

A study of rollover strength of electric mini baja roll cage

林憲聰、梁卓中

E-mail: 345828@mail.dyu.edu.tw

ABSTRACT

The increasing environmental pollution, the decreasing oil deposits, the noise emissions, the deteriorating traffic conditions in the big cities have forced the car industries to search for alternative energy sources and new concepts. And the electric vehicle seems to become an important solution to the problem. In this paper the design of SAE Mini Baja-Like, a small electric racing can has been finished, according 2010 Baja SAE Rules. And then three cases are studied: the first case dealing with determination of the critical sliding velocity of Mini Baja rolls over from a tilt table, the second case considers rollover of Mini Baja which sits on a platform traveling at a velocity v which is suddenly stops, and the third one repeats the second problem except that the platform is brought to stop according to a given deceleration profile, thus simulating the FMVSS 208 rollover test procedure. A numerical model is created to validate the rollover environment. And the engineering draw software Solidworks and finite element software Hypermesh are used to draw and mesh for Baja frame. Finally, rollover simulations are performed by using finite element analysis software LS-DYNA. The dynamic response of the center gravity and the structural deformation and damage of Mini Baja Roll Cage frame are studied in details. The results shows that the sliding velocities of FMVSS 208 are so higher and not suitable for Mini Baja Rollover test. And the suitable testing sliding velocities for rules are suggested in this paper.

Keywords : SAE Mini Baja、LS-DYNA、FMVSS 208、lateral rollover

Table of Contents

封面內頁 簽名頁 中文摘要.....	iii	ABSTARCT.....	iv	誌謝.....	vi	目錄.....	vii	圖目錄.....	x	表目錄.....	xiv
符號說明.....	xv	第一章 前言.....	1	1.1研究背景與動機.....	1	1.2文獻回顧.....	3	1.3本文目的.....	10	第二章 Mini Baja翻覆數值分析理論基礎.....	14
2.1Mini Baja翻覆之數值分析理論.....	15	2.1.1運動方程式.....	15	2.1.2時間積分.....	16	2.2LS-DYNA程式之數值分析技巧.....	16	2.2.1前處理器.....	17	2.2.2LS-DYNA主程式處理.....	20
2.2.3後處理器.....	21	第三章 車輛翻覆作動之數值模擬環境建構與驗證.....	26	3.1常用翻覆指標.....	26	3.1.1墜落型測試程序翻覆指標.....	28	3.1.2 FMVSS 208美規側向翻覆測試程序.....	29	3.1.3跳動型測試程序翻覆指標.....	30
3.2數值環境建構.....	32	3.2.1剛體車輛之有限單元模型.....	32	3.2.2翻覆測試環境之建構.....	33	3.3結果比較.....	34	第四章 電動Mini Baja車結構設計.....	49	4.1Mini Baja結構設計法規.....	49
4.2電動Mini Baja基本諸元.....	51	4.3電動Mini Baja結構設計.....	52	第五章 電動Mini Baja翻覆之實例分析.....	61	5.1電動Mini Baja有限單元建構.....	61	5.1.1電動Mini Baja數值模型簡介.....	61	5.1.2電動Mini Baja部件材料與元素特性.....	61
5.2墜落型翻覆測試程序.....	62	5.2.1應用LS-DYNA探討車輛翻覆臨界滑動速度.....	63	5.2.2墜落型翻覆結構分析.....	64	5.3FMVSS 208美規與跳動型翻覆測試程序.....	64	5.3.1 FMVSS 208美規側向翻覆結構分析.....	66	5.3.2跳動型翻覆結構分析.....	68
5.3.3考慮電動Mini Baja之安全性修改測試條件.....	70	第六章 結論.....	93	參考文獻.....	96						

REFERENCES

- [1]2010 Baja SAE Rules Table of Contents, 2010.
- [2] <http://www.louisiana.edu/Advancement/PRNS/news/2006/487.shtml> (2006) [3] http://www.eng.uwo.ca/mechanical/previous/Mini_Baja_East_2004.htm (2004) [4]H. Shimizu, J. Harada and C. Bland, "Advanced Concepts in Electric Vehicle Design", 1997.
- [5]SAE, "SURFACE VEHICLE RECOMMENDED PRACTICE", 1999.
- [6]B. Zollinger, R. Todd, "Rethinking the Design Paradigm: A Customer-Focused Approach to Design a Mini-Baja Vehicle", SAE Paper, NO.2000-01-2651, 2000.
- [7]A. Hac, "Rollover Stability Index Including Effects of Suspension Design", SAE Transaction, 2002-01-0965, 2002.
- [8]M. Allen, R. LeMaster, "A Hybrid Transmission for SAE Mini Baja Vehicle", SAE Paper, NO.2003-32-0045, 2003.
- [9]C. Parenteau, D. Viano, M. Shah, M. Gopal, J. Davies, D. Nichils, J. Broden, "Field relevance of a suite of rollover tests to real-world crashes and injuries", Accident Analysis and Prevention 35103-110, 2003.

