ADINA System Newsletter

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We are glad that there is much interest in the new capabilities in ADINA 8.0. Many users have asked about the release of the ADINA System 8.0. Our plan is to release this new version in September 2002.

The new capabilities in ADINA 8.0 were presented at our recent Seminar in Munich, Germany on June 5 - 6. We want to thank all who came to the Seminar for your support, especially to those who took the time to prepare and present their applications. Among the many interesting applications presented, we highlight in Figure 1 the helmet impact analysis performed (with ADINA 7.5) by the engineers at MET S.p.A.

In this Newsletter, we present a special section on the use of ADINA in the biomedical field where finite element analysis is playing an increasingly important role in recent years, and show an important new feature for flow visualization in ADINA 8.0.

Helmet Impact Analysis

MET S.p.A (www.met-helmets.com) is a leading sports helmet manufacturer based in Talamona, Italy. Engineers at MET have used ADINA successfully to analyze their new helmet design. Their simulation model as shown in Figure 1 consists of the head with the helmet impacting on the anvil at a velocity of 4.57 meters/second. The objective is to ensure that the helmet provides adequate protection for the head, in particular, the deceleration on the head must not exceed 250g.

In the past, engineers at MET had to rely on results obtained from actual impact tests performed on prototype models in the laboratory to evaluate the performance of a new helmet design. Now, with the use of ADINA, the engineers are able to gain better insight into how the helmet performs, e.g. clearance distance between the head and the anvil can be obtained easily from the simulation results. Comparison of the simulation and laboratory test results shows very good agreement.

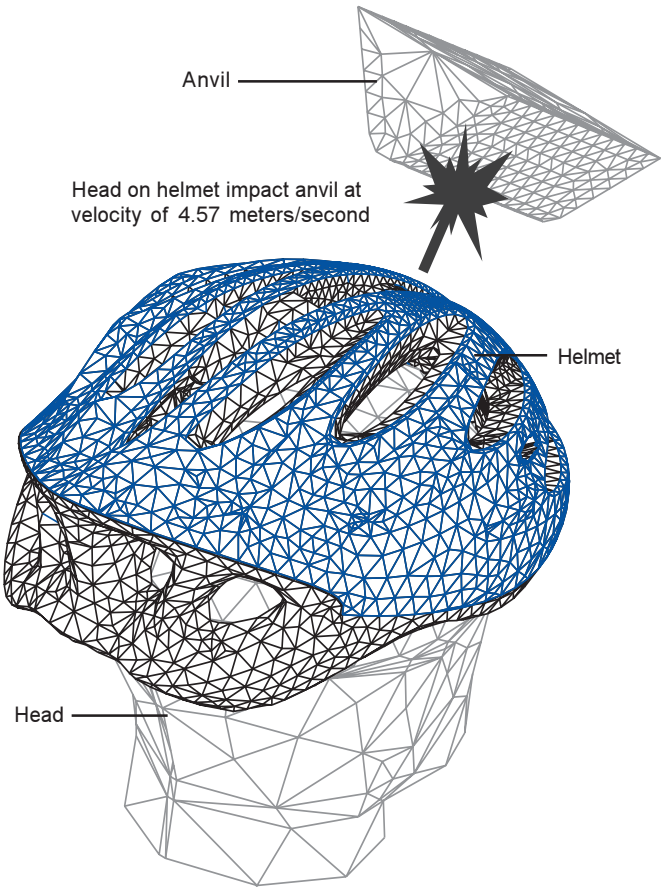

Figure 1: Helmet Impact Analysis
Geometry model created with Unigraphics
(Courtesy of MET S.p.A.)

Training Classes

The next ADINA-AUI training course will be held at ADINA R & D on September 19-20, 2002.

Inside This Issue

ADINA IN BIOMEDICAL APPLICATIONS

In recent years, there has been great interest in the use of engineering analysis for biomedical applications. In particular, finite element analysis has been used successfully in a wide range of applications including the following:

- Artificial Organs
- Medical Devices
- Cartilage/Bone Mechanics
- Eye Surgery
- Ablation Procedures
- Drug Delivery
- Crash Injury Prediction
- Hemodynamics
  - circulation of blood
- Orthotics
  - support and bracing of weak or ineffective joints or muscles
- Prosthetics
  - artificial replacement of missing body parts
- Bioreactors
  - in which living organisms synthesize useful substances or break down harmful ones
- Cell Mechanics
  - cell deformation, division, and failure

The ADINA System has many features that enable accurate simulation of the above-mentioned applications.

- One key advantage is our unique capability in **fully coupled fluid-structure interaction** analysis. This capability is extremely useful in the analysis of blood flow problems, especially those involving arteriosclerosis, aneurysms, grafts, or endovascular stents. It can also be used effectively for simulating blood flow through the heart valves, through arterial bifurcations, and through the lungs.

- The **versatile contact algorithms** in ADINA are well-suited for the simulation of contact in prosthetic knees, in catheter related procedures, and in artificial hearts. Frictional effects can of course be included in these simulations. The accuracy of our contact and element formulations is also essential in crash test simulation and prediction of occupant injury.

