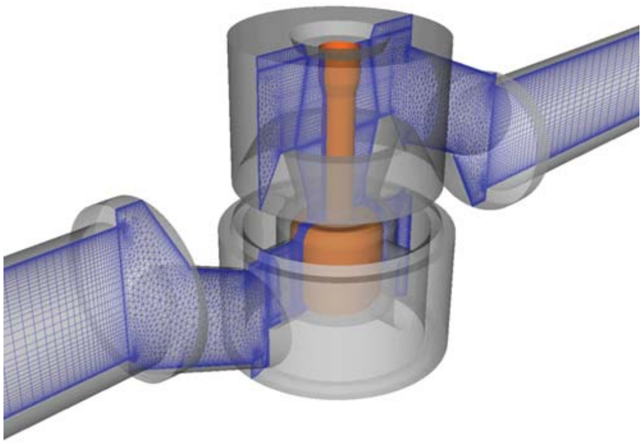
FocalPoint The Newsletter for Gridgen® Users

Volume 7 Issue 2 Fall 2004

Gridgen Hybrid Meshes for High-Fidelity, Efficient Simulations

Courtesy of Combustion Research and Flow Technology, Inc. / Jeremy Shipman, Ashvin Hosangadi, and Vineet Ahuja



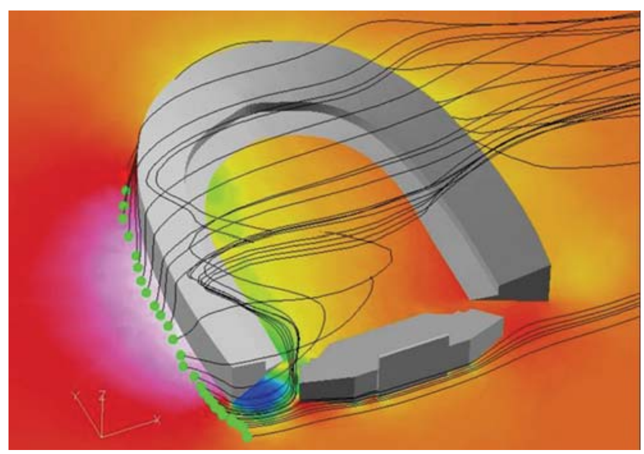
Pressure regulator valve geometry with the hybrid grid (shown along the symmetry plane) used to mesh the valve flowpath.

Researchers at Combustion Research and Flow Technology, Inc. (CRAFT Tech) have been using Gridgen in conjunction with the multi-element unstructured flow solver CRUNCH CFD® in studies of flowfields that involve both complex geometries and physics. For such cases, a purely structured or purely unstructured approach can be insufficient to satisfy both the complexity of the geometry and the high fidelity required to resolve local physics in an efficient manner. By using a multi-element approach, an optimal combination of structured and unstructured blocks can suit both the geometrical and physical characteristics of the system. For example, high aspect ratio hexahedral blocks are created or extruded in regions where strong localized gradients exist, such as boundary layers, shear layers, and jets. For complex surfaces that require boundary layer resolution, prism layers are extruded in regions where it would be difficult to construct structured blocks. Tetrahedral blocks are then used to

(Continues on page 2)

CFD at Ohio Northern

Article by Jed E. Marquart, Ph.D., College of Engineering, Ohio Northern University



Wind patterns around and inside the Ohio State Stadium

The T.J. Smull College of Engineering at Ohio Northern University is composed of three departments encompassing five majors: Departments of Mechanical and Civil Engineering, and the Department of Electrical and Computer Engineering and Computer Science. Approximately 400 engineering students study in this strictly undergraduate engineering setting.

