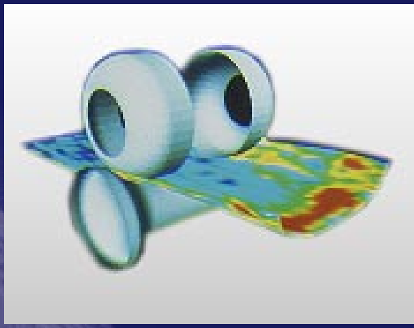
ANSYS News

ANSYS Leverages Leading-Edge Technologies



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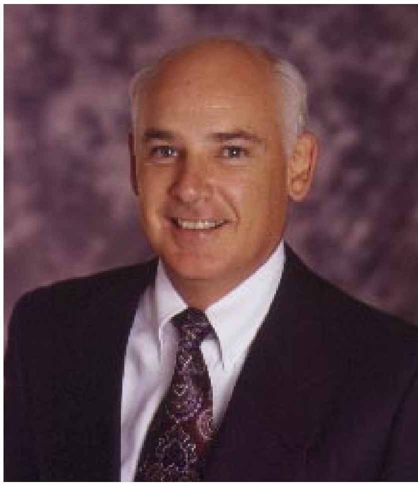
Message from the CEO



Peter J. Smith
President and CEO

The ANSYS Approach:

Enterprise-Wide Engineering Solutions

ANSYS, Inc. had a record third quarter this year. We continued to experience accelerated growth in our core ANSYS® software. New licenses grew at a rate of over 60 percent above the third quarter of 1994.

We released ANSYS 5.2 on schedule and shipped the first software package September 18, 1995. This release occurred less than 12 months after the 5.1 release, meeting our commitment to speed up implementation in delivering industry-leading products. ANSYS 5.2 advances include numerous power capabilities such as PowerGraphics, PowerSolver, PowerParallel, and PowerOptimization. A comprehensive set of p-elements was added and the graphical user interface enhanced.

We increased our people investment in both the development and marketing of ANSYS products and services. Recent additions to ANSYS, Inc. include development expertise in the meshing, geometry transfer, nonlinear, and user-interface areas. We also added specialists in marketing, advertising, and public relations.

Partnership activity is at an all-time high. We are integrating ANSYS with the industry's best third-party software technologies. Major third-party agreements include Livermore Software Corporation for integration of the LS-DYNA explicit solver within ANSYS*, and CAD interfunctionality agreements with Computervision Corporation and Unigraphics®. In addition, we continue to work with other leading CAD vendors.

We reinforced our commitment to the Pro/ENGINEER® community with the PTC-ANSYS joint letter, and with the timely release of ANSYS/ProFEA®.

The ANSYS/AutoFEA™ relationships steadily expand, with substantial development and marketing activities underway. We are on track to ship the 3-D ANSYS/AutoFEA product within 60 days of the release of the Mechanical Desktop product from Autodesk®.

Partnering with these and other world-class developers provides you with instantly optimized products designed to meet your analysis needs.

We recognize what today's companies require to succeed in an increasingly competitive global marketplace: improved products, produced at less cost, that get to market fast. Competitive companies demand a design environment that offers not only increased cost efficiency and significant gains in productivity, but also maximizes flexibility for the future. This, to us, translates into a flexible environment; one that supports the best-of-breed solutions today, encourages

*See related article on page 3.

integration of customer-specific applications and specialized third-party programs, and provides flexibility for future technological advances. This is the ANSYS approach.

The open architecture of our products gives customers what they need. ANSYS embodies an extensive family of data-compatible products. Users select only what they require and can easily transition among ANSYS products. ANSYS files are compatible across all platforms and products, from PCs to workstations to supercomputers. ANSYS runs on a wide variety of hardware platforms, enabling users to have access to world-class design and simulation tools. Learning to use ANSYS is facilitated by the standard graphical user interface that provides Windows-like interface uniformity across all products. All these features add up to flexible, compatible ANSYS products designed for you.

Our recent achievement of ISO-9001 certification represents the technical excellence and reliability of our quality system; one that provides a solid foundation on which we build our open strategy. The continuous addition of high-quality, cutting-edge technologies is consistent with the customer-driven open structure of ANSYS, Inc.

You can depend on ANSYS, Inc. for flexible, technologically-advanced design and analysis software packages. We will accelerate growth of the core ANSYS product, maintain our commitment to prompt delivery of premium products, and partner with world-class developers. To ensure the success of our open architecture environment, we will continue to take a critical view of ourselves, our processes, and our corporate strategies. In this leadership role, we will deliver enterprise-wide engineering solutions.

Sincerely,

Peter J. Smith
President and CEO

ANSYS® News®

Fourth Issue
1995

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Published four times a year for ANSYS and FLOTRAN customers and others interested in the field of design analysis applications. There is no charge for a subscription; contact Mary Al Caldwell to be put on the mailing list or to change your address. Although the contents of *ANSYS News* have been carefully reviewed, ANSYS, Inc., does not warrant it to be free of errors or omissions.

Leveraging Leading-Edge Technologies

Today's market leaders utilize flexible engineering solutions to dominate competitors. ANSYS, Inc. provides these solutions through open business partnerships that meet the expanding needs of users with versatile, technologically advanced software. ANSYS third-party programs support world-class partners whose products possess industry-leading capabilities. When integrated with the ANSYS program, these products provide customized, cost-effective solutions with a single, intuitive user interface.

ANSYS Avenues

ANSYS, Inc. recently established the innovative third-party programs system, ANSYS Avenues. Through ANSYS Avenues, users obtain world-class, leading-edge software that is applicable to every industry. ANSYS Avenues allows users to effectively utilize their industry knowledge by giving them a forum to translate their knowledge into a working tool. Users can create their own customized solutions from within the ANSYS environment.

The ANSYS program simulates a wealth of engineering disciplines, such as heat transfer, statics, dynamics, and computational fluid dynamics. ANSYS Avenues supplies users with a multitude of additional solutions already available in ANSYS. The open architecture allows users and third-parties to harness all of these capabilities, while developing specialized solutions tailored to meet individual needs. ANSYS connects islands of individual productivity, resulting in powerful strategic solutions that meet corporate-wide needs.

ESP

The ANSYS Enhanced Solution Partners (ESP) program, supports high-quality vertical application developers, and leads customers through the ANSYS Avenues of solutions. Vertical application developers in the ESP program use ANSYS as a platform to create custom products. Customers in need of a customized software program can choose from an ESP Directory (posted on the ANSYS Homepage), or engage ANSYS Customer Services for immediate professional assistance.

The Application Programmer's Interface (API) is a key feature of the ESP program that provides a flexible environment to transform industry-specific knowledge into usable design software. Developers use the API to create their own niche applications. Partners create customized pre- and postprocessors, menus, commands, documentation, and data libraries.

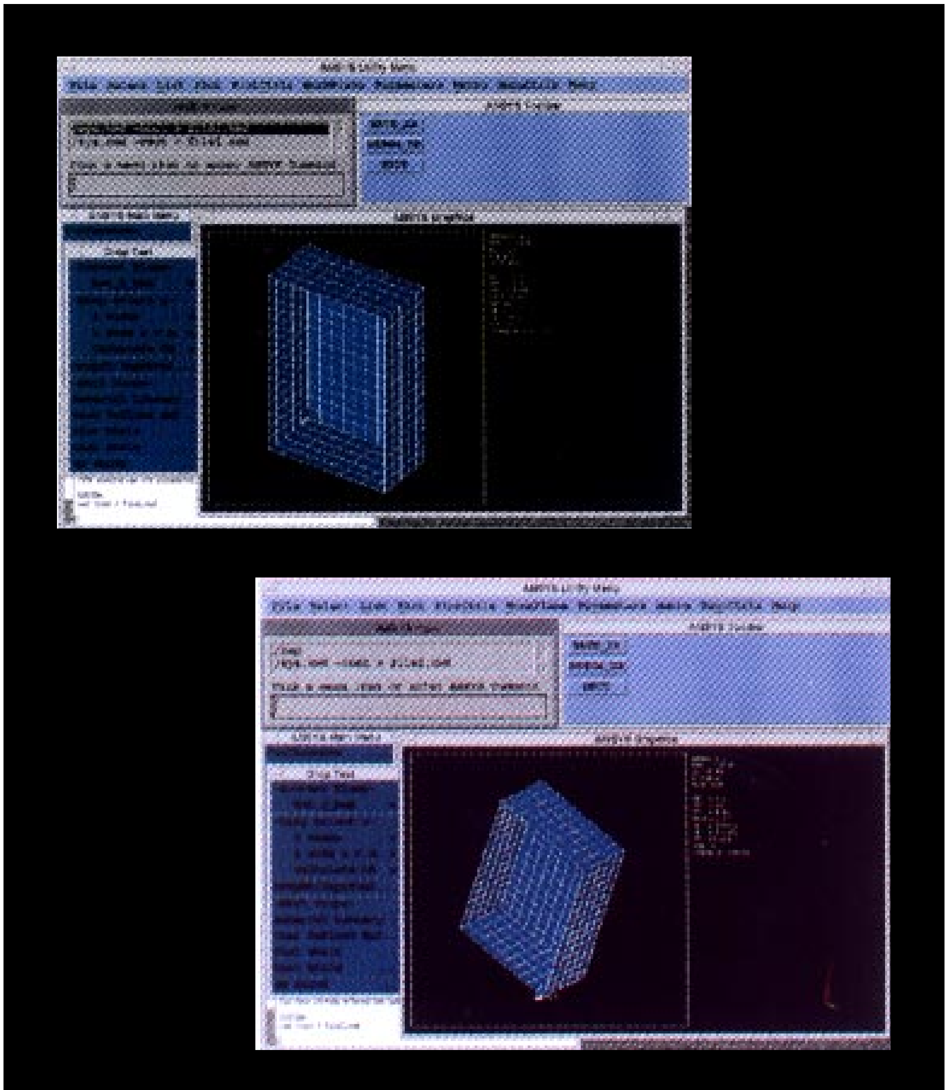
Creating Custom Products

The following is one example of how an ESP program member, like Silverado Software & Consulting, Inc. (SSC), can utilize the open architecture of the ANSYS program as a foundation for the creation of vertical applications.

