PADT News

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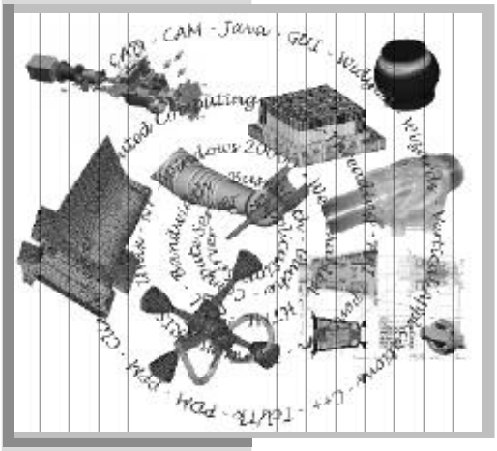

"We Bring Dimension to Your Ideas"

CAE Developments Promise Continued Productivity Gains

By Eric Miller
Director, CAD & Software Services

The world of mechanical engineering has dramatically changed in the past 25 years. A large catalyst for this change has been the development and implementation of a variety of Computer Aided Engineering (CAE) tools in the areas of design, analysis and manufacturing. These tools have resulted in significant reductions in engineering hours, schedule and cost while increasing the durability and performance of products. Several recent developments in this area promise to continue this trend of productivity gains, and PADT is poised to take advantage of them.

The most significant development in the past 10 years is the continued trend for more powerful and less expensive computers. The days of million dollar mainframes have been replaced by desktop systems that can deliver incredible performance for less then $4,000. Because of the spread of computer technology to business and the public at large, the price / performance value of systems should continue to decrease. The impending introduction of Intel's "post-RISC" based Itanium chip will result in a quantum leap in this area.

What this means for CAE users is that they can not only get more done in less time, but they can also do much more complex work. PADT has already experienced this in the areas of design and analysis. PADT feels that the continuation of this trend will result in greater fidelity in the virtual representations of the product development process, resulting in higher quality products and reduced development costs. Examples would be the capture of more design intent in large assembly models, more time dependent / non-linear analysis, parametric variational analysis studies, and more automated feature based NC programming.

Another significant change that has just begun to affect the industry is the introduction of a new generation of software tools, often called "intermediate" solutions. These are usually based upon proven technologies, but they have repackaged those technologies in a new way that emphasizes ease of use, automation and graphics. A good example of this is Design Space from ANSYS, Inc.

Design Space is a Finite Element analysis tool that uses modern interface technologies and automation to remove much of the tedious work previously required to conduct analysis. A "browser like" interface leads the user through the analysis process, intelligently handles meshing and solving, and then automates the post-processing phase by creating a standard report. In the future, this technology will be enhanced to provide access to the more complex types of analysis that

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Rapid Prototyping Success Stories

Over the past five years, PADT has built a considerable reputation as a provider of very high quality Rapid Prototyping solutions. Using a combination of leading edge technologies and detailed workmanship, the manufacturing staff has been able to exceed customer expectations while controlling cost and meeting or beating some very demanding schedule requirements. With over 300 different rapid prototyping customers, it is difficult to select a few as examples of the successful implementation of this technology. This is especially challenging due to the proprietary nature of most of the models that PADT creates. However, we have found three distinct case studies that underscore the advantages and benefits of conducting rapid prototyping in support of product development.

Custom Electrical Power Turbine

The first example presented here is one that shows the advantages of combining several CAE technologies in one project. The customer, who wishes to remain anonymous because of the nature of their project, came to PADT with a request for a custom turbine generator system for a robotic application. They needed a device that would sit in a steady stream of gas and convert flow into power for movement, communication and on-board actions. PADT's Power Systems and Space Systems teams combined with the manufacturing group to

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PADT

Phoenix Analysis & Design Technologies
146 5 N Fiesta Blvd.
Suite 107
Gilbert AZ, 85233
Tel: 480 813-4884
Fax: 480 813-4807
www.padtinc.com

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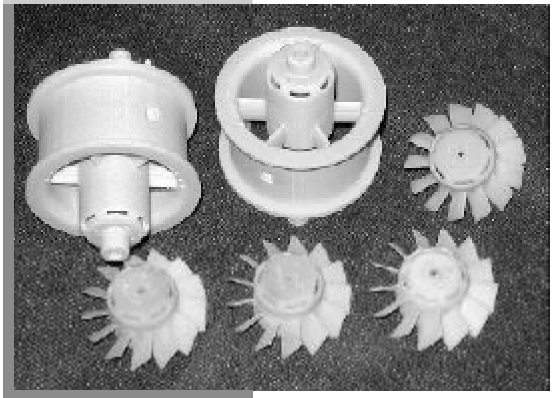
provide a solution in very little time and for a relatively small cost.