- The **mass transfer** capability in ADINA can be used for modeling drug delivery systems, substance exchange in lungs and in bioreactors.

- Our **extensive material library** includes materials suitable for modeling various biological parts – orthotropic models for bones, poroelasticity models for bone and brain tissues, hyperelastic models for blood vessels, and viscoelastic models for cells. In addition, hyperviscoelastic materials implemented in ADINA 8.0 are suitable for the modeling of blood vessels.

- Other new features in ADINA 8.0 that further strengthen our position in biomedical applications include the **surface tension** boundary condition for solids, used in the simulation of cell mechanics, and an improved **Joule heating** capability for the simulation of ablation procedures.

We are confident that the use of finite element analysis in the field of biomedical applications will continue to grow significantly. The use of ADINA for such applications indeed follows naturally from our mission:

- To provide **one** finite element program that can be used to perform comprehensive analyses of structures, fluids, and fluid-structure interactions.

Artificial Lung Analysis

An interesting example of the use of ADINA in the biomedical field is the artificial lung analysis (Figure 2) performed by engineers at Michigan Critical Care Consultants (MC3 – www.mc3corp.com). This application is highlighted in the Application Showcase on our web site.

Excellent results obtained from their analyses were already presented at the American Society for Artificial Internal Organs (ASAIO) Conference.

- S.D. Chambers, R.H. Bartlett, J.P. Montoya, 3-D Computational Fluid Dynamics in Artificial Lung Design: Steady and Transient Models, ASAIO J 46(2): 231, 2000

Recently, engineers at MC3 used ADINA to redesign the artificial lung housing with a flow separator for distributing the blood through the fiber bundle (where oxygen is transferred to the blood and CO_2 is removed from the blood), resulting in a decrease in the pressure drop of about 40%. This redesign has been critical to their successful tests conducted on animals. Prior to the redesign, the heart of the animal could not withstand the resistance of the device.

References

Some references where ADINA is used for analysis in the biomedical field are listed below.

[1] H.F. Younis, C.I. Chung, R.D. Kamm, Challenges in Developing an Accurate Model for Carotid Bifurcation Blood Flow and Wall Mechanics, First MIT Conference on Computational Fluid and Solid Mechanics, 1434-1439, 2001

[2] C. Rogers, D.Y. Tseng, J.C. Squire, E.R. Edelman, Balloon-Artery Interaction During Stent Placement. A Finite Element Analysis Approach to Pressure, Compliance, and Stent Design as Contributors to Vascular Injury, Circulation Research, 84, 378-383, 1999

[3] A.L. Lachapelle, S.Q. Lui, D. Tang, Numerical Simulation for Flow in Grafted Arteries with Fluid-Structure Interactions, 2001 ASME Bioengineering Conference, 387, 2001

[4] S. Shirouzu, M. Kawakami, H. Sugano, A Coupled Fluid-Structure Analysis of Mechanical Interactions between Pulsatile Blood Flows and Arteries, 2001 ASME Bioengineering Conference, 759-760, 2001

[5] R.N. Natarajan, G.B.J. Andersson, The Influence of Lumbar Disc Height and Cross-Sectional Area on the Mechanical Response of the Disc to Physiologic Loading, Spine, 24, 1873-1881, 1999

[6] T.M. Chu, N.P. Reddy, J. Padovan, Three-dimensional Finite Element Stress Analysis of the Polypropylene, Ankle-Foot Orthosis: Static Analysis, Med Eng Phys.,17:372-9, 1995

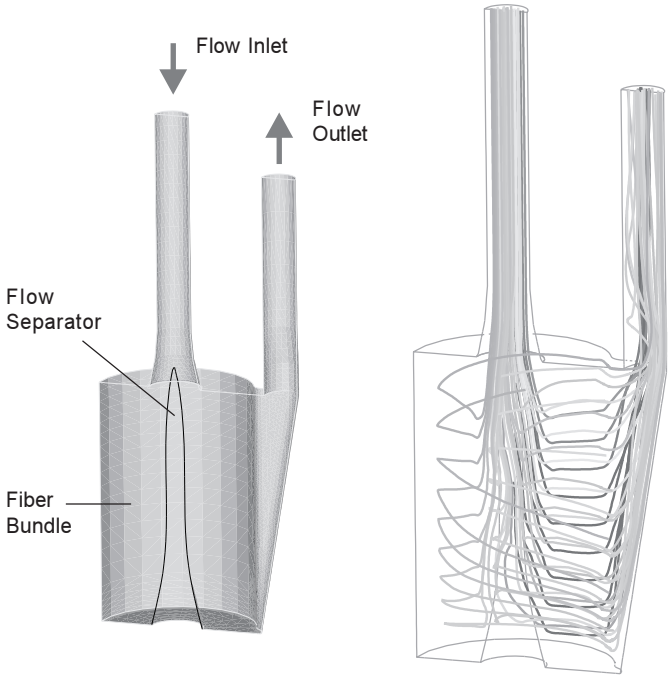

Figure 2: Analysis of Artificial Lung with Particle Trace Plot

Flow Visualization

In the analysis of 3-D fluid flow problems, it is important to be able to visualize the flow field in the fluid. We are pleased to inform you that powerful new features to enable easy flow visualization are added in ADINA 8.0.