Designers of electronic consumer products such as portable telephones, beepers, stereo equipment, and laptop computers, increasingly rely on finite element analysis to ensure a rugged and reliable product. One area of particular interest is the simulation of dropping an object onto an essentially unyielding surface. Historically, only specialists in dynamics and nonlinear response performed this analysis. This is no longer the case.

Using ANSYS as a platform for vertical add-ons, customers in all industries create products designed for their specialized area of work. ANSYS distributor SSC, of Huntington Beach, California, recently used ANSYS' customizable graphical user interface and programmer tools to create a custom preprocessor for drop shock problems. This product greatly reduces the set-up time for companies assessing the ability of their products to survive an impact when dropped, as shown in Figures 1A and 1B (page 4).

SSC took advantage of the open architecture of ANSYS to create a seamless interface between the ANSYS program's powerful and intuitive pre- and postprocessing capabilities and an external solver. This custom preprocessor allows design engineers to set up and launch a droptest simulation within minutes. SSC incorporated the ability to solve for the transient structural response of a falling object as it impacts a flat surface into the ANSYS 5.2 graphical user interface, as shown in Figure 2 (page 5).



Figures 1A and 1B

Plots of finite element models with two different orientations.
The models are reoriented conveniently through graphical picking of two nodes.

In effect, SSC added a new module called DROPTEST to the ANSYS program. The DROPTEST module is accessible from the main menu and allows the user to easily set up impact problems with intuitively designed ANSYS dialog boxes, and solve with the external solver. Calculated results are automatically translated to an ANSYS-compatible File.RST format, enabling postprocessing in either POST1 or POST26. The user never needs to leave the ANSYS environment to set up, run, and postprocess an impact problem. For more information regarding SSC's custom preprocessor, contact Bill Jones at ssc@kaiwan.com.

In the future, look for significant growth in the number and breadth of ESP program members.

Premium Partnering

Value-added technology partners who integrate or bundle their product with ANSYS are another essential component of ANSYS Avenues. Such partners offer leading-edge solutions that are complementary to the ANSYS program. ANSYS works cooperatively with these partners to integrate the technologies so that users can access an extensive range of solutions within a completely user-friendly software environment.

When engineers demand leading-edge, cost-efficient design and analysis software, ANSYS, Inc. responds. ANSYS joined forces with Livermore Software Technology Corp. to create ANSYS/LS-DYNA, an industry-leading tool for analyzing general, high-speed large-strain impact/contact problems, crash-worthiness simulation, failure analysis, and material forming processes including metal, glass, and plastic (Figure 3). This partnership integrates an explicit solver for dynamic analyses with ANSYS, the world's leading finite element software.

The ANSYS/LS-DYNA software program challenges the competition in product quality and price performance. The first release will provide users with the fastest result times for explicit dynamic analysis in the industry. The explicit features of LS-DYNA will merge with the ANSYS pre- and postprocessor, and are accessed via the ANSYS graphical user interface. The easy-to-use graphical user interface spans the entire ANSYS product line, offering users a consistent look and feel, regardless of the problem being solved.

LS-DYNA embodies the kind of quality value-added technology incorporated in ANSYS Avenues that guarantees users the cutting-edge technology needed to gain and keep a competitive edge. Through ANSYS Avenues, ANSYS, Inc. continues to adapt to existing engineering environments and make them more productive.

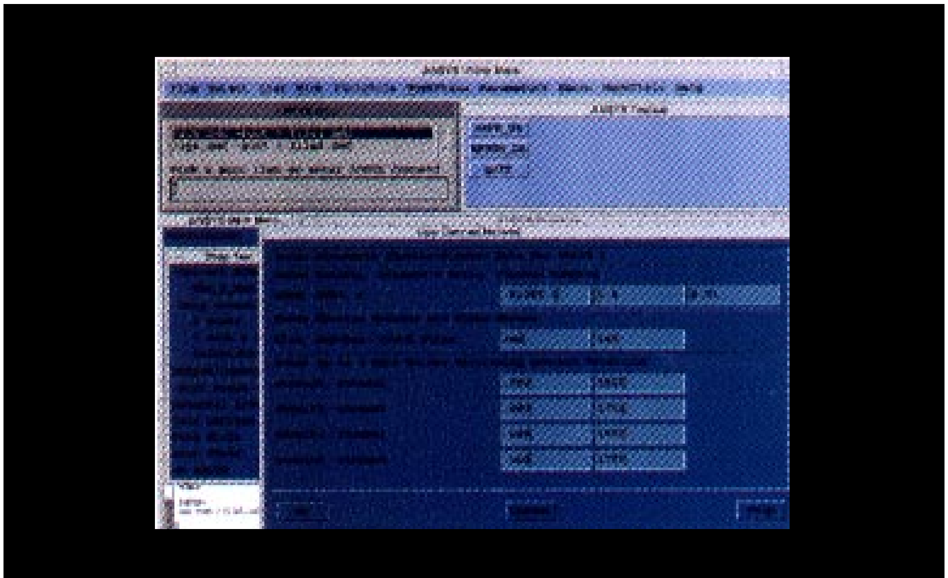


Figure 2

An example of material property definition demonstrating how to specify elastic plastic material property data using SSC's customized preprocessor.

by Bill Bulat, Technical Engineer
Silverado Software & Consulting, Inc.
Huntington Beach, CA

John Twerdok, Director
Corporate Alliances

Jennifer Valachovic
Marketing Services

Best in the Business

ESP program members and the value-added technology partners are just two of the ANSYS Avenues channels through which customers can work with ANSYS, Inc. For more information regarding these exciting new programs, contact John Twerdok at jtwerdok@ansys.com. ANSYS Avenues offers members a marketing assistance program, access to the ESP Directory, and promotion through *ANSYS News* articles, in addition to industry-leading technology.

ANSYS leadership enables the engineering of smart, flexible products. ANSYS delivers customizable, integrated software programs by leveraging state-of-the-art, world-class technologies. As the first ISO-9001 certified design analysis software company, ANSYS guarantees design and analysis solutions customers can rely on now and in the future. ■

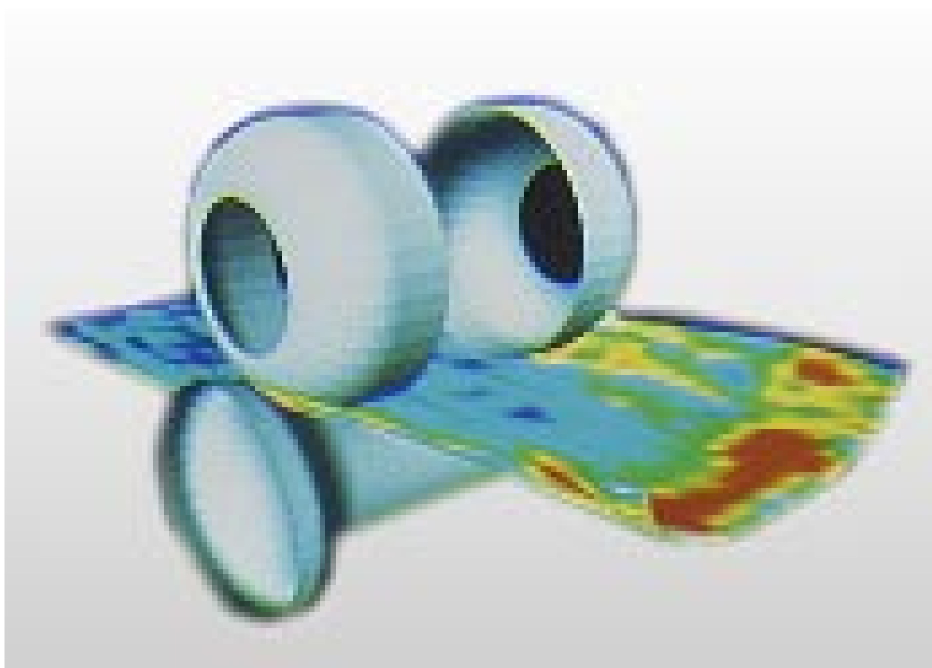


Figure 3

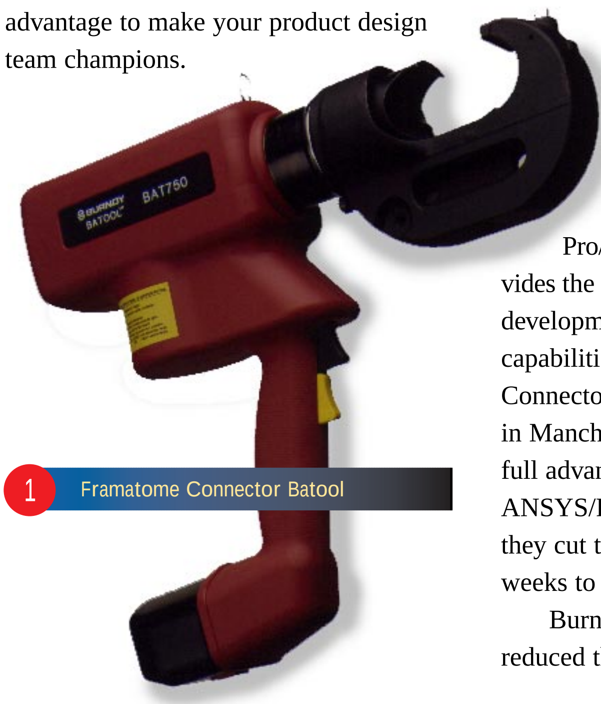
Metal Forming Process

Designer Series Update:

Capturing the Advantage

In the world of professional sports, teams compete all season to see if they have what it takes to become champions. Team owners focus on ways to increase their team's chances of capturing the first place title. If an advantage can be gained by signing a certain player, positioning players a certain way, or even by wearing lucky uniforms, you can guarantee that team will take advantage of that opportunity. The same can be said for companies staying competitive in the global marketplace.