The customer's specifications for geometric constraints, flow rates and power needs were used as a starting point to develop a physical design and a performance model. After a simple trade study, it was obvious that an axial flow turbine, much like a cooling fan in reverse, would be the best fit for this application. A performance model was created and linked to PADT's existing electric motor performance simulation software. The design of the rotor was varied parametrically until the best efficiencies were obtained. In parallel to aero/performance design, a parametric solid model of the rotor and the housing were created. When the best design was determined, the parameters were fed to the solid model and the final geometry was created.



After review with the customer, it was determined that some of the input values for the study were not well known, so several different variations on rotor geometry would be required. This did not present a problem because the solid models were parametric and the method of manufacturing was very flexible.

Because of the loads involved, PADT chose to use Selective Laser Sintering manufacturing for this project. This process uses a laser to sinter powdered material, in this case glass filled nylon, in a layer-by-layer fashion, to create solid, free form parts. The various rotor geometries and the common housing geometry were converted into the industry standard STL format and transferred to PADT's Sinterstation. After some small modifications to the build parameters, all of the parts were created in a 5 hour run. Upon completion, they were removed, cleaned and delivered to the design team.

That same day, the team mounted the housing to a blower and tested each rotor with an electric motor to verify the analytical design. After all of the rotors were tested, the parts were shipped to the customer where they were placed upon the actual prototype system and tested. The customer reports excellent results and good correlation with the design estimates of performance. Bottom line: within two weeks, this complex development project went from concept to finished parts.

Rainbird Sprinklers

During the past five years, PADT and the Rain Bird Sprinkler Mfg. Corp. have worked together to implement Rapid Prototyping as an integral part of Rainbird's irrigation product design process. The experienced engineering staff at Rainbird's Tucson facility create very complex assemblies for the control and distribution of water for a variety of applications.

Most people think of sprinklers as simple devices, but the industrial systems that these engineers develop are some of the most complicated assemblies that PADT has ever seen. They often contain turbines, gear boxes, fluidic controls and complex and sensitive valves. Using full 3D solid models and analysis software, they take the design to a detailed level from within a virtual environment. Once they get close to the desired geometry, they are ready for prototyping and testing.

Because of a long and established working relationship, Rainbird has easy access to PADT's RP capabilities. Once an engineer needs parts, they use e-mail to send the geometry to PADT. The prototyping staff reviews the files, prepares them for the appropriate technology, and then submits the job. When the parts are complete, they are carefully cleaned and shipped via messenger to Rainbird. What is unique about this is that the entire process often takes less then 24 hours from request to receipt of parts!

The receiving engineer can send the files when they leave for the day and have parts to test the following afternoon. And, because PADT uses several water-resistant materials, they can verify their assembly and mechanisms, and also test the systems in a "real world" manner. PADT has often provided parts for use in flow studies or to evaluate the behavior of complex mechanisms and gear trains.

The primary success of this effort is achieved because of the ability that Rapid Prototyping delivers to create accurate, robust and precise plastic parts in a very short time. Because they are created quickly and because the price is low, these prototypes can become an integral part of the design process. Their use results not only in reduced development time, but in better and more robust products.

Friction Test Apparatus

Another good example of using RP technol-

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Government Contracts Fund New Product Development Programs

By Dr. Mark Johnson
Director, Power Systems

One of PADT's business units, Power Systems, is dedicated to three related internal research and development (IR&D) programs. These projects are primarily funded under the Small Business Innovation Research (SBIR) program, which is a government sponsored initiative to commercialize innovative new technologies and thereby strengthen the US economy. Small businesses participate in the program by developing innovative, cutting edge technologies and commercializing them in a three-phase process. The first phase is a feasibility study, the second phase is a prototype demonstration, and the third phase is commercialization.