- [10]M. Gopal, K. Baron, M. Shah, " Simulation and Testing of a Suite of Field Relevant Rollovers ", SAE Paper, NO.2044-01-0335, 2004.
- [11]B. Patel, P. Atkinson, " Towards A Definition of A Test Methodology for Rollover Resistance and Rollover Performance ", SAE Paper, NO.2004-01-0736, 2004.
- [12]T. Nobels, W. Deprez, I. Pardon, S. Stevens, O. Viktorin, J. Driesen, J. Keybus, R. Belmans, " Design of a Small Personal Electric Vehicle as an Educational Project ", 2004.
- [13]蔡智榮, " 乘用車輛曲行測試翻覆可能性之研究 ", 財團法人車輛研究測試中心, 2004。
- [14]J. Le, R. McCoy, C. Chou, " Early Detection of Pollovers with Associated Test Development ", SAE Paper, NO.2005-01-0737, 2005.
- [15]楊模樺, " 電動車輛用鋰電池發展趨勢 ", 工研院材料所, 2005。
- [16]C. Conroy, D. Hoyt, A. Eastman, S. Erwin, S. Pacyna, T. Holbrook, T. Vaughan, M. Sise, F. Kennedy, T. Velky, " Rollover crashes:Predicting serious injury based on occupant, vehicle, and crash characteristics ", Accident Analysis and Prevention 38835-843, 2006.
- [17]J. Brandse, S. Buijssen, C. Huijskens, P. Lemmen, E. Hassel, " Methodology for Simulation Rollover Case ", SAE Paper, NO.2006-01-0558, 2006.
- [18]A. Burke, J. Miranda, " Mini baja Frame Design using Topological Optimization and Impact Testing ", SAE Paper, NO.2006-01-0952, 2006.
- [19]A. Owens, M. Jarmulowicz, P. Jones, " Structural Considerations of a Baja SAE Frame ", SAE Paper, NO.2006-01-3626, 2006.
- [20]R. Marimuthu, B. Jang, S. Hong, " A Study on SUV Parameters Sensitivity on Rollover Propensity ", SAE Paper, NO.2006-01-0795, 2006.
- [21]C. Chou and F. Wu, " Analysis of Vehicle Kinematics in Laboratory-based Rollover Test Modes ", SAE Paper 2006.
- [22]R. McCoy, C. Chou, R. Velde, " A Dynamic Component Rollover Crash Test System ", SAE Paper, NO.2006-01-0721, 2006.
- [23]黃建勳, 于志宇, " 應用ADAMS/Car於SUV車之動態翻滾抵抗性能改善 ", 華創車電技術中心 懸吊轉向組, 2006。
- [24]雷貴安, " 車輛翻覆測試之數值模型建立與分析 ", 2006。
- [25]M. Bidez, J. Cochran, D. King, D. Burke, " Occupant Dynamics in Rollover Crashes: Influence of Roof Deformation and Seat Belt Performance on Probable Spinal Column Injury ", Annals of Biomedical Engineering, Vol.35, NO.11, 2007.
- [26]T. Forbes, J. LaPierre, L. Leahy, B. Mies, O. Roberts, K. Tarry, B. Thistle, A. Young, " Worcester Polytechnic Institute SAE Baja Design Report ", 2007.
- [27]N. Rose, W. Neale, S. Fenton, D. Hessel, R. McCoy, C. Chou, " A Method to Quantify Vehicle Dynamics and Deformation for vehicle Rollover Test Using Camera-Matching Video Analysis ", SAE Paper, NO.2008-01-0350, 2008.
- [28]D. Viano, C. Parenteau, M. Gopal, M. James, " Vehicle and Occupant Responses in a Friction Trip Rollover Test ", SAE Paper, NO. 2009-01-0830, 2009.
- [29]B. Behrens, K. Droessler, " UW-Platteville 2009 Mini Baja Team Design Report ", SAE Paper, Vehicle Number 22, 2009.
- [30]A. Guzzomi, V. Rondelli, A. Guarnieri, G. Molari, P. Molari, " Available energy during the rollover of narrow-track wheeled agricultural tractors ", 2009.
- [31]許?譚、陳俊雄、張光仁, " 車輛翻覆早期預防安全系統 ", 車輛工程學術研討會, 2010。
- [32]S. Mandell, R. Kaufman, C. Mack, E. Bulger, " Mortality and injury patterns associated with roof crush in rollover crashes ", ELSEVIER, Accident Analysis and Prevention 42 1326-1331, 2010.
- [33]朱孝文, " 小型運動休閒越野車之結構設計與碰撞安全分析 ", 2011。