Companies constantly strive to release their products first. If an opportunity exists guaranteeing an improved development process, and a faster time-to-market than the competition, companies will take full advantage. The ANSYS Designer Series™ provides that advantage to make your product design team champions.



1 Framatome Connector Batool

The Designer Series integrates industry-leading computer-aided design (CAD) packages with the unlimited analysis capabilities of the ANSYS program. This integration provides the same environment throughout the entire production process; no time is wasted on data transfer, design modifications are made in seconds, and the overall development cycle is shortened. Here are a few examples of the power packed in the ANSYS Designer Series line-up.

ANSYS/ProFEA: A Powerful Starter and Finisher

The powerful combination of Pro/ENGINEER and ANSYS provides the design capabilities to start your development process and the analysis capabilities to finish. Framatome Connectors USA Inc., Burndy Electrical, in Manchester, New Hampshire, took full advantage of the benefits of ANSYS/ProFEA. Using the program, they cut their development cycle from 28 weeks to just nine weeks.

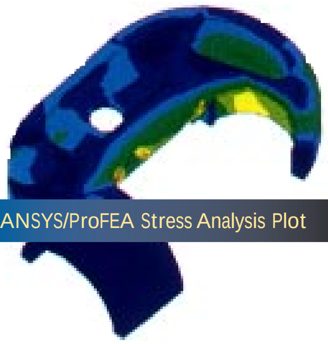
Burndy Electrical drastically reduced the weight of their Framatome Connector Batool™ (Figure 1) by 18 percent, using ANSYS/ProFEA. Weight plays a major role in this product, which is used on high-tension cables by line workers, often under harsh conditions, in awkward positions, and usually towing other equipment.

Burndy selected ANSYS/ProFEA (Figure 2) after years of having to delay their development process by alternating between design and analysis software packages. *"We didn't see any other package more tightly linked with Pro/ENGINEER,"* said John Franzini, Advanced Design Engineer Group Leader. *"ANSYS/ProFEA lets us go back and forth between design and analysis with just a few mouse clicks, and optimization is automatic."*

2 ANSYS/ProFEA Solid Model

Within the analysis process, over 82 stress analyses were performed (Figure 3) in 11 separate optimization runs. Burndy created a new design that provided more strength and reduced the weight by 4.2 pounds. *"Our development cycle took nine weeks from concept to prototype,"* said Franzini. *"The most important fact in the analysis was that the critical geometry modeled in Pro/ENGINEER was incorporated completely into ANSYS/ProFEA. None of our details were sacrificed, and there was no guesswork involved in the geometry."*

As a result of this analysis, Framatome Connectors is currently redesigning another product, and expects to add more to this list in the future.



3 ANSYS/ProFEA Stress Analysis Plot

"Framatome Connectors USA Inc., Burndy Electrical has always been an engineering products company, producing many industry innovations that have become standards," said Gene Pecora, Director of Engineering for Framatome Connectors. *"Framatome Connectors is committed to delivering the products required by our customers, competitively priced, and within the shortest possible time. This new ANSYS/ProFEA design analysis system offers the technical capability that provides our new product success in the marketplace."*

ANSYS/AutoFEA: Providing the Fastest Pitch from Conception to Product

Design engineers fight the battle every day. They design products on a CAD package, transfer the data to an analysis package, and then move to the machining process, all while staying within strict deadlines. The ultimate solution represents a tool that combines all of these processes into one familiar environment. ANSYS/AutoFEA provides the solution.

In a seminar created and presented by ANSYS and Autodesk, the ANSYS/AutoFEA program shocked all on-lookers by designing a part "live" from concept to reality in less than five hours. ANSYS analysis capabilities seamlessly integrate with the AutoCAD® design environment, and for this seminar, they work directly with an NC machining code to make this five-hour procedure possible.

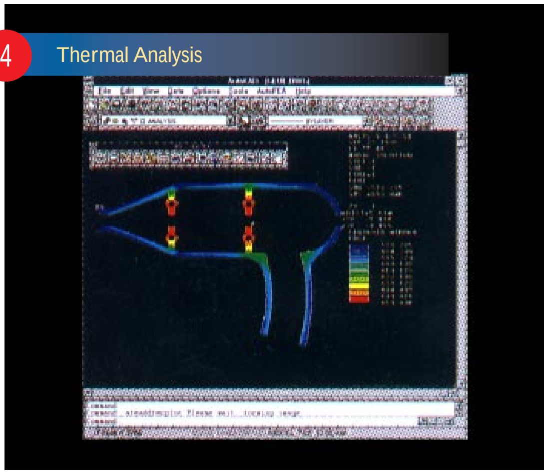
The product created in this procedure was a commercial glue gun housing. The purpose of the analysis was to design a product minimizing the material. A critical concern was heat generation on the inside of the product. The AutoCAD model created was the subject of thermal and stress analyses in ANSYS without leaving the AutoCAD environment. These analyses were conducted directly with the AutoCAD model, and changes that resulted were made in minutes, thanks to the smooth transition of the two programs. The thermal plot is shown in Figure 4 and stress analysis plots are shown in Figures 5 and 6.

Once the design and analysis process was complete, the data was transferred to an NC machining code and the product was manufactured right on the spot. *"This entire process displays the possibilities for design engineers to boost their productivity,"* said Sue Batt, Vice President, ANSYS Design Business Unit. *"The entire process was completed in only five hours."*

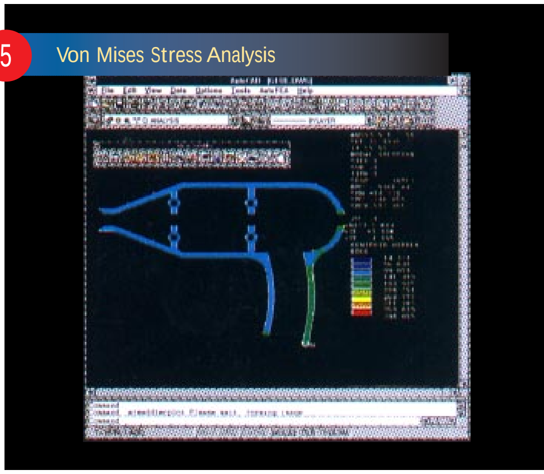
Conclusion

When choosing the design simulation tools to make your team number one, the ANSYS Designer Series remains unbeatable. The combined efforts of the ANSYS program with Pro/ENGINEER or AutoCAD can take your ideas from start to finish without the hassle of changing from code to code. ■

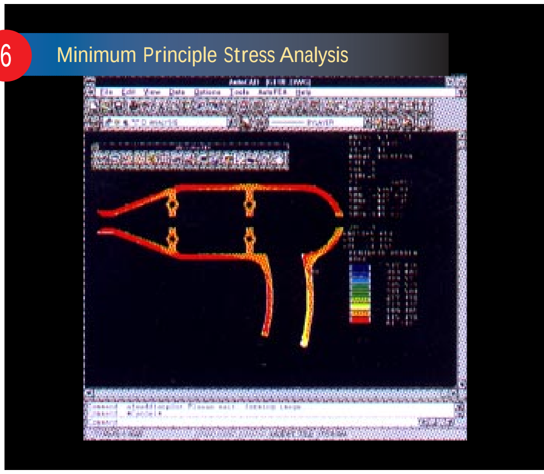
4 Thermal Analysis



5 Von Mises Stress Analysis



6 Minimum Principle Stress Analysis



by Daniel Parrish
Marketing Services

Any way you slice it, ANSYS can help put you a cut above the competition! Looking for a quick way to graphically query internal regions of your solution field? Are you tired of wading through the visual clutter associated with 3-D vector plots? The new Q-Slice feature at ANSYS 5.2 is the tool for you. A Q-Slice is a planar surface that slices through the computational domain. The scalar and vector values at the nodes of the cut elements are

"Graphics Advice? Try Q-Slice!"

interpolated onto the planar surface, and then graphically rendered in two dimensions. By repeatedly offsetting the slice position, the entire domain may be systematically scanned. Simply use the working plane to slice through your model at a section of interest. With the Q-Slice option invoked, requested scalar or vector quantities are displayed only on the slice cross-section. The model outline is also drawn for positional clarity. Figures 1A and 1B illustrate how to activate Q-Slice plotting. Current display capabilities include vector, normal, and topographic contour plots. Figures 2 and 3 illustrate Q-Slice's usefulness when postprocessing FLOTRAN® CFD results. ■

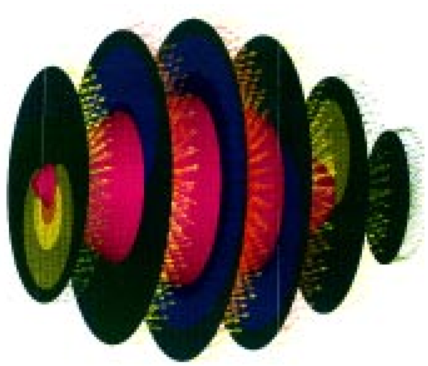
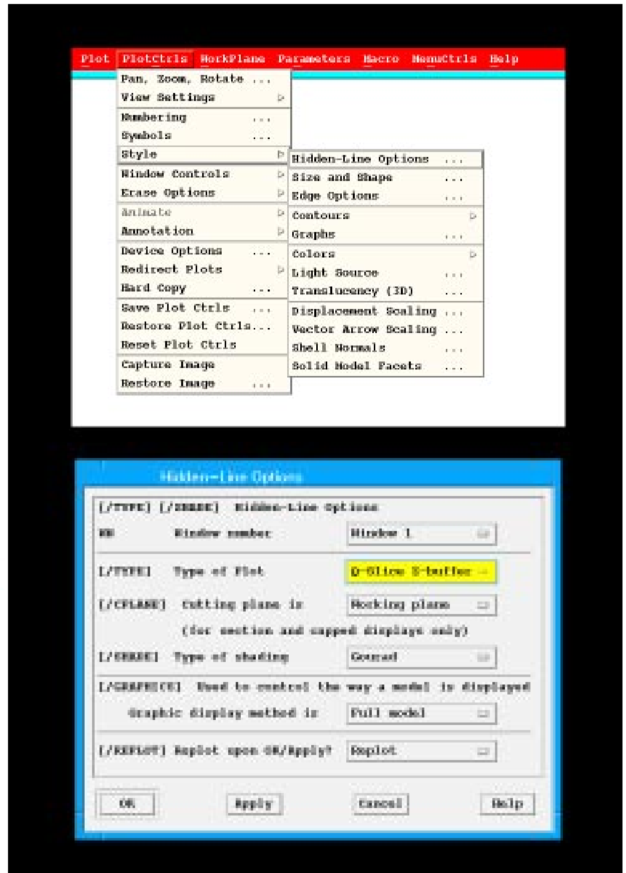


Figure 3

Flow around a thrown football: 60 MPH, 10 Revs/Sec, 15 degree angle of attack. Slices indicate air velocity vectors and pressure contours.