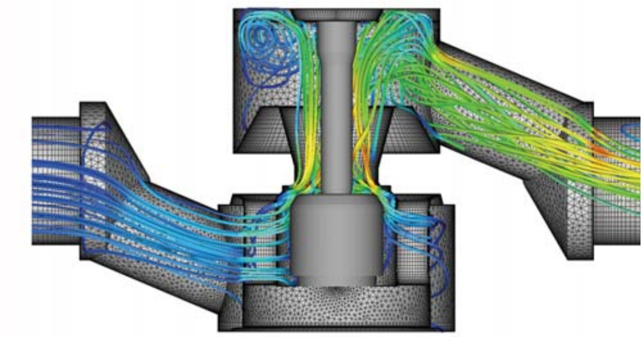
In 1992, Dr. Jed E. Marquart, Professor of Mechanical Engineer

(Continues on page 5)

INSIDE THIS ISSUE

Multi-Element Meshes cont.

(Continued from page 1)



Streamlines colored with Mach number illustrating the many secondary flow structures in the valve flowpath.

efficiently fill the remaining volume and stitch together the disjointed topologies of the grid. The capacity to handle diverse grid topologies is an important attribute of the CRUNCH CFD® code, and Gridgen's ability to construct hybrid grids provides a level of flexibility and control of localized resolution that can allow the user to obtain accurate solutions to complex problems in the most cost-efficient manner.

This strategy has proven to work very efficiently for simulations of a variety of systems, including aircraft/aero-propulsive simulations and turbomachinery/fluid handling systems such as pumps, compressors, and valves. In this article, the multi-element approach is demonstrated for a pressure-regulating valve found in the feed systems of liquid rocket test stands at NASA Stennis Space Center. As shown on the first page, this valve has a very complex flowpath that consists of complicated pipe junctions and multiple channels feeding a chamber that contains a variable area poppet with tight clearances in the valve seat region. Traditional structured grids are very difficult to generate for such a complex geometry, which for a purely hexahedral grid forces an awkward block topology with highly skewed and irregular cells. For a contiguous multi-block structured grid, severe constraints on grid resolution are placed on critical regions of the flow domain such as the seat region of the valve where the flow sharply accelerates. Conversely, a grid comprising only tetrahedral and prism elements is cumbersome to build because of difficulties with prism extrusion in the concave corners and tight clearances associated with certain regions of the geometry. These shortcomings are overcome in the multi-element approach wherein high quality grids are efficiently generated in all regions of the valve geometry.

A cross-section of the multi-element grid is depicted in the picture on the first page, illustrating the various regions in which each cell type was used. In the axisymmetric portions of the geometry, namely the seat region and the areas around the poppet, hexahedral blocks are created by rotationally extruding structured domains around the valve body axis. The high aspect ratio hexahedral cells are ideally suited for resolving the high pressure and velocity gradients near the valve seat and enabling boundary layer clustering on the enclosed walls that exist on all sides of the domain. The remaining portions of the valve body comprise non-axisymmetric regions with complex pipe junctions and ports. Prism layers are extruded from triangular surface grids in these areas to resolve the boundary layers associated with these complex-shaped surfaces. Straight sections of the geometry such as the inlet/discharge ducts and the four ports channeling flow into the valve body are meshed with high aspect ratio hexahedral cells along the walls and a core of prisms through the center. The remaining portions of the volume are then filled with tetrahedral cells that connect the disparate topologies in different regions of the valve.

Both steady and unsteady CFD simulations were performed using CRUNCH CFD® with the aim of investigating the processes that occur within the valve leading to a chatter-like behavior observed when the valve is operational. The figure on this page shows streamlines colored by Mach number obtained from the steady simulation. The streamlines show some of the secondary flow structures present in the feed channels and the large recirculation that develops in the top of the valve body. The multiple corners, disparate shapes, and tight clearances that make up the flowpath of the valve result in flowfield regions having a variety of length and time scales, ranging from low Mach number regions to supersonic flow in the vicinity of the valve seat. The multiple corners cause transient phenomena, such as shedding vortices, that are resolved in the unsteady simulations and lead to observed flow-induced unsteadiness.

