- [12] B. V. Mehta, I. Al-Zkeri, J. S. Gunasekera, A. Buijk, Evaluation of MSC.SuperForge for 3D Simulation of Streamlined and Shear Extrusion Dies, Proceedings of the 2nd International Automotive Conference, Dearborn, MI., Oct. 2000.
- [13] DEFORM Users Manual 2000, Scientific Forming Technologies Corporation, Columbus, Ohio.
- [14] 郭彰, 微結構熱壓成型之製程研究, 大葉大學機械工程研究所碩士論文, 2005。
- [15] 張永彥, 塑膠模具設計學-理論、實務、製圖、設計, 全華科技圖書股份有限公司, pp.5-70, 2005。
- [16] 陳火紅, 祈鵬, MSC Patran/Marc 培訓教程和實例, 科學出版社, 2004。
- [17] Frank M. White, " Viscous Fluid Flow-Second Edition ", McGraw-Hill International Editions, p53.
- [18] 陳緯旭, 應用微射出成型製作光學讀取頭之光柵製程分析, 大葉大學機械工程研究所碩士論文, 2004。
- [19] Yi-Je Juang, " Polymer processing and rheological analysis near the glass transition temperature ", The Ohio State University , p.57, 2001.
- [20] 劉士榮, 高分子流變學, 洪秀婉, 1985。