Figures 1A and 1B

Graphical user interface location for Q-Slice feature.

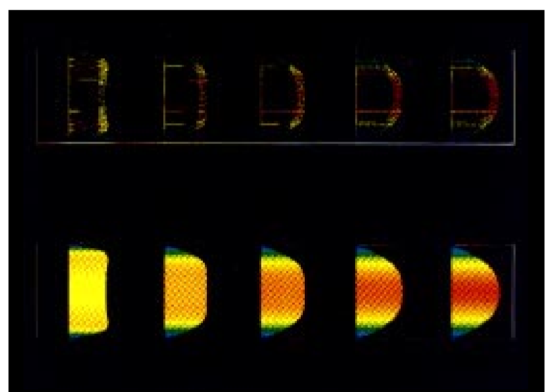


Figure 2

Velocity vectors and topographical contours of axial velocity developing flow in a 2-D planar channel.

by Mark A. Troscinski, Development Engineer
Development Department

Paul F. Tallon, Development Engineer
Graphics Development Department

Keeping Focus:

ANSYS Analysis of a Space Qualified Telescope

One of the most critical factors in the design of a telescope is the image degradation resulting from its structural response to external loads. Optical surface deflections as small as a wavelength of light (~ 2e-5 inch) can be devastating to the telescope's optical performance.

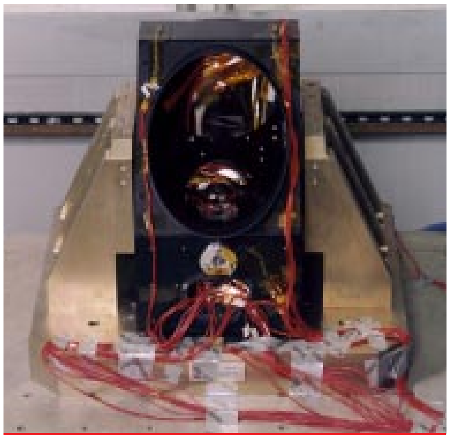


Figure 1

The Aerojet Corporation's space qualified AVT telescope.

The ANSYS analysis presented here is for the Aerojet Corporation's space qualified AVT telescope. The ultimate goal was to develop a method of consistently creating accurate optical/mechanical models for design optimization purposes. The model's validity was evaluated by analytically simulating interferometric optical tests conducted on the actual telescope, while a series of steady-state thermal loads were applied. Theoretically, a uniform temperature soak will not degrade the image quality of this monometallic reflective telescope as long as its thermal and structural material properties remain linear-isotropic.

The measured temperature distribution at various thermocouple points were used as boundary conditions for a nonlinear steady-state finite element model (FEM) thermal analysis using ANSYS. Electronic leads to these thermocouples can be seen in Figure 1, where the actual telescope is displayed in its test environment. The calculated temperature distribution was then applied to the corresponding structural FEM, and the displacements evaluated. The optical surface displacements were then interpolated into a rectangular array of data points suitable for input into the optical analysis program ASAP, and the change in image quality evaluated.

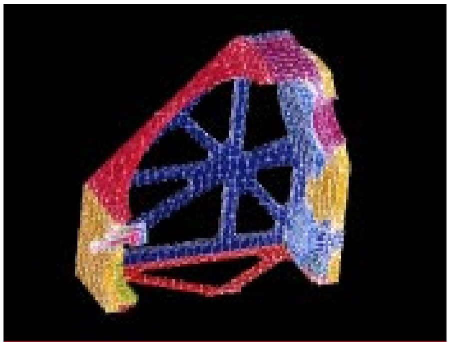


Figure 2

ANSYS solid model of the telescope.

Finite Element Model

Figures 2 and 3 show the ANSYS FEM used in this analysis. This 56,000 node FEM was created in less than 45 minutes from a Pro/ENGINEER assembly model using Pro/MESH™. This meshing required the proper balance of mesh sizes between those of contacting and noncontacting regions in mating parts. The time spent in achieving this successful mesh was far less than that required using any other available technique.

This three-dimensional (3-D) FEM was originally composed of the 10 node SOLID92 tetrahedron elements. However, using this element type, the model's 56,000 nodes strained the solution time and memory requirements. To avoid this problem, the midsize nodes were eliminated and the element type changed to SOLID72 tetrahedrons with nodal rotation DOF in order to reduce the number of equations. Test runs of similar problems with analytical

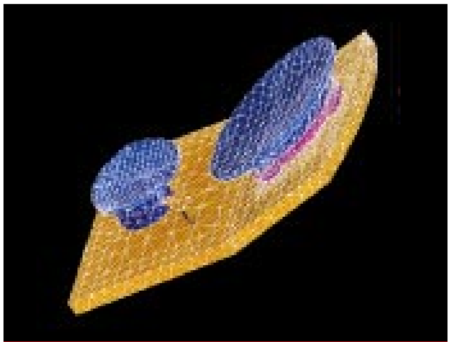


Figure 3

ANSYS solid model of the optical surfaces.

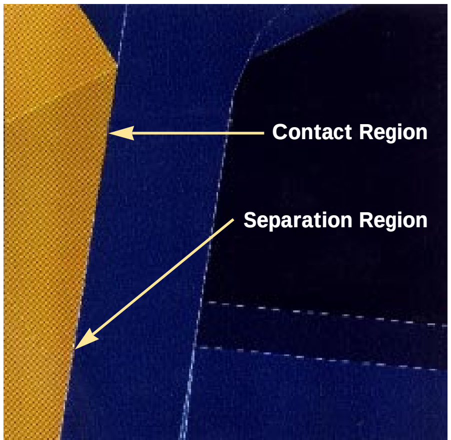


Figure 4

Close-up on model showing elements not in contact.

solutions proved that this element's performance was quite satisfactory.

FEM Component Interfaces

The raised datum surfaces in various components were not directly modeled, in an effort to simplify meshing. Instead, local structural and thermal contact were enforced using Pro/MESH "Regions". Contact between these regions and their adjacent mating surfaces was defined within Pro/MESH. The resulting FEM's adjacent elements on opposite sides of these contact interfaces share common nodes. Adjacent elements outside these regions do not share nodes and are, therefore, not in contact, as illustrated in Figure 4. Other contacting surfaces without such raised regions had this FEM "contact" enforced in regions near their bolt holes. This process makes for a more realistic model since contact along the entire common area of every possible interface would have made the FEM overly stiff.

Table 1

Thermal Load Cases

Load Case	Description
1	X Gradient, Mean Temp.~20°C
2	Y Gradient, Mean Temp.~20°C
3	Z Gradient, Mean Temp.~20°C
4	-15°C Temperature Soak
5	-50°C, 6°C X-gradient, 4°C Y-gradient
6	-57°C, 6°C X-gradient, 2°C Z-gradient
7	-94° C Temperature Soak

Thermal Load Cases

Seven thermal load cases were applied to this system. They are the result of temperature measurements made at various points on the structure during thermal cycling tests. A description of these load cases is shown in Table 1.

Nonlinear Material Properties

Since both the conductivity and thermal coefficient of expansion (TCE) of the telescope's SXA metal matrix were a function of temperature, both a nonlinear thermal and structural analysis were made. Fortunately, the structural nonlinearities were very smooth and the problem converged very quickly.

Some input data extrapolation was necessary, however, since the thermal coefficient of expansion data did not extend across the entire range of test temperatures. The graph in Figure 5 shows the second order fit that was applied to this. Higher order fits produced erroneous results in the extrapolated region.

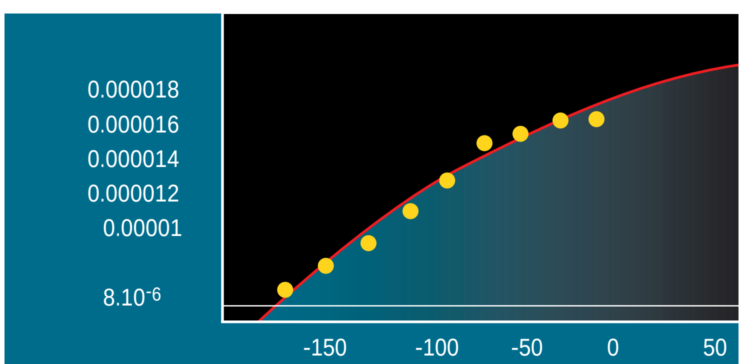


Figure 5

SXA metal matrix thermal coefficient of expansion.

Image Degradation Analysis

The optical analysis software ASAP was used to evaluate the Optical Path Difference (OPD) errors produced by the AVT telescope's optical surface deformations. This is the quantity measured directly in the interferometric optical tests being analytically duplicated. The actual image quality is related to the OPD through a Fourier Transform relationship. A two-dimensional (2-D) plot of the OPD errors produced by a single, relatively flat mirror should be exactly the same as an ANSYS FEM surface normal deflection plot scaled up by a factor of two. An example model was created to illustrate this effect.

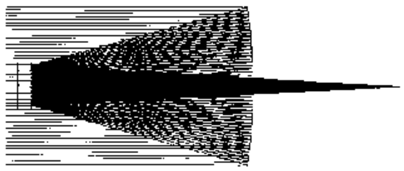


Figure 6
Raytrace through the Cassegrain telescope with the deformed primary mirror.

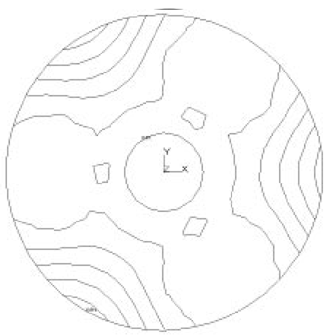


Figure 7
Primary mirror finite element model surface normal deflections.

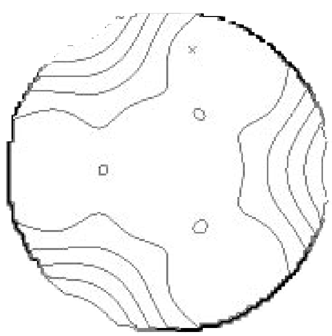


Figure 8
OPD/2 errors in the Cassegrain telescope, as determined through raytracing.

Example Analysis

The two-mirror optical model, illustrated in Figure 6 is an axisymmetric Cassegrain design that is very common in astronomical telescopes. The primary mirror is the largest mirror in this figure and is the only one being deformed in this example. Figure 7 shows the primary mirror surface normal deflections produced in ANSYS by surface normal gravity loads and nine arbitrarily positioned back support point constraints. The OPD is calculated by first interpolating these deflections, within ANSYS, into a rectangular array of data that is suitable for input into ASAP. For data points within the optical surface's clear aperture, this process is tremendously simplified with the ANSYS submodeling routine "CBDOF." Extrapolation of this data to points outside the clear aperture is performed with a custom ANSYS macro. This array of data is then superimposed upon the nominal primary mirror surface, within ASAP, using a simulated spline and a raytrace through the entire system. Figure 8 shows the OPD that results from this raytrace after it was divided by the factor two mentioned in the previous section. The resulting contour map is virtually identical to that of the ANSYS displacement contour map, as it should be. This intricate level of detail seen in the OPD plot would have been lost if the standard practice of representing these deformations with a truncated set of polynomials was used. Figures 9, 10, and 11 show an isometric view of this OPD error, an ideal image diffraction intensity profile, and the real intensity profile resulting from the primary mirror deformation.

OPD Analysis

Figures 12 and 13 (page 12) illustrate a raytrace and resulting OPD map through the nominal (undeformed) AVT telescope. The experimental and analytical root-mean-square (RMS) OPD errors produced by the seven thermal load cases is tabulated in Table 2 (page 12). The lack of strong correlation between the two sets of data can be partially attributed to the

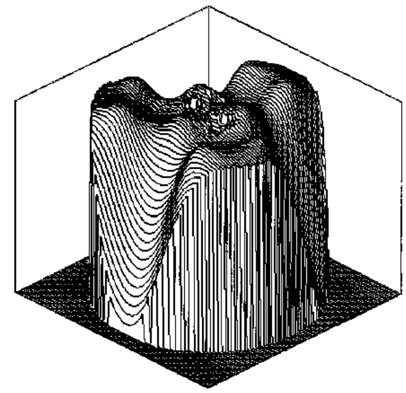


Figure 9
An isometric view of the Cassegrain telescope's OPD errors.

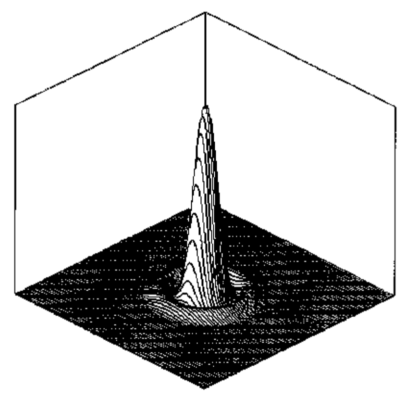


Figure 10
The intensity distribution of the on-axis image in the NOMINAL Cassegrain system.

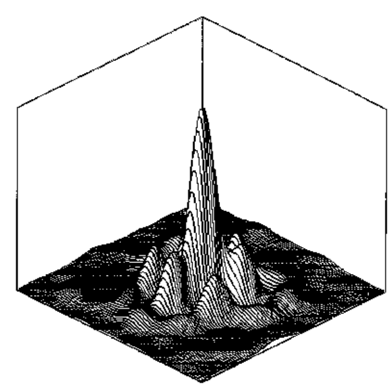


Figure 11
The intensity distribution of the on-axis image in the DEFORMED primary mirror Cassegrain system.

Table 2		
Thermally Induced RMS OPD Errors		
Thermal Load Case	Analytical RMS OPD Error	Experimental RMS OPD Error
Nominal — Initial	100%	688%
1	224%	N.A.
2	153%	N.A.
3	126%	N.A.
4	104%	622%
5	2,053%	778% — 1,467%
6	2,199%	1,133% — 1,146%
7	2,733%	1,333% — 1,644%

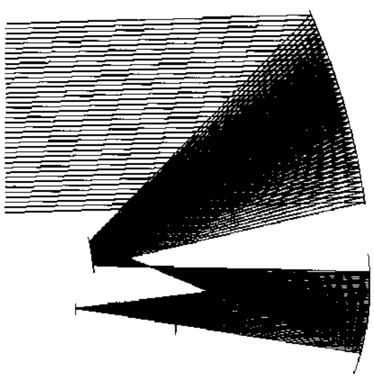


Figure 12
Raytrace through AVT telescope.

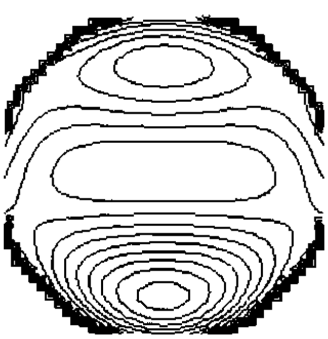


Figure 13
OPD errors in nominal AVT telescope.

relatively large initial OPD in the experimental system and the large variance between dual measurements at particular temperatures. The functional form of the OPD errors was also not available. It is therefore possible that some of the thermal deflections could have actually reduced and even reversed the sign of the experimental system's OPD errors. The evaluation of such action is not possible in the analytical solution without assuming the OPD's functional form. Due to the large deflections in directions orthogonal to both systems' optical axes, a re-evaluation was made of the methods used to calculate the OPD errors, the results of which are presented on the next page.

Methodology Re-evaluation

The analysis outlined in the previous section and in the example uses a method that is a standard in the opto-mechanics industry. An optical surface's component of displacement in the direction of its optical axis (in this case the global Z axis) is always used to evaluate its shape change for OPD error calculations. This works quite well in problems such as the example analysis section of this article, since the primary mirror's deflections are predominantly in the Z direction. In a thermal soak analysis, however, this method will have the effect of reducing a concave mirror's radius-of-curvature (RC) when it undergoes a uniform temperature increase, when in fact, it will increase since the mirror simply scales up with temperature. Likewise, a uniform temperature change in a monometallic optical system, such as the AVT, will not change its OPD error as long as the material properties remain linear-isotropic and the internal temperature distribution change is uniform. This effect may become quite significant in the analysis of an off-axis system, such as the AVT telescope, due to the incoming rays' large angles of incidence and the resulting high misalignment sensitivities of the individual optical components.

The solution to this problem uses the FEM's full three-dimensional nodal displacement vector, as illustrated in Figure 14. Since an optical surface's local tangential displacements have no effect upon the propagation or OPD of individual rays, the surface normal component is calculated. In practice, this is easily obtained within ANSYS by switching to a spherical coordinate system (RSYS) at the center-of-curvature of the optical surface of interest to obtain the radial component of displacement. The deviation of the optical surfaces from this spherical coordinate surface does not produce significant errors. A correction factor is then applied that converts this radial displacement to an equivalent axial (Z) displacement. When temperatures are increased, the RC will now effectively increase by producing a positive “W” displacement for the left-facing mirrors in this analysis.

Conclusion

Special care must be taken in evaluating the OPD error produced by thermal loads in a FEM of an off-axis optical system. The opto-mechanical model’s accuracy should be first verified with a uniform temperature soak and linear-isotropic materials before being used for analysis. The OPD errors must remain unchanged in such a test case for the results in other analyses to be accurate. Time did not allow for such a test here since the algorithm outlined in the previous section has not yet been implemented into the ANSYS macros written for this analysis.

The work presented here is the result of a contract with the University of Arizona’s Optical Sciences Center for the Aerojet Corporation. ■

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Tucson, AZ

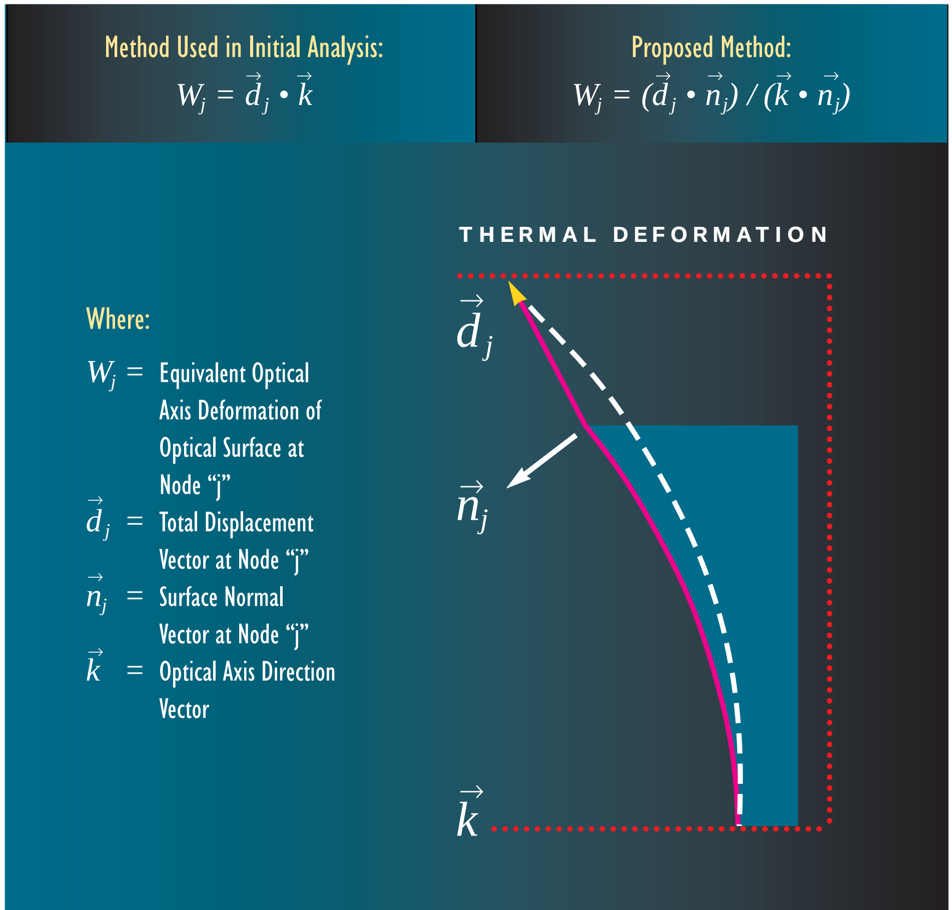

Figure 14
Optical surface thermal deformation analysis.

Windows® 95: What is it? What Does it Mean for ANSYS?

Two historical events now claim the same date, August 24. Some historians cite August 24, 79 AD as the day when the Italian city of Pompeii was buried by the violent eruption of Mount Vesuvius. Exactly 1,916 years later, the "eruption"of perhaps the most publicized software release in the history of mankind buries us again. With a reported roll-out advertising budget in excess of 100 million US dollars, Microsoft Corporation released the latest version of the Windows operating system, Windows 95. In light of all the publicity surrounding this event, we thought it appropriate to write about Windows 95 from the perspective of the ANSYS user.

Figure 1 The Windows 95 GUI

What Exactly is Windows 95?

Windows 95 is the newest version of the Windows family following Windows 3.x on the Intel-based desktop. When a computer user updates a personal computer (PC) to Windows 95, it essentially replaces the systems services provided by MS-DOS® and Windows 3.x. This new combined system operates most of the time in 32-bit mode and displays the latest user interface (UI) created by Microsoft® after three years of usability studies.

What Windows 95 is Not

There seems to be a lot of confusion about the internal architecture of the new operating system. Many articles in the media indicate that Windows 95 is a completely rewritten operating system. This statement is not entirely accurate. Although there are many portions of the system that were indeed rewritten to take advantage of the 32-bit architecture, many others were barely touched, primarily for reasons of compatibility with existing Windows 3.x applications and devices drivers needed to operate many PCs in service today.

This fact does not, in any way, tarnish Microsoft's accomplishment. Microsoft is trying to move its 16-bit user base from the 16-bit world to the 32-bit. Remember that 32-bit chips from Intel® (the 386) have existed since 1987, with almost no 32-bit software available to exploit this power in the mass market. Only applications such as ANSYS 4.4 (1989), with the help of technologies such as the Phar Lap DOS Extender, gave PC users an early taste of 32-bit software technology.

Microsoft has another 32-bit operating system, as most ANSYS users know. Windows NT™, released in 1993, is a full implementation of a 32-bit operating system for the Intel-based platform. It has an advanced file system, with full pre-emptive multi-tasking, and sophisticated security options. Windows NT also does an excellent job in insulating the different programs running in the system so that one errant application cannot shut down the entire system. All of these features make Windows NT a very robust and stable operating system, ideal for ANSYS work. The problem is that these same features make compatibility with existing Windows 3.x applications difficult. Microsoft realized, that because of the perception that NT was developed for "high end" computing, it would not be the operating system for the mass market at this time.

Windows 95, then, is a good compromise between adequate 32-bit architecture and compatibility with its vast installed user base (about 80 million).

Similarities Between Windows 95 and Windows NT

Windows 95 is mostly 32-bit

Having a system with a 32-bit architecture is important because it means, finally, that the software you buy will be taking advantage of technology that has been on our desktops since 1987; the year that Intel brought the 386 chip to market. We need operating systems and applications that are able to take full advantage of modern hardware.

Microsoft's primary goal for Windows 95 was to provide a modern 32-bit architecture without sacrificing compatibility with existing 16-bit Windows 3.x programs. As a result, Microsoft made compromises that left significant portions of the system's 16-bit architecture intact, guaranteeing this compatibility.

For Windows NT, the goals were completely different. The primary goal was to have a solid 32-bit architecture with whatever level of compatibility that could be achieved under these constraints.

Multi-Tasking

Windows 95 and NT share the ability to operate more than one program at a time. Windows 3.x also tried to do this, but was not completely successful. When using Windows 3.x, multi-tasking depended on the cooperative nature of the different operating applications. In other words, system throughput was not under the direct control of the operating system. Windows 95 improves this capability dramatically, as long as you operate 32-bit software. The improvements are not as obvious if you run the legacy Windows 3.x programs. Windows NT provides fully pre-emptive multi-tasking. In this instance, the operating system (and the user by assigning priorities) maintains control rather than the applications.

Basic Networking Tools Included

This is one area in which both NT and 95 shine equally well. Both systems come equipped with client versions of TCP/IP (essential component for connectivity with the UNIX® world), Netbios, and Netware (the best selling network OS from Novell®). Installation of any of these is very simple.

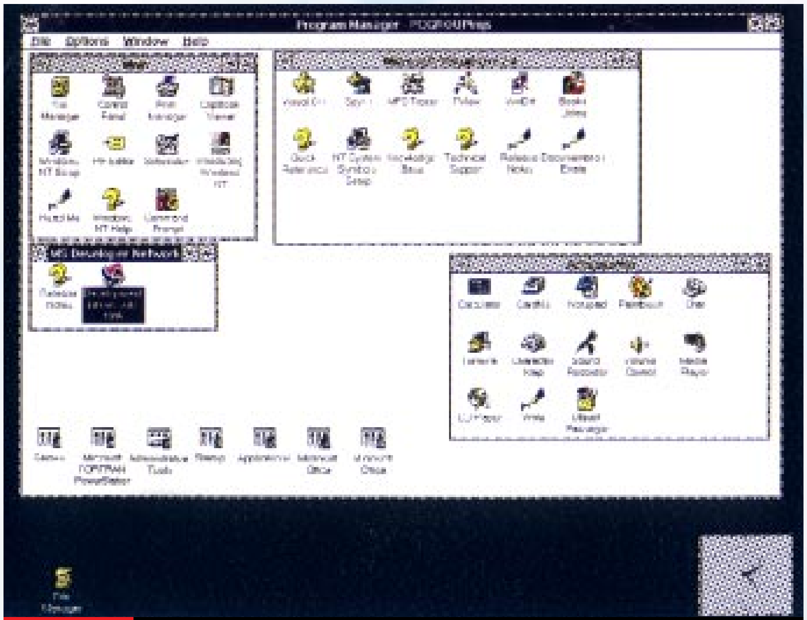

Figure 2 The Windows NT 3.5 GUI

Each Target a Different Segment of the Market

Windows 95 is not a replacement operating system for NT. As a matter of fact, the reverse may be true. Many companies will bypass Windows 95 altogether and use Windows NT for client/server applications across the enterprise. These companies, including ANSYS, Inc., see the advantages of 32-bit systems and may decide to take advantage of the best implementation of this architecture. During the last 18 months, the Information Technology (IT) department of ANSYS, Inc. has been busy transitioning most of the company's operations from minicomputers to Pentium™-based PCs running Windows NT.

Differences Between Windows 95 and Windows NT

Windows 95 Available Only on Intel-Based Platforms

As with its predecessors, Microsoft wrote Windows 95 to run only on Intel and Intel-compatible architecture. They wrote Windows NT so that it could be easily ported to other computer architectures. In addition to the flagship product on the Intel platform, NT is available on the Digital® Alpha® PC, the MIPS R4000, and the PowerPC™.

Windows 95 has a New User Interface Shell

After conducting a usability study, which reportedly took three years, Microsoft redesigned the shell that is used to operate the systems. When we turn the computer on, most of us think that the shell we see is the operating system. The new shell uses the folder paradigm, and has a new "task bar" that helps users keep track of all programs running at any particular time. It also includes a designated use for the right mouse button. The new shell is part of Windows 95 and will be available in a future upgrade to Windows NT. (Figures 1 and 2 compare graphical user interfaces [GUI].)

Windows NT Supports SMP (Symmetric Multi-Processing)

In plain English, this means that if you buy a PC with more than one Pentium and you operate Windows NT, the system will use the second Pentium as the load on the first one increases. Windows 95 does not have this feature. Therefore, the second Pentium is idle.

Windows NT has a More Advanced (and Secure) File System (NTFS)

Windows 95 supports long filenames. Microsoft accomplished this by making a few changes to the DOS FAT system, taking advantage of unused space on the directory tables to save the long name. VFAT is the name given to this special implementation of the FAT system. The VFAT system, developed independently of Windows 95, made its debut in Windows NT 3.5. One feature of this new system is that if an older DOS or Windows program is operating, the system supplies a shortened version of the file name whenever the application attempts to open files. If the application is a 32-bit application, such as ANSYS 5.1 on NT, the system supplies the long name to the application.

NTFS, the new file system introduced in Windows NT 3.1, not only supports long filenames, but also better security within the desktop (protecting files between different users of one PC) or across the network.

Windows NT has More Security Features

NT comes with additional security features found in the new file system, as well as many other security features for the rest of the system and the network itself. This may be an important factor for people working for government organizations.

Windows 95 will ask you for a password if it is connected to a network, but its local disk is essentially wide open by default, just as Windows 3.x allowed. There are a few options available that add some degree of protection, but these are not as robust as the ones available on NT, which was designed with C2 level security (a U.S. Department of Defense security standard) as a design goal.

Windows 95 Minimum RAM (Memory) Requirement is 8 Mb

Minimizing memory requirements was another major design goal that Microsoft pursued during the design of Windows 95. Originally, they attempted to design the system for a minimum of 4 Mb. The practical minimum is 8 Mb, whereas Windows NT 3.5 requires 12 Mb.

How does this Affect ANSYS 5.2?

Now that you have all this information on Windows 95, you probably would like to know if it affects how or where you use ANSYS products.

ANSYS 5.1 and 5.2 are not currently capable of operating under Windows 95, due to Microsoft compiler technology limitations used in the creation of these products. ANSYS, Inc. will be receiving updated versions of these compilers from Microsoft that will allow us to create a new ANSYS 5.2 for Windows NT and Windows 95. Please stay in touch with your ANSYS Support Distributor (ASD), because they will have the latest information regarding when we will be able to make this update to ANSYS 5.2.

In terms of performance, we expect that operating ANSYS 5.2 under NT will outperform a similarly configured PC running Windows 95. The memory requirements should remain the same. ANSYS derived these based on what ANSYS needs rather than the operating system. File compatibility, an ANSYS hallmark, will be there between the two Windows systems, as well as with our UNIX offerings.

Which one should you use? That will depend on who you are and what kind of work you do. We recommend that users who use ANSYS regularly (at least three times a week), with medium to large models, should use NT. Windows NT is a more complete operating system, lacking only the new shell. As stated above, Microsoft will be incorporating this new shell on NT soon. If you are a casual ANSYS user (using it once a month or less), a student, or a home user, then Windows 95 will make more sense for you. Whatever your preference, ANSYS, Inc. is proud to offer you the choice.

Where Can I Find More Information?

The ANSYS Web server on the Internet contains a pointer to the Microsoft Web site that points to a Microsoft white paper. The white paper discusses the differences and similarities between Windows NT and Windows 95, with Microsoft's own recommendations as to which operating system is best for you.

Visit the ANSYS Web server for more information (http://www.ansys.com). If you would like to comment on the article or have any questions, my e-mail address is jmanich@ansys.com. ■

by Joe Manich, Technical Leader
Windows 95 Team

Partners in Multiphysics Design:

ANSYS/Emag and FLOTRAN

ANSYS, the king of design simulation, just added another crown jewel! Imagine trying to physically study white-hot molten steel as it flows in toroidal-shaped eddy patterns within an electromagnetic induction furnace. In this application, magnetic Lorentz forces provide the sole driving potential for turbulent fluid motion in the molten steel. Operating temperatures in excess of 2500°F make verifying real furnace design concepts impractical and expensive. However, with the ANSYS-exclusive nodal body force coupling between electromagnetics and CFD at ANSYS 5.2, coupled-field simulation of these systems is now possible.

Inductotherm, a leading manufacturer of induction melting systems, recently requested ANSYS, Inc. to demonstrate this coupled-field capability by simulating an Inductotherm Furnace. The subject furnace operates at a 3000 kW power level, 65 Hz frequency, and holds over 27 tons of molten steel. A cutaway sketch of a typical furnace is shown in Figure 1.

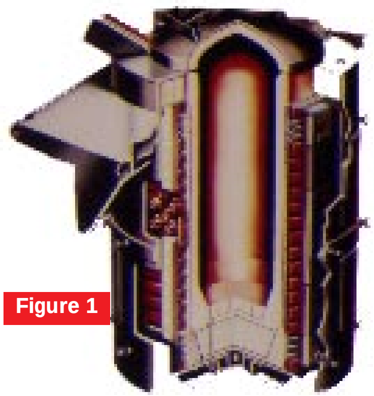

Figure 1

A 2-D axisymmetric, time-harmonic ANSYS/Emag model was used to represent the electromagnetic characteristics of the furnace. The model utilized PLANE13 coupled-field solid elements to perform the electromagnetic field simulation. INFIN110 infinite boundary elements were also used to treat the far-field effects surrounding the furnace. For this demonstration, the furnace was assumed to be at operating temperature, with the steel being molten throughout. An AC current applied to the field coils produces an electromagnetic field within the furnace. The harmonic solution results are expressed in terms of the complex potential (real and imaginary or amplitude and phase angle) calculated at each node, from which field values, eddy currents, and forces are calculated.

Induction heating is initiated by subjecting the steel to an alternating magnetic flux. The field induced in the steel produces eddy currents, with associated Joule heating effects. When the steel melts, the eddy currents, in combination with the magnetic field, produce Lorentz forces of sufficient strength to stir the liquid metal. Element values of Lorentz force are computed from the vector cross product of the eddy current density and the magnetic flux density values within each element. The element forces are then distributed to the nodes in the form of nodal body forces per unit volume.

The FLOTRAN model of the melt region consists of axisymmetric FLUID141 elements. The k-e turbulence model was used to include the time-averaged effects of turbulent exchange within the melt. The nodal body force loads were used in the momentum source terms of the Navier-Stokes equations to drive the flow. The combined ANSYS/Emag/ FLOTRAN results are illustrated in Figure 2.

Upon reviewing the ANSYS/Emag/ FLOTRAN results, Inductotherm commented, *"The flow patterns and velocity magnitudes are in close agreement with our observations. We are quite encouraged with these results, and ultimately wish to include thermal effects in future investigations."* ■

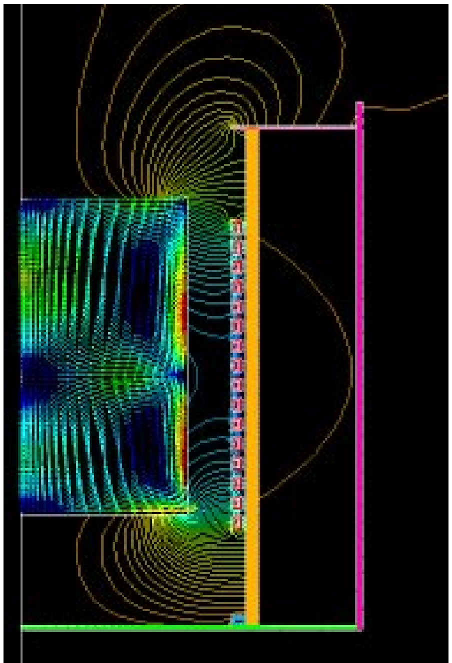

Figure 2

Emag flux lines and FLOTRAN velocity vectors indicating two toroidal flow eddies.

by Mark A. Troscinski, Development Engineer
Development Department

Mike Yaksh, Senior Technical Consultant

A Closer Look:

IMAG Industries, Inc. – China Office

IMAG Industries Inc. was originally founded in 1981 in Santa Clara, California, and today they have offices in Hong Kong, Australia, and China. This article presents an overview of IMAG in China, including a variety of services provided to complement ANSYS products.

As the ANSYS Support Distributor (ASD) for China, IMAG has three representative offices, with a staff of more than 60 professionals. The Beijing office, which opened in 1984, is responsible for customers in central and northern China. The Shanghai office, which opened in 1991, provides support and services for customers in eastern China. The Chengdu office, which opened in 1993, is responsible for southwest Chinese customers.

IMAG has also established two China-registered local operating companies: IMAG Technologies, Co., in Beijing, and IMAG Technologies Shenzhen, Ltd., in Shenzhen.

In July 1994, IMAG became the only ASD in China, and, over the past two years, ANSYS sales have grown tremendously. To improve local support of ANSYS products and provide more effective training and consulting services, IMAG recently added two ANSYS consulting and application engineers.

IMAG guarantees support of all products sold. ANSYS is one of the main products IMAG carries, but other products such as ADAMS® and EMS are available. ANSYS customers are provided with superior hot-line telephone support. Staff members include five ANSYS consulting and application engineers. All engineers have Masters or Doctorate Degrees in the areas of computational mechanics, solid mechanics, and fluid mechanics, to name a few disciplines that complement the ANSYS engineering environment.

Most of the ANSYS customers in China are industrial companies, universities, and research institutes.

Most of the ANSYS customers in China are industrial companies, universities, and research institutes. IMAG has very good partnerships with many universities, including Southwest Jiaotong University, Beijing University, and Qinghua University. There are many successful ANSYS users in China. Dongfang Power Station Group replaced traditional design/prototype/ test/analysis with computer-aided engineering (CAE) using ANSYS, and achieved a design cycle reduction from 24 months to three months. Stories like that will be highlighted at the first ANSYS Chinese Users Conference, hosted by IMAG in November 1995.

Zhang Guo-ming, the ANSYS Product Manager of IMAG, is responsible for the Chinese ANSYS business team, and offers most of the ANSYS training courses. Each business team member has a special area to address in the training classes. Zhao Fang-yuan, Chengdu office, focuses on substructures, solid modeling, and magnetics. Chen Hong-jun, Beijing office, addresses the areas of fatigue, heat transfer, and nonlinearities. Cao Zhong-qing, Chengdu office, oversees optimization and coupled field. Wang Hao, Shanghai office, focuses on fluid flow and dynamics.

The training schedule includes basic and advanced programs. Basic field training is also provided in China, and advanced training at IMAG headquarters in the United States. The focus of basic training is software operation, finite element theory, and applications for engineers. Advanced courses cover topics such as dynamics, nonlinearities, fatigue analysis, fracture mechanics, optimization, submodeling and substructures, heat transfer, magnetics, fluid flow, and coupled field. IMAG also offers specialized training courses according to customers' needs. ■

by Zhang Guo-ming, ANSYS Product Manager
IMAG Industries, Inc.
Beijing, China

A Closer Look:

JLR Computer Analysis, Inc.

Located within two miles of the Boeing Everett plant, where the world's largest airplanes are designed and built, JLR Computer Analysis, Inc. has provided technical solutions to customers for over 14 years. Lu and Jim Radochia founded the company in 1981 to provide the ANSYS program and other analysis consulting services. Two years later, JLR became an ANSYS Support Representative. When the ANSYS Support Distributor (ASD) program was created, ANSYS appointed JLR as the exclusive ASD for the Pacific Northwest. Today, they continue to offer consulting services, software/hardware sales, support, and training.

JLR Management Team
From Left to Right: Lu Radochia, Jim McKinney, Jim Radochia, Claudia Krakora, Mark Fondrk, Doug Scott, Brian Burkhart

JLR's experienced consulting team, led by Dr. Mark Fondrk, has analysis and simulation experience in a wide range of industries such as transportation, electronics, medical, consumer products, nuclear, and machinery. The engineers on staff average 14 years of ANSYS usage each. Typical projects are as diverse as analyses of large truck castings, composite towers, nuclear fuel rods, medical equipment components, electronic circuit boards and chips, large mechanical machines, and failure for forensics. The JLR consulting staff is experienced in the full range of ANSYS and FLOTRAN computational fluid dynamics (CFD) capabilities, including nonlinear, dynamics, heat transfer, fracture mechanics, and parametric modeling. Many projects begin with a computer-aided design (CAD) model from customers.

Companies as large as Boeing and Allied Signal, and as small as one-person consulting shops, license ANSYS from JLR. The customer support staff, led by Brian Burkhart, provides advice on how to use the program. Brian is well known to customers for being meticulous and complete in, not only answering their questions, but also in offering advice to help them complete their work more efficiently. The staff has gone well beyond standard customer support by doing things such as giving out home phone numbers to support customers working weekends on critical projects.

To complement technical support services, JLR regularly gives ANSYS classes at their training facility. When a customer needs either an introductory or advanced course at times other than those regularly scheduled, they will schedule classes with minimal notice. Classes are given by Jim Radochia, Mark Fondrk, Brian Burkhart, and Doug Scott. The larger classroom holds up to 12 people, the smaller up to six.

Claudia Krakora provides licensing support. She organizes and maintains the in-house computer network. Her background helps her fully understand the technical aspects of the licensing process so that customer orders and changes are completed quickly and efficiently.

In addition to offering ANSYS products and services, JLR also carries complementary software and computer hardware. ADAMS (Mechanical Dynamics, Inc.) (MDI) performs mechanical system simulation and is often used to determine the system loads that are applied to individual components by ANSYS. They offer ANSYS or ADAMS with SGI®, HP®, IBM®, and Digital engineering workstations.

Recently, the JLR Homepage became available on the World Wide Web (http://www.halcyon.com/jlr). Along with e-mail, they use electronic technologies to communicate more frequently and efficiently with customers. They hope to have them regularly contribute to the JLR Homepage.

Many ANSYS customers view JLR as an extension of their own in-house staff, handling their tough problems and ones that need immediate attention. JLR is their "Partner in Technology". ■

by Jim Radochia, President
JLR Computer Analysis, Inc.
Everett, WA

Engineering Methods, Inc.:

A Day at the Races

Engineering Methods, Inc. (EMI), one of the midwestern ANSYS Support Distributors (ASD), hosted their first Carburetion Training Day at the world-renowned Indianapolis Motor Speedway. The roar of the race cars was an enticement for ANSYS customers, and combined with a full day of ANSYS seminars and training, it was a checkered flag event.

Peter Smith, President and CEO; Len Zera, Vice President North American Sales; and Dennis Bosak, Midwest Regional Sales Director, spent the morning with ANSYS customers at a "Productivity Quotient®" seminar presented by the EMI staff. Attendees completed a survey that measured their organization's effectiveness against best industry practices.

In the afternoon, attendees chose between a number of technical break-out sessions including:

- Mastering Structural Nonlinearities
- Mastering Design Optimization
- Mastering Computational Fluid Dynamics

Carburetion Training Day closed with a presentation by Mike Gutilla, Director of Vehicle Products/MDI Motorsports, on the use of ADAMS software by the Newman Haas and Ford racing teams.

Attendees of the first annual Engineering Methods, Inc. Carburetion Training Day listen as Motor Speedway personnel give information regarding the historic garage area in Gasoline Alley.

Engineering Methods, Inc. Presents the "EMI Awards"

Since 1979, Engineering Methods, Inc. has focused considerable attention on their customer base. EMI created the "EMI Awards" (pronounced "emmy") in 1994 to honor engineers who use ANSYS to produce gains for their companies. *"Making our customers feel well taken care of and appreciated has been part of the reason for EMI's success,"* said President, Jean Hunckler. *"The 'EMI Awards' are just another way for us to recognize their achievements."*

Each spring, EMI solicits nominations from their customer base, which includes more than 200 users from a seven state area. Criteria for the awards consist of the ANSYS user who has increased interest and demand for finite element analysis (FEA), growth in complexity from one year to the next, and benefits to the user's company.

After judging the entries, EMI presents the "EMI awards" at the yearly user's conference. EMI President, Jean Hunckler, and ANSYS, Inc. Chief Technologist and Founder, John Swanson, presented impressive trophies to this year's winners: Shoufeng Hu, Wright Laboratory, Wright-Patterson AFB, Ohio, "Rising Star Award"; and Mike Hunnell of the Whirlpool Corporation, St. Joseph, Michigan, "Super Star Award".

Shoufeng Hu, an ANSYS user of more than two years, uses the software to evaluate and develop ceramic and metal matrix composites for high-strength and high-temperature applications.

Mike Hunnell, a twelve-year user of ANSYS, has directly increased the use of ANSYS and ANSYS/ProFEA at Whirlpool Corporation, a worldwide Fortune 100 company. Mr. Hunnell has expanded the areas of structural, dynamic, and computational fluid dynamics analysis to the point that use of finite element analysis has tripled in the past two years.

EMI is already receiving nominations from customers for the 1996 awards for next summer's 7th Annual User's Conference. ■

by Luanna Heiliger, Customer Relations Manager
Engineering Methods, Inc.
West Lafayette, IN

The following information represents a partial listing of ANSYS and FLOTRAN seminars and the dates the seminars will be presented. For complete details on the seminars listed below, contact the ANSYS Support Distributor (ASD) shown for that particular seminar. Contact your ASD if you are interested in a seminar not listed here. For seminars held at ANSYS, Inc., contact Training Registrar at (412) 873-2882. Reservations are recommended at least two weeks in advance.

DATE (Week of)	Introduction to ANSYS	Design Optimization	Dynamics	ANSYS /ProFEA	Heat Transfer	FLOTRAN	Substructures	Solid Modeling	Structural Nonlinearities	Special Topics (See footnotes)
Jan. 1-7										
Jan. 8-14	EMI FIG DRD ECI JLR STR ANS	STR		DRD				EMI		ING[2] ING[6] CAD[17] IMAG[4] INAS[26]
Jan. 15-21	CEC OCAE SSC MCR TADC INAS	IMAG	ITAL	ITAL	OCAE SSC			ECI	HGE	ANS[4] ANS[8] ANS[7] CAD[14] ITAL[27] ITAL[1]
Jan. 22-28	ITAL JAR AET	ANS	SSC TADC IMAG		ANS ING AET	ITAL	IMAG	IMAG	SSC CEC EMI	ANS[2] CAD[15] CAD[25] ECI[10]
Jan. 29-Feb. 4	MTI SSC			MTI	SSC	FIG				CAD[16]
Feb. 5-11	DRD EMI ECI STR ING CAEA ANS				CAEA IMAG			DRD EMI	ITAL	ANS[3] CAD[11] CAD[14] IMAG[25]
Feb. 12-18	STR TADC	FIG		CAD ITAL	STR INAS	ING			ECI ANS	ANS[2] ITAL[27] AET[4] ITAL[1] ITAL[26]
Feb. 19-25			ANS	DRD JAR	INAS	ECI ITAL				DRD[5] ANS[9] CAD[13]
Feb. 26-Mar. 3	SSC ITAL	EMI	CEC	ECI	SSC				FIG	CAD[23] CAD[14]
Mar. 4-10	SSC EMI ECI DRD MTI OCAE ANS	ING		MTI	SSC	IMAG		EMI	DRD IMAG	ING[1] CAD[24] OCAE[3]
Mar. 11-17	CEC JLR IMAG TADC AET			EMI ITAL	CEC ECI ITAL	AET ANS				ANS[10] CAD[20] CAD[22] CAD[21] ITAL[27] IMAG[12] ITAL[1]
Mar. 18-24	JAR STR MCR HGE			DRD	FIG ANS	ITAL	STR ITAL	ING		DRD[5] ANS[2] ANS[3] ECI[10] CAD[11] CAD[14]
Mar. 25-31	ITAL	MTI	STR						MTI TADC	CAD[18] CAD[19] IMAG[26]

Company Key

AET Advanced Engineering Technologies, Inc.
ANS ANSYS, Inc.
CAD CAD-FEM GmbH
CAEA Computer Aided Engineering Assoc.
CEC Concurrent Engineering Corp.
DRD DRD Corporation
ECI Engineering Cybernetics, Inc.
EMI Engineering Methods, Inc.
FIG Figes, Ltd.
HGE HGE, Inc.
IMAG IMAG Industries, Inc.
INAS Institutal Pentru Analiza Sistemelor
ING Ingeciber S.A.
ITAL ITALCAE srl
JAR Jordan, Apostal, Ritter, Assoc., Inc.
JLR JLR Computer Analysis, Inc.
MCR MCR Associates, Inc.
MTI Mallett Technology, Inc.
OCAE Ohio Computer Aided Engineering
SSC Silverado Software & Conslt, Inc.
STR Structures and Computers Ltd.
TADC Taiwan Auto-Design Co.

Special Topics Key

1 ANSYS/AutoFEA
2 ANSYS Rev. 5.2 Update
3 Finite Element Modeling
4 Electromagnetics
5 Advanced ANSYS/ProFEA
6 ANSYS 5.2 p-Elements
7 Introduction to Electromagnetics
8 Circuit-Coupled Electromagnetics
9 Random Vibrations
10 Advanced FLOTRAN
11 FEA with ANSYS/ED Intro
12 ANSYS Solvers
13 ANSYS/FEA with Autocad
14 ANSYS Basics: 1 Intro ANSYS/FEA
15 ANSYS Optimization-Advanced
16 ANSYS Nonlinearities 1: Basics
17 ANSYS Nonlinearities 2: Buckling Analysis
18 ANSYS Nonlinearities 3: Rubber & Foam Like Materials
19 ANSYS Nonlinearities 4: Viscoelasticity & Viscoplasticity
20 ANSYS Field Calculation 1: Magnetics
21 ANSYS Field Calculation 2: Coupled Fields
22 ANSYS Field Calculation 3: Piezoelectrics
23 ANSYS Composites
24 ANSYS Fatigue
25 ANSYS Macro Language & User Programming
26 Intro to FEM
27 ANSYS/ProACTIVE

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