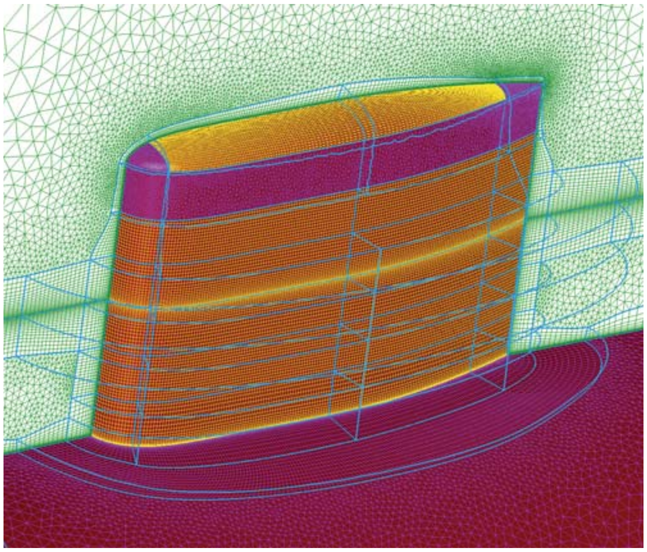
Based on material presented at the 40th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, July 2004, Paper AIAA-2004-3663. ■

Meet our newest Employee....Brendan Dhein - Engineer, Product Development

Brendan Dhein is the newest member of Pointwise having just graduated in May 2004 with a B.S. in Computer Engineering from the University of Florida. While working on his undergraduate degree, Brendan had internships at Phillips Semiconductor, Apple, and Intel. Brendan is the engineer responsible for Gridgen's port to the Mac and we look forward to his future contributions to Gridgen.

UT SimCenter & Gridgen

Article by Steve Karman, Ph.D., University of Tennessee at Chattanooga



Caption need from Steve.

Gridgen is the mesh generator of choice at the University of Tennessee both in research and as a teaching tool.

Gridgen is used on research projects by professionals in the University of Tennessee SimCenter at Chattanooga to generate meshes for a wide variety of computational simulations. The types of meshes generated range from fully structured, multiple block meshes to mixed structured-unstructured meshes. Most simulations solve the Reynolds averaged Navier-Stokes equations and require tight clustering of mesh points near viscous boundaries. The Reynolds numbers vary from the low thousands to over a billion. This range in Reynolds number puts severe restrictions on the mesh generation process. Although the trend in mesh generation is moving toward fully unstructured meshes, structured meshes still offer considerable advantages that should be exploited.

Fully structured meshes for complicated geometries, such as the submarine body shown in the figure above, can take a considerable amount of time to generate compared to unstructured mesh. And the nature of the grid blocking employed can result in an excessive number of grid points in regions where no viscous grid is required. However, unstructured meshing for viscous applications can also be difficult, especially in concave corners and with extreme clustering requirements. Hybrid grids offer a compromise solution. Structured blocks can be used in obvious viscous regions, such as the juncture between the conning tower and the submarine body and the interface between the air and water. Unstructured meshes, including viscous meshes on the surface, can be used to discretize the remaining regions of the domain. Combined, structured and unstructured meshes can provide high quality meshes that result in accurate and efficient flowfield results.

Pointwise has also provided additional licenses to UTC, under the Gridgen Teaching Partnership, for students to use in conjunction with a graduate course on numerical mesh generation. In addition, student may use these licenses in their graduate research.