In ADINA 8.0, the user can display results inside the 3-D fluid flow domain, for example, velocity vectors in the fluid can be plotted. In addition, an important flow visualization tool is implemented – particle tracing.

Particle traces are used in fluid flow to visualize the motion of massless particles that are placed in the flow field. This feature can be used for both steady and unsteady (transient) flow conditions. Figure 2 shows an example of a particle trace plot for the steady flow analysis of the artificial lung. In Figure 3, we show the particle trace plots for a transient fluid-structure interaction (FSI) analysis at various solution times. You can view the animation of the particle tracing for this transient analysis on the News Group web page of our web site.

ADINA News Group

Thanks to feedback from some of you, we now post the animations on our web site instead of sending them as email attachments. To view the animations, go to www.adina.com and click on News, followed by News Group. Currently, the following animations are posted:

- Viscous Droplet under Gravity with Surface Tension Effects
- Radio-Frequency Ablation of Tissues using the Joule Heating Capability (biomedical)
- Analysis of Automotive Hydraulic Engine Mount
- Simulation of Neutrophil (Cell) Passing through a Capillary (biomedical)
- Particle Tracing for 2-D and 3-D Transient Fluid Flow Analysis

Members of the ADINA News Group are informed regularly about new features in the ADINA System. If you are not yet a member, our News Group web page describes how you can join.

WCCM V

We will be participating in the technical exhibition at the Fifth World Congress on Computational Mechanics (WCCM V). Please stop by at our booth if you are attending the Congress.

Date: July 8 - 12, 2002
Venue: Vienna University of Technology
Wiedner Hauptstrasse 8 - 10
A-1040 Vienna, Austria

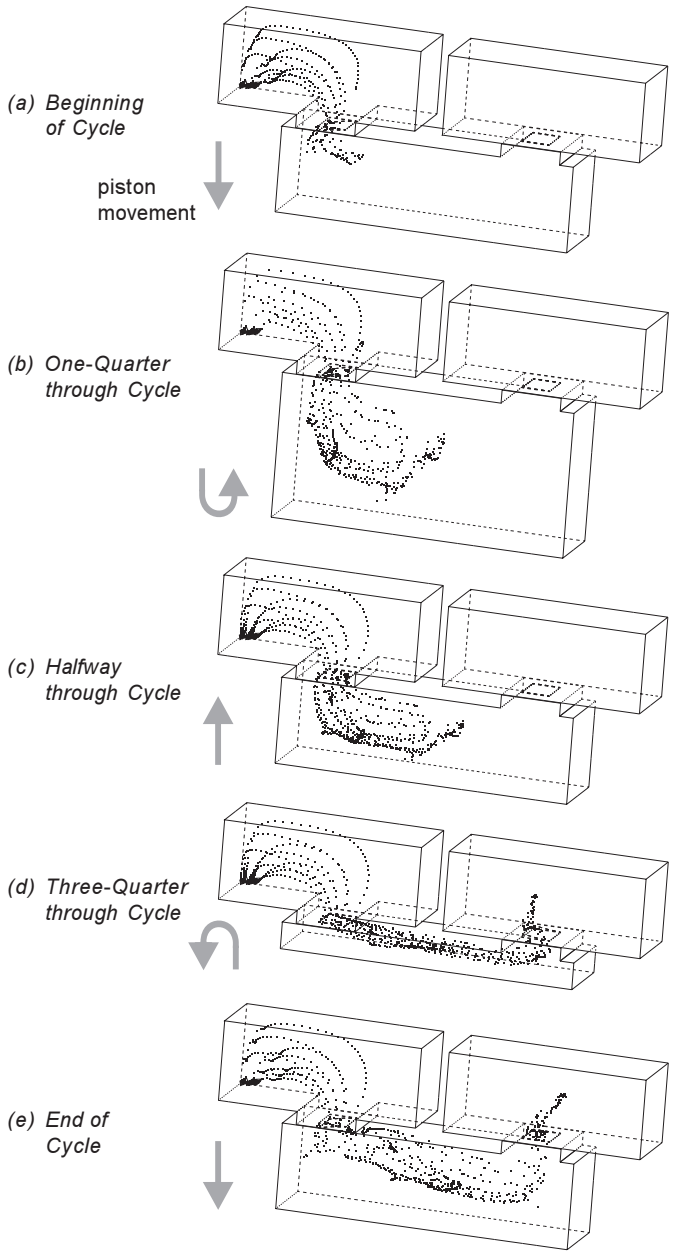

Figure 3: Particle Tracing for Transient FSI Problem

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