PADT has now been a participant in the SBIR program for 1½ years. PADT's objective is to employ our established design, analysis, and manufacturing expertise, combined with innovative concepts, to develop products that make a difference. The three products presently being developing all involve alternative power generation. Future projects will focus on space systems and vacuum sciences.

Miniature Turbomolecular Pump

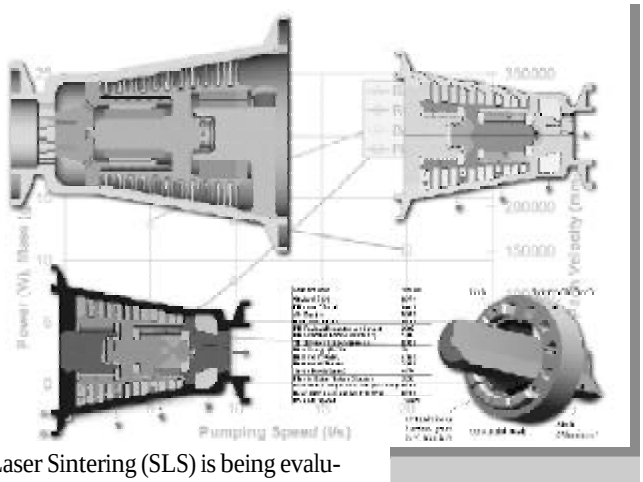
This project, currently in Phase II, is funded by NASA and will result in a miniature, low power consumption, low cost vacuum pump that is suitable for space and portable applications. NASA's challenge is to explore the solar system with missions to Mars, Jupiter, and beyond. These missions require an ultra-high vacuum to determine the elemental composition of soil and atmospheric samples. PADT's tubomolecular pump (TMP) will satisfy that need.

PADT's TMP pump concept has been developed with extensive finite element modeling using ANSYS® to understand the trade-offs between rotational speed, stress, dynamic characteristics, and thermal behavior. The result is a pump with an extremely high rotor speed, supported by a novel magnetic bearing system, and stabilized by a proprietary damper. Prototype hardware is now being fabricated, and testing should begin by the second quarter of this year. Analysis based design has proven to be the key to overcoming significant technical challenges.

Miniature Fuel Cell Air Handler

PADT has developed an integrated design/analysis/manufacturing system for producing custom vane air handlers. The work, currently in phase II, has been funded by the Army Research Office (ARO) and provides compression systems to support development in, and provide efficiency improvements for, the burgeoning fuel cell industry.

The design system employs, at its heart, a fully parametric model of the assembly using Unigraphic's SolidEdge. The assembly model is directly linked to a spreadsheet, which is used to drive performance analyses and provide input for finite element evaluation using ANSYS®. The last piece of the production system is an integrated manufacturing approach.



Presently, Selective Laser Sintering (SLS) is being evaluated for this task. The linkage between the parametric CAD, analysis, and manufacturing provides an extremely powerful system for designing and fabricating custom compressors.

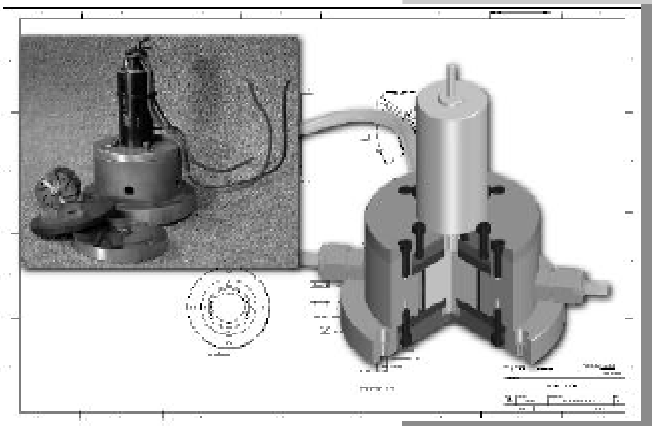
Early prototypes are delivering effective compressor efficiencies of 90% with very small flow rates. The goal of the design system is to allow PADT's engineers to simulate, design, manufacture and deliver customer air handlers to the fuel cell industry in less then three weeks from project initiation.