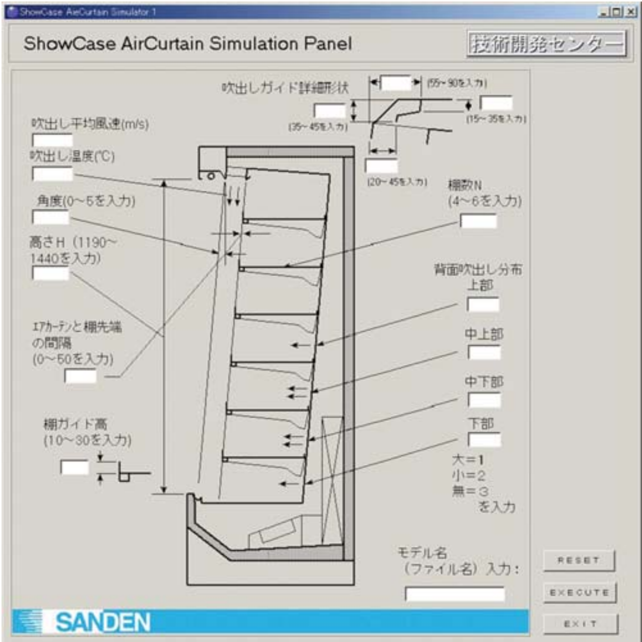
Students begin their Gridgen training in this graduate course by following one of the tutorial cases included in the User's Manual, the 2D circular arc bump case. Progressively more complicated Gridgen assignments are given culminating in the students generating a 3-D multiple block viscous mesh about an isolated wing geometry.

As the course progresses, students are exposed to some of the theoretical details of the techniques used by Gridgen to perform various mesh generation tasks. Initially the lectures concentrate on the methods used during the early stages of the meshing process. For instance, various distribution functions for placing grid points along curves are described, including a two-sided hyperbolic tangent distribution function commonly used within Gridgen. Later the transfinite interpolation method is derived and students are assigned a programming task to perform TFI to initialize interior grid points, given a boundary point distribution. Students are then shown the derivation of the Winslow smoothing technique and are assigned another programming task to write a Winslow smoother to improve on the mesh produced from the TFI exercise. The basic theory and concepts of Delaunay triangle mesh generation are introduced. Finally, students are tasked to develop a 2-D triangle meshing program designed to introduce the major tasks involved in this process. During each of these programming assignments, students are shown what to expect by demonstrations in the classroom using Gridgen. ■

Interested in our Gridgen Teaching Program?

SANDEN Uses Glyph for Refrigerator Air Curtains

Courtesy of SANDEN Corporation, R&D Technical Headquarters, FACE Strategy Center / Mr. Akira Shimizu

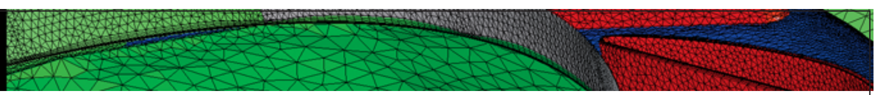


GUI control panel for SANDEN'S script.

SANDEN Corporation produces refrigerated open showcases. Demands for saving energy in open showcases are increasing every year. The focus of development is on improving air curtain performance because a significant part of the heat load imposed on showcases comes from heat flowing through the air curtain. Design of air curtains has been conventionally based on results of repeated experiments using physical test models in different designs. One of the recent trends is to reduce the number of experiments by using CFD technology to predict the product's performance. However, creating CFD analysis models of showcase air curtains in different design requires considerable time and expertise because of numerous design parameters needing adjustments.

We decided to integrate our expertise and know-how of CFD modeling of air curtains into a CFD software tool that can be used by mechanical designers to study numerous design parameters and to check the performance of new designs before actually building prototypes for testing. For the grid generation part of the software tool, we used the Glyph scripting language in Gridgen. We developed a program with a graphical user interface (GUI) that allows easy setting of design parameters such as outlet air velocity and its profile, geometry of flow control plates, air outlet angle, height of outlet opening, number of shelves, distances from the air curtain outlet to the shelves, height of shelf tips, profile of back side air flow velocity, and so on. Analysis conditions are also entered in the GUI in order to output control files for the CFD solver. By this system, we succeeded in compressing the time needed for generation of analysis grid for a multiple shelf open showcase from 3-5 days to as short as several minutes. Based on this success, we are planning to develop and use similar systems for different types of showcase designs such as flat type showcase and double or triple air curtains. ■

