

# Tolerance Analysis and Validation of Assembled Parts

洪桓祥、劉大銘

E-mail: 9314490@mail.dyu.edu.tw

## ABSTRACT

This thesis is based on the geometric building block concept, and represent the adjacent relationship between geometric building blocks by graph representation feature, dimension and tolerance graph. In the graph, the node represents the geometric building block. The arc represents the dimension adjacent relationship of two geometric building blocks. And using the geometric building block 's parameter, degree of freedom, to detect over- and under- constraining conditions. When the feature, dimension and tolerance graph is well-defined, it will be the foundation of tolerance allocation, then perform tolerance allocation by linear programming. Based on the design database, the program developed by this thesis contains two main modules and several subsidiary programs. The two modules are : (1) file conversion module, (2) Building validation graph module.

Keywords : graph representation , degree of freedom , tolerance allocation , linear programming

## Table of Contents

簽名頁 授權書.....	iii	中文摘要.....	iii
.....iv 英文摘要.....	v	誌謝.....	v
.....vi 目錄.....	vii	圖目錄.....	vii
.....x 表目錄.....	xiii	第一章 緒論.....	xiii
.....1 1.1 研究背景.....	1	1.2 研究動機與目的.....	1
.....2 1.3 文獻探討.....	2	1.4 程式開發環境的需求.....	2
.....4 1.5 論文大綱.....	4	第二章 公差模擬的模型.....	4
.....6 2.1 公差語義和替代方法.....	6	2.2 幾何建構圖塊的定義.....	6
.....7 2.3 公差種類的定義.....	10	2.3.1 公差區.....	10
.....11 2.3.2 由幾何建構圖塊來建立公差種類.....	11	2.4 建立基準座標系統.....	11
.....15 2.4.1 基準座標系統的建構.....	16	第三章 特徵、尺寸與公差圖形表示法.....	19
.....19 3.1 特徵和尺寸圖形.....	19	3.1.1 明確尺寸和隱含尺寸.....	19
.....23 3.1.2 由廣義座標系統來定義基準.....	24	3.2 特徵、尺寸和公差圖形.....	24
.....24 3.2.1 修改某些特徵和尺寸圖形中的隱含尺寸.....	25	3.3 拆解後的圖元和具大小的特徵.....	27
.....27 3.4 特徵、尺寸和公差圖形的應用.....	28	3.4.1 偵測過度束縛或是不足的情況.....	28
.....28 3.4.2 尺寸.....	28	3.4.3 公差.....	31
第四章 線性規劃數學模型.....	34	4.1 線性規劃數學模型.....	34
.....34 4.1.1 線性規劃問題的構成.....	34	4.1.2 線性規劃問題的求解.....	35
.....35 4.1.3 電腦模擬程式的邏輯.....	36	第五章 程式設計與建構.....	37
.....37 5.1 程式架構.....	37	5.1.1 程式規劃.....	37
.....38 5.1.2 程式發展工具.....	38	5.2 Solidworks 環境與其應用程式介面簡介.....	42
.....42 5.3 電腦輔助分析系統的簡介.....	42	5.4 檔案格式轉換模組.....	44
.....44 5.4.1 節點資訊的擷取.....	44	5.4.2 拓樸資訊的擷取.....	45
.....45 5.4.3 使用者增刪資料.....	46	5.4.4 節點資訊的擷取.....	46
.....48 5.5 驗證圖形建立模組.....	52	第六章 實例探討.....	55
6.1 雙組圓軸與圓孔的中心距最佳化.....	55	6.1.1 圖檔產生與擷取建立驗證圖形所需的資料.....	56
.....63 6.1.2 檔案格式轉換與建立驗證圖形.....	63	6.1.3 使用線性規劃於公差配置分析.....	70
.....75 7.1 結論.....	75	第七章 結論與未來展望.....	75
.....76 7.2 系統完整性探討與未來展望.....	76	7.1 結論.....	75
.....76 參考文獻.....	78	7.2 系統完整性探討與未來展望.....	76
錄A.....	80	.....76 參考文獻.....	78

## REFERENCES

1. T. Kandikjan, J.J.Shah, J.K.Davidson, "A mechanism for validating -dimensioning and tolerancing schemes in CAD systems" , -Computer-Aided

Design, 2001. 2. Zhang BC. Geometric modeling of dimensioning and tolerancing -PhD thesis, Arizona state University, 1992. 3. O. W.Salomons , F.J.Haalboom, H.J.Jonge Poerink,F.van Slooten, -F.J.A.M.van Houten , H.J.J. Kals , "A computer aided tolerancing -tool I: Tolerance specification" , Computers in Industry, 31, pp.161 - 174, 1996. 4. O. W.Salomons , F.J.Haalboom, H.J.Jonge Poerink,F.van Slooten, -F.J.A.M.van Houten, H.J.J. Kals , " A computer aided tolerancing -toolII : Tolerance analysis " , Computers in Industry, 31, pp.175 - 186, 1996. 5. Rao, Singiresu S., Engineering optimizati on theory and practice, -3ed, Wiley & Sons, 1996. 6. Nash, Stephen G. and Sofer, Ariela, Linear programming and nonlinear -programming, McGraw-Hill, 1996. 7. Homem deMello, Luiz S., Lee, Sukhan, Computer-Aided Mechanical -Assembly Planning, Wiley, & Sons, 1991. 8. Lin, Chih-Young; Huang, Wei-Hsin; Jeng, Ming-Chang and Doong, -Ji-Liang,Study of an assembly tolerance allocation model based -on Monte Carlo simulation,J of materials Processing Technology, -v70, pp.9-16, 1997. 9. Parkinson, DB., Assessment and optimization of dimensional tolerances, -Computer Aided Design, v17, pp.191 - 199, 1985. 10. M.F.Spotts, Allocation of Tolerances to minimize cost of assembly, -Journal of Engineering for Industry, ASME, v95, pp.762 - 764, 1973. 11. G.H.Sutherland, and B.Roth, Mechanism design: accounting for -manufactuing tol erance and cost in function generating problems, -Journal of Engineering for In dustry, ASME, v97 ,pp.283 -286, 1975. 12. P.F.Ostwald, and J.Huang, A method for optimal tolerance selection, -Journal of Engineering for Industry, ASME, v99, pp.558 -565, 1977. 13. Richard J.Gerth, Walton M.Hancock, Computer aided tolerance -analysis for improved process control, Computer & Industrial -Engineering v38, pp.1 - 19, 2000. 14. Victor J Skoronski and Joshua U Turner, Using Monte-Carlo variance -reduction in stastical tolerance synthesis, Computer Aided -Design, v29, n1, pp.63 - 69, 1997. 15. 林俊明"電腦輔助公差分析之研究" , 大葉大學碩士論文2000。 16. 劉大銘、洪桓祥 , "機械件裝配特徵的公差分析" , 中國機械 工程師學會第二十屆學術研討會論文集(固力與設計) , 2002。 17. SolidWorks 2003 線上說明手冊。