Portable Hybrid Power Supply

PADT is also working on a Phase I SBIR to develop a 15W avg/300W peak power supply that employs a fuel cell and a rechargeable battery pack in combination with a safe hydrogen fuel source. This work has just begun and is funded by the Army Research Office (ARO). The purpose of the power supply is to provide personal power for 1-3 day missions for the dismounted soldier. The power could be used for communications, heating or cooling, or night vision goggles.

PADT is teaming with AeroVironment (Monrovia, CA) and H-power (Belleville, NJ) to develop this product and a brass board prototype will be operational by May of this year. If Phase II funding is awarded, the design and assembly of functional prototypes will begin later in 2000. The goal of this project is to develop a flexible, robust and stealthy system to power the equipment for the ground soldier of the future.

All of these IR&D projects give PADT a unique chance to use the same skills and knowledge that is applied to customer problems on a daily basis. These efforts have been very rewarding and have helped the company to further understand the overall needs of the complete product development process.



Tcl/TK Puts a New Face on ANSYS®

By Terry Santiago
Senior Analytical Engineer

ANSYS® users have for many years used APDL (ANSYS Programming Design Language) to create tailor-made parametric tools. In many cases, ambitious analysts have also used UIDL (User Interface Design Language) to create customized submenus and functions within the analysis environment. The blending of APDL and UIDL allows programmers to create vertical applications that run on top of ANSYS®. These sorts of applications have been built to perform everything from turbine blade model generation to electronic package analysis. Unfortunately, while UIDL goes a long way toward providing a tool set for building custom applications, it is quite limited in terms of functionality. This is why many programmers are now turning to Tcl/Tk as an alternative to UIDL. ANSYS, Inc. uses Tcl/Tk for new user interface features such as the Mechanical Toolbar and the Contact Wizard.

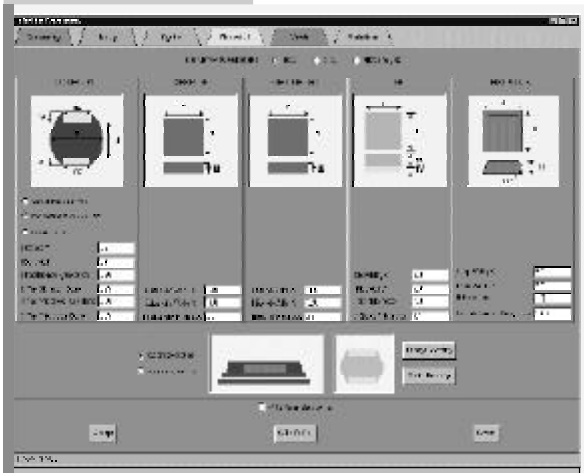


Figure 1: Form page from PADT's TCL/Tk addon to ANSYS® for parametric simulation of ball grid arrays

Tcl/Tk (pronounced "tickle T. K.") is a software command language and toolkit that was developed by John Ousterhout at the University of California, Berkeley. There are several advantages to using Tcl/Tk over other GUI builders, such as Visual C++ and Visual Basic. Tcl/Tk is relatively easy to use, cross platform compatible, widely utilized, and it is freely available from a variety of sources.

Figure 1 shows an example of an ANSYS® vertical application that was created for modeling ball grid array packages. In this case Tcl/Tk provided the functionality needed to create folders, animations, warning boxes, and other "action oriented" widgets. These tools afforded much greater utility and accessibility for this application. The end product is significantly more user-friendly than it would have been if using UIDL alone.

ANSYS® has always encouraged analysts to customize their software to build vertical applications, by making the APDL and UIDL programming manuals available on-line for customers. To further enhance the programmer's ability to build custom Tcl/Tk GUI's, ANSYS® has recently provided 1) a method of invoking Tcl/Tk from the analysis environment and 2) a set of custom Tcl/Tk and APDL commands to communicate between the ANSYS® and Tcl/Tk environments.

Figure 2 shows a simple example of an ANSYS®/Tcl/Tk application. This application queries an X coordinate and then creates a node on the X axis. Simply type the contents of Figure 2 into files named "simple.mac" and "simple.tk" respectively and place them in your ANSYS® working directory. You can invoke the program after starting ANSYS® by typing "simple" in the ANSYS® input window.