Distributor Highlight



Virtual-Tech

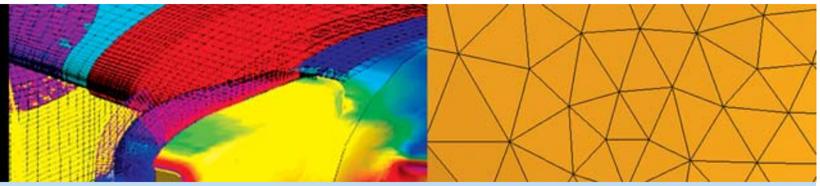
Virtual-Tech Consulting (VTC), Pointwise's Gridgen distributor in Malaysia, provides advanced computational based engineering simulations, design optimization solutions, and engineering services to Southeast Asia.

Various industries, such as automotive, aerospace, building, civil and offshore structures, environmental, marine, power generation, turbo-machinery and academic institutions use VTC collaborative engineering solutions. Additionally, VTC provides CFD, FEA, manufacturing process simulation, design optimization consultancy and other services to the engineering community.

In addition to Gridgen, VTC also distributes GT-SUITE, GT-POWER, ALGOR, AAA, Star-CD, modeFRONTIER and other engineering simulation solutions.

Information about VTC can be found on their web site at www.vtcasia.com. Mr. Dieter Lim, OL, is the main Gridgen contact at VTC and can be reached at dieter@vtcasia.com.■

Gridgen Product News



The current production Gridgen release is Version 15.05. Its Native CAD Readers support an increasing arrary of CAD formats, including PTC's Wildfire 2 and Unigraphics' NX 2. Support for a new hardware platform, HP-UX 11 on Itanium, was also added.

V15.06 is currently targeted for a November release. Several new features are currently in Beta test including a port to Mac OS X, improvements that give you more flexibility in how and where extrusion is applied, and a major increase in robustness for meshing shells (faceted database surfaces imported from STL files).

We're planning to release some of the new CAD and solid modeling features from our recently completed Navy research (see Fall 2003 Focal Point) after the start of the new year. These improvements include IGES export and trimmed surface creation. We presented our research results at last spring's Gridgen User Group Meeting.

CFD at Ohio Northern

(Continued from page 1)

ing, developed a senior technical elective course entitled Computational Fluid Dynamics. Initially, the course enrolled seven students, and was taught using a single SGI Indigo workstation, along with several CFD codes developed in the Flight Dynamics Directorate at Wright-Patterson Air Force Base. Dr. Marquart had previously been an engineer in an applied CFD group at WPAFB.

The CFD course remains very popular among the mechanical engineering students. The CFD Lab at ONU is presently composed of seven Gateway PCs, along with twelve multi-processor Sun Blade 1000 workstations. The workstations are networked to provide multiprocessing capability for the solution of larger CFD jobs and faster runtimes. In addition to student-written codes developed during the course, the following commercial codes are used for homework and projects: Gridgen, Cobalt, Fieldview, Star-CD, and ANSYS.

A requirement of the course is that the students complete a substantial CFD analysis of their choice from start to finish. They are free to choose the geometry, flow conditions, and the desired results to be investigated. With a fairly wide-open choice of problems, the cases selected have ranged from examining flow over a golf club head during the swing to simulating the mixing of two dissimilar liquids during an overturning process, as well as many other interesting (and sometimes very unique) configurations.

This past year saw several interesting projects, including the simulation of flow over a NASCAR Ford Taurus geometry, as well as the examination of wind patterns and characteristics around and inside the Ohio State Stadium ("The Horseshoe"). For all of these projects, Gridgen played a huge role, permitting the students to generate high-quality grids in a short amount of time, despite their previous lack of grid generation and CFD experience.

Students presented their work at the AIAA Regional Student Conference in April of 2004, at Purdue University.

The grids were generated using Gridgen, the flow solver was Cobalt, and the postprocessing was done using Fieldview. Since the duration of the projects was on the order of eight weeks from inception to completion, it was essential that the students be able to pick up the tools quickly and put them to effective use within a short period of time. These software tools provided the students with the ability to complete their projects on time, and with the desired level of accuracy. ■

213 South Jennings Avenue Fort Worth, Texas 76104-1107 Toll-free 888-GRIDGEN
Tel (817) 377-2807 Fax (817) 377-2799 support@pointwise.com www.pointwise.com

FocalPoint is a publication of Pointwise, Inc. It is for Gridgen users and people interested in learning more about Gridgen and numerical grid generation. It includes information about the latest release of Gridgen, future development plans, and tips on how to get the most out of Gridgen while saving time in grid generation.

POINTWISE®

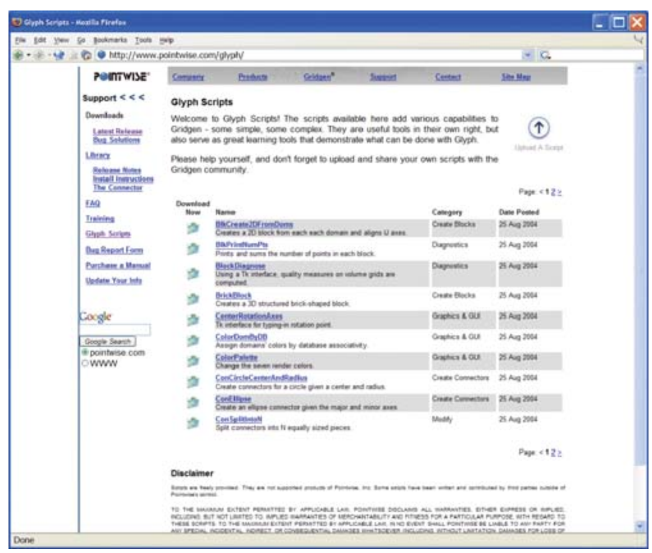
213 South Jennings Avenue
Fort Worth, Texas 76104-1107

Focal**Point** The Newsletter for Gridgen® Users

Volume 7 Issue 2 Fall 2004

Glyph Scripting Update

Several new macros and templates were released for the Glyph scripting language with V15.05. The new scripts can split a connector at a given percentage of its arclength, read a segment file into the database as point entities (not curves), intersect and split two connectors, and a neat macro for changing display style, enable state, and layer for database entities. You can find these latest demonstrations of what can be done with Glyph in the utils directory on your installation media. Hopefully you've also noticed that we've dedicated a special place on our web site, www.pointwise.com/glyph, to sharing Glyph scripts. If you have a script you'd like to share, please upload it to our web site.



Here's a tip for making it easier to use these utility scripts. Create a variable in your Gridgen RC file that's the path to the util directory in your Gridgen installation. On Windows, this might look like the following (for a standard Gridgen installation):

```
gg::varSet utils "C:/PROGRA~1/Pointwise/
          GridgenV15/utils"
```

Whenever you want to run one of the utility scripts, use the Execute command in the Script menu. This opens the file Browser. Instead of navigating the file system via the Browser, click Type In… **dir**. The Browser is replaced by a list of your variables including the one defined above. Click on it and you'll immediately jump to the util directory. Obviously, you can use this trick to create variables for other frequently used directories on your computer.

If you would like to learn more about scripting, join us at our Gridgen User Group Meeting 2005. We will be offering a special seminar focusing on Glyph scripting on Monday, April 25, 2005. For more information about the Gridgen User Group Meeting 2005, please visit our webpage www.pointwise.com/ugm. ■