車輛側面撞擊事故中人體之損傷分析

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摘 要

側面碰撞車禍所造成的乘員傷亡程度僅次於正撞事故的乘員傷害。因此了解側撞事故中乘員動態反應，探討其損傷原因，進而發展車體安全防護的相關設計，以減少乘員傷害風險，實為大眾所關心的議 題。利用數值分析技巧研究車輛結構的防撞性以及乘客與車體結構間的關係，已成為可行的分析方法 。不但節省試驗成本，且縮短車輛研發時程，還能獲得更準確的數據以提供改善車體安全性設計之依 據。為了更加了解側面碰撞事故所造成的乘客傷害及發展更安全的車體結構設計，本論文藉由有限元 素分析軟體LS-DYNA3D 進行有限元素側撞人偶各部位模擬驗證，進一步與實驗值進行可信度比較，並使用其依據美國聯邦汽車安全標準FMVSS214所規範之實車碰撞試驗條件進行全車側撞模擬分析，以探 討乘員於車禍事故中的動態反應及評估其受傷原因，並經由胸部創傷指標及骨盆加速度峰值來分析乘 員損傷程度。為了精確了解真實車禍事故對人體損傷的影響，本研究分析兩種撞擊事故型態，並由乘 員損傷程度與動態行為探討乘客艙空間的侵入問題以及評估在不同的側撞事故型態下的乘員安全性。

關鍵詞 : 側面碰撞，LS-DYNA3D，側撞人偶

目錄

參考文獻

1. http://www.nhtsa.gov/ 2. Low, T. C., Prasad, P., "Dynamic Response and Mathematical Model of the Side Impact Dummy", SAE Paper No.902321, (1990) 3. Shkolnikov M. B., Dholakia, R., Surtani, M. S., "Numerical Simulation of a Vehicle Side Impact Test:Development, Application and Design Iterations", SAE Paper No. 960101, (1996) 4. Prasad, P., Low, T. C., Chou, C. C., Lim, G. G., Sundararajan, S., "Side Impact Modeling using Quasi-Static Crush Data", SAE Paper No. 910601, (1991) 5. Midoun, D. E., Rao, M. k., Kalidindi R., "Dummy Models for Crash Simulation in Finite Element Programs" ,SAE Paper No. 912912,(1991) 6. KirKpatrick, S. W., Holmes, B. S., Hollowell, W. T., Gabler, H. C., Trella, T. J., "Finite Element Modeling of the Side Impact Dummy(SID)", SAE Paper No. 930104, (1993) 7. Midoun, D. E., Abramoski, E., Rao, M. k., Kalidindi R., "Development of a Finite Element Based Model of the Side Impact Dummy", SAE Paper No. 930444, (1993) 8. Kanianthra, J. N., Rains, G. C., Trella, T. J., "Strategies for Passenger Car Designs to Improve Occupant Protection in Real World Side Crashes", SAE Paper No. 930482, (1993) 9. Sundararajan, S., Chou, C.C., Lim, G.G., Prater, J. A., Clements, R.R., "Dynamic Door Component Test Methodology", SAE Paper No. 950877, (1995) 10. Tominaga, K., Yamaguchi, S., kizuki, K., "Numerical Analysis of Side Impact Phenomena Using MADYMO-3D DOT-SID Dummy", SAE Paper No. 962414, (1996) 11. Shkolnikov, M.B., Dholakia, R., Surtani, M. S., "Numerical Simulation of a Vehicle Side Impact Test:Development, Application and Design Iterations", SAE Paper No. 960101, (1996) 12. Deng, Y. C., Tzeng, B., "Side Impact Countermeasure Study Using A Hybrid Modeling Technique", SAE Paper No. 962413, (1996) 13. Stein, D. J., "Apparatus and Method for Side Impact Testing", SAE Paper No. 970572, (1997) 14. Lim, G. G., Chou, C.C., Sundararajan, S., Upmeyer, S.J., Celentino, M.F., Morgowicz, M.V., "Development of a Door Test Facility for Implementing the Door Component Test Methodology", SAE Paper No. 970568, (1997) 15. Marzougui, D., Kan, C.D., Bedewi, N. E., "Development and Validation of an NCAP Simulation Using LS-DYNA3D" , FHWA/NHTSA National Crash Analysis Center, The George Washington University, Ashburn, (1997) 16. Shkolnikov, M. B., Bhalsod, D., "LS-DYNA3D Finite Element Model of Side Impact Dummy SID", SAE Paper No. 971525, (1997) 17. Malkusson, R., Karlsson, P., "Simulation Method for Establishing and Satisfying Side Impact Design Requirements", SAE Paper No. 982358, (1998) 18. Maruthayappan, R., Rao, A., Gupta, V., Samaha, R.R., Trella, T.J., "Improved Finite Element SID for In-Vehicle Simulation", SAE Paper No. 1999-01-0716, (1999) 19. Chang, N.A., Han, I.B., "Development of Finite Element US-SID and Euro-SID Model", SAE Paper No. 2000-01-0160, (2000) 20. Kirkpatrick, S.W., "Development and Validation of High Fidelity Vehicle Crash Simulation Models", SAE Paper No. 2000-01-0627, (2000) 21. Pfeiffer, R., Side Impact Modelling to Develop Energy Absorbing Pole Structures, Master Thesis, Chalmers University of Technology, Goteborg, (2001). 22. Zaouk, A.k., Marzougui, D., "Development and Validation of a US Side Impact Moveable Deformable Barrier FE Model", FHWA/NHTSA National Crash Analysis Center, The George Washington University, Ashburn, (2002). 23. Rivas, B.C, Izquierdo, D.L., Development of Energy Absorbing Roadside Structures, Master Thesis, Chalmers University of Technology, Goteborg, (2002). 24. Schuller, E., Beier, G., Steiger, T., "Injury Patterns of Restrained Car Occupants in Near-Side Impacts", SAE Paper No. 890376, (1989) 25. Huelke, D.F., Sherman, H.W., Steigmeyer, J.L., "Side Impacts to the Passenger Compartment-Clinical Studies from Field Accident Investigations", SAE Paper No. 890379, (1989) 26. Hultman, R.W., Laske, T.G., Chou, C.C., Lim, G.G., Chrobak, E.I., Vecchio, M.T., "NHTSA Passenger Car Side Impact Dynamic Test Procedure-Test-To-Test Variability Estimates", SAE Paper No. 910603, (1991) 27. Miltner, E., Salwender, H.J., Injury Severity of Restrained Front Seat Occpants In Car-To-Car Side Impacts, University of Heidelberg, Germany, (1993). 28. Farmer, C.M., Braver, E.R., Mitter, E.L., Two-Vehicle Side Impact Crashes: The Relationship of Vehicle and Crash Characteristics To Injury Severity, Insurance Institute for Highway Safety, Arlington, USA, (1996). 29. Augenstein, J., Bowen, J., Perdeck, E., Singer, J., Horton, T., Rao, A., Digges, K., Malliaris, A., Steps, J., "Injury Patterns in Near-Side Collisions" SAE Paper No. 2000-01-0634, (2000) 30. Zaouk, A.K., Eigen, A.M., Digges, K.H., "Occupant Injury Patterns in Side Crashes" SAE Paper No. 2001-01-0723, (2001) 31. Cesari, D., Ramet, M., "Pelvic Tolerance and Protection Criteria in Side Impact", SAE Paper No. 821159, (1982) 32. Marcus, J.H., Morgan, R.M., Eppinger, R.H., Kallieris, D., Mattern, R., Schmidt, G., "Human Response to and Injury from Lateral Impact", SAE Paper No. 830634, (1983) 33. Morgan, R.M., Marcus, J.H., Eppinger, R.H., "Side Impact-The Biofidelity of NHTSA's Proposed ATD and Efficacy of TTI", SAE Paper No. 861877, (1986) 34. Viano, D.C., "Evaluation of the SID Dummy and TTI Injury Criterion for Side Impact Testing", SAE Paper No. 872208, (1987) 35. Viano, D.C., "Biomechanical Responses and Injuries in Blunt Lateral Impact", SAE Paper No. 892432, (1989) 36. Cavanaugh, J.M., Walilko, T.J., Malhotra, A., Zhu, J.Y., king, A.I., "Biomechanical Response and Injury Tolerance of the Pelvic in Twelve Sled Side Impacts", SAE Paper No. 902305, (1990) 37. Cavanaugh, J.M., Walilko, T.J., Malhotra, A., Zhu, J.Y., king, A.I., "Biomechanical Response and Injury Tolerance of the Thorax in Twelve Sled Side Impacts", SAE Paper No. 902307, (1990) 38. Campbell, K.L., Wasko, R.J., Henson, S.E., "Analysis of Side Impact Test Data Comparing SID and BIOSID", SAE Paper No. 902319, (1990) 39. Viano, D.C., "Evaluation of Armrest Loading in Side Impacts", SAE Paper No. 912899, (1991) 40. Cavanaugh, J.M., Huang, Y., Wasko, R.J., king, A.I., "SID Response Data in a Side Impact Sled Test Series", SAE Paper No. 920350 , (1992) 41. Irwin, A.L., Walilko, T.J., Cavanaugh, J.M., Zhu, J.Y., king, A.I., "Displacement Responses of the Shoulder and Thorax in Lateral Sled Impacts", SAE Paper No. 933124, (1993) 42. Cavanaugh, J.M., Zhu, J.Y., Huang, Y., king, A.I., "Injury and Response of the Thorax in Side Impact Cadaveric Tests", SAE Paper No. 933127, (1993) 43. Zhu, J.Y., Cavanaugh, J.M., king, A.I., "Pelvic Biomechanical Response and Padding Benefits in Side Impact Based on a Cadaveric Test Series", SAE Paper No. 933128, (1993) 44. Cavanaugh, J.M., Walilko, T., Walbridge, A., Huang, Y., king, A.I., "An Evaluation of TTI and ASA in SID Side Impact Sled Tests", SAE Paper No. 942225, (1994) 45. Cavanaugh, J.M., Walilko, T., Chung, J., king, A.I., "Abdominal Injury and Response in Side Impact", SAE Paper No. 962410, (1996) 46. Pintar, F.A., Yognnandan, N., Hines, M.H., Maltese, M.R., Mcfadden, J., Saul, R., Eppinger, R., Khaewpong, N., Kleinberger, M., "Chestband Analysis of Human Tolerance to Side Impact", SAE Paper No. 973320, (1976) 47. NHTSA, "Federal Moter Vehicle Safety Standards: Side Impact Protection," Code of Federal Regulations, 49CFR571.214, Washington, D.C.,

Current through October 14, (1997) 48. LS-DYNA THEORETICAL MANUAL, V960, 1998. 49. Laboratory Test Procedure For FMVSS No.214 "Dynamic" Side Impact Protection, NHTSA, August, (1999) 50. http://www.sri.com/ 51. 財團法人車輛研究測試中心, "2002年實車碰撞技術應用研討會論文集" ,91/12/23 52. http://www.ftss.com/ 53. 財團法人車輛研究測試中心, "2002年實車碰撞技術應用研討會論文集" ,91/5/21~22 54. http://www.dentonatd.com/ 55. Ray, M.H., Hargrave, M.W., Carney, J.F., III, Hiranmayee, K.M., Side-impact Crash Test and Evaluation Criteria for Roadside Safety Hardware, Transportation Annual Record 1647:97-103, (1998) 56. http://www.tfhrc.gov/ 57. Franz, U., Graf O., "Accurate and Detailed LS-DYNA FE Models of the US- and EUROSID: A Review of the German FAT Project", CAD-FEM GmbH, Grafing/ Munich, Germany, (2000) 58. LS-DYNA Keyword User Manual, V960, (1998) 59. "Testing for Side Impact Protection-Passenger Cars, 1991 Ford Taurus, Contract No: DTRS-57-95-C-00010(TTD#3)" MGA Proving Grounds, Burlington, WI53105, March 31, (1997) 60. MADYMO User's Manual, Version 5.4, TNO, the Hague, The Netherlands, May, (1999) 61. http://www.ncac.gwu.edu 62. Brown, C.M., Ford Taurus Broadside Collision With a Narrow Fixed Object, FOIL Test Number 95S008, US-DOT, FHWA RD 96 105, NTIS Reference PB97-173652, (1997) 63. Markusic, C.A., "Vehicle Safety Compliance Testing for Occupant Crash Protection, Windshield Mounting, Windshield Zone Intrusion, and Fuel System Integrity, "Final Report of FMVSS NO.208, 212, 219, and 301 Compliance Testing, NHTSA No.CP0203, Department of Transportation, November 1992, Washington, DC.