By examining the first file, "simple.mac", we can see that it performs three functions. The first is to initialize a parameter, _nx. The second is to invoke the Tcl/Tk application to run the script "simple.tk" from within ANSYS®. The third is to check to see if the OK button was pressed, and if so, create a node at the specified location.

The Tcl/Tk script, "simple.tk" uses two custom Tcl/Tk commands to communicate with the ANSYS® environment: "ans_getvalue" and "ans_sendcommand". The first retrieves the value of a parameter in the ANSYS® environment. The second sends a command to the ANSYS® environment (in this case, it sets a parameter). The script also uses two standard Tk widgets, an entry box and a button, to create the input window and "OK" button shown in Figure 2. The last two lines of this file cause the Tcl/Tk GUI to remain visible until the variable "exitDialog" is set (When the OK button is depressed).

To learn more about programming in Tcl/Tk and customizing ANSYS® for use with Tcl/Tk, the following resources are recommended:

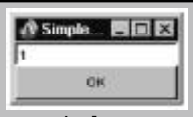
"Tcl and the Tk Toolkit", Ousterhout, Addison Wesley Publishing, 1994

"Effective Tcl / Tk Programming", Harrison & McLennan, Lucent Technologies 1998

"ANSYS Gui Style Guide, Ch. 5 ANSYS Programming Interaction" , ANSYS Inc.

www.scriptics.com and www.tcltk.com

Figure 2: Simple Dialog Box, ANSYS® Macro and Tcl/Tk Script



simple.mac

```
/prep7
! INITIALIZE PARAMETER
_nx=1
! INVOKE TCL/TK APPLICATION
~eui,'source [file join [pwd] simple.tk]'
! IF OK BUTTON WAS PRESSED, CREATE NODE
*if,_button,EQ,2,then
  n,,_nx
*endif
```

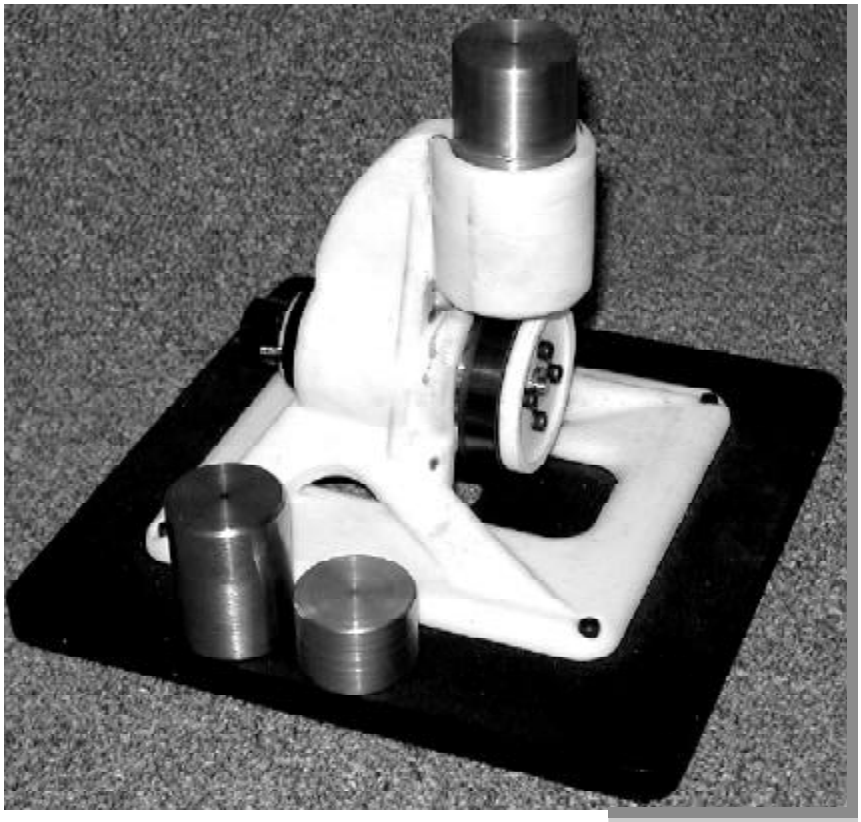
simple.tk

```
namespace eval simple {
  #CREATE A NEW WINDOW
  destroy .simple
  set parent [toplevel .simple -class Ansys]
  # READ IN PARAMETERS FROