

Advances In Finite Element Analysis In Fluid Dynamics 1993: Presented At The 1993 ASME Winter Annual

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Development of Numerical Models for Injury Biomechanics Research: A Review of 50 Years of Publications in the Stapp Car Crash Conference

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ABSTRACT – Numerical analyses frequently accompany experimental investigations that study injury biomechanics and improvements in automotive safety. Limited by computational speed, earlier mathematical models tended to simplify the system under study so that a set of differential equations could be written and solved. Advances in computing technology and analysis software have enabled the development of many sophisticated models that have the potential to provide a more comprehensive understanding of human impact response, injury mechanisms, and tolerance. In this article, 50 years of publications on numerical modeling published in the Stapp Car Crash Conference Proceedings and Journal were reviewed. These models were based on: (a) author-developed equations and software, (b) public and commercially available programs to solve rigid body dynamic models (such as MVMA2D, CAL3D or ATB, and MADYMO), and (c) finite element models. A clear trend that can be observed is the increasing use of the finite element method for model development. A review of these modeling papers clearly indicates the progression of the state-of-the-art in computational methods and technologies in injury biomechanics.

KEYWORDS – Numerical model, Lumped-mass, Rigid body dynamics, Finite element, Human model

INTRODUCTION

On the golden anniversary of the Stapp Car Crash Conference, this review article was written for two purposes. The first aim is to highlight the development of mathematical models in the advancement of transportation safety over the past 50 years. The second aim is to provide motivation for a single common numerical human model for the further advancement of transportation safety. For these reasons, the emphases of this review are different from those in previously published review papers on numerical models. Readers are referred to other review papers pertaining to modeling principles and applications, such as those reported by King and Chou (1976) and Prasad and Chou (1993, 2002).

This review is restricted to papers published in the Stapp Car Crash Conference Proceedings and Journal.

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It highlights the importance of this forum to transportation safety.

The models reviewed in this paper generally fall under the following three categories, depending on the development of modeling techniques:

1. **Lumped-mass models** where the equations of motion and differential equations solving techniques were developed by authors and/or publicly available subroutines.
2. **Linkage models**, such as the one developed by McHenry (1963), where a limited number of linkages and joints with properties imbedded in the software, for evaluations of restraint system and vehicle responses in early design state. More sophisticated models included those developed using MVMA2D, CAL3D, and MADYMO.
3. **Finite element models** using either implicit or explicit solvers where large displacement and nonlinear problems can be solved using the available libraries of elements, material laws, and contact algorithms. Many of these codes

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Advances in finite element analysis in fluid dynamics, presented at the Winter Responsibility: sponsored by the Fluids Engineering Division, ASME ; edited by M.N. . Engineers, New Orleans, Louisiana, November December 3 , Scaling in two-phase flows: presented at the Winter Annual Meeting of the Responsibility: sponsored by the Fluids Engineering Division, ASME ; edited by . Coupled boundary and finite element methods for the solution of the dynamic fluid-structure interaction problem flow systems: presented at the ASME Winter Annual Meeting, New Orleans, Louisiana, November December 3, Results 1 - 25 of 30 Advances in finite element analysis in fluid dynamics, presented at the presented at the ASME Winter Annual Meeting, New Orleans, Louisiana, November December 3, Catalog Record Only. Results 1 - 25 of 33 Advances in finite element analysis in fluid dynamics, presented at New Orleans, Louisiana, November December 3, Catalog Record presented at the ASME Winter Annual Meeting, New Orleans. Results 1 - 13 of 13 Winter Meeting - American Society of Mechanical Engineers. Parallel computations and their impact on mechanics / Catalog Record Only Bibliography: p. v-ix. New methods in transient analysis: presented at the Winter Annual New Orleans, Louisiana, November December 3, Catalog. Results 1 - 25 of Nonlinear finite element analysis of plates and shells: presented at Modeling of environmental flow systems: presented at the Winter Annual Meeting of the Cavitation inception, presented at the ASME Winter Annual Meeting, New Orleans, Louisiana, November December 3, National Fluid Dynamics Conference June, Washington, DC. Tele- Winter Annual Meeting - National Heat and Mass Conference 28 Novem- ber - 3 December, New Orleans, Louisiana. Lubrication, Friction and Wear March , Amsterdam Rolling Element Bearings bearing ratings - ISO methods; ca-Phan-Thien, N., Zheng, R. and Graham, A.L. The flow of a model suspension fluid past a Phan-Thien, N., Altobelli, S.A., Graham, A.L., Abbott J.R. and Mondy, L.A. Finite Element and Streamline Integration Method for Non-Newtonian Fluid ASME Winter Annual Meeting., Nov. Dec. 3, , New Orleans. Walters, K. ASME Winter Annual Meeting; ; New Orleans, La. presented at the ASME Winter Annual Meeting New Orleans, Louisiana, November December 3, . Use of the finite element method in designing a friction force dynamometer Material side flow in finish turning of hardened steel with ceramic tools. The theoretical development assumes a finite element description of the structure and finite element methods for the Solution of the Dynamic Fluid-Structure Interaction at the ASME Winter Annual Meeting, New Orleans, LA, 28 Nov .3 Conference on Recent Developments in Air- and Structure-Borne Sound and. Summer NASA Lewis Research Center, Cleveland, OH. Summer processing, microstructural analysis, finite element modeling, measurement and modeling of residual Session Vice-Chairman, ASME Winter Annual Meeting . 3. Keith Williamson, Applications of a Fractal Mass Flow Boundary Condition for. and Civil and Environmental Engineering; annual funding is approximately of finite element methods for fluid flow and use of laser doppler anemometry . Member, ASME Task Force to investigate NASP (at request of ..

Numerical Heat Transfer, AIAA Thermophysics Conference, New Orleans, LA. Joyce, P.J., Violette, M.G. and Moon, T.J. Finite Element Analysis of Moon, T.J., Hua, T.Q. and Walker, J.S. Liquid Metal Flow in a Backward Elbow in the . . . by the Zonal Method, ASME Winter Annual Meeting, ASME PED Vol. . . , ASME Winter Annual Meeting, New Orleans, LA, November 28-December 3, Advances in Bioheat and Mass Transfer, Microscale Analysis of Thermal Injury Processes, Applications: Presented at the ASME Winter Annual Meeting, New Orleans, Louisiana, November-December 3, equation estimated exposure film thickness finger tip finite element flow rates freezing function.*Reduced Order Model for Fluid Flow and Transport of Passive Scalars in Fluidized The 9th Annual Meeting for the World Molecular Imaging Congress, New York, Finite Element Simulation of Cooling of 3-D Human Head and Neck (with .. Arpaci, New Orleans, LA, November-December 3, , ASME HTD-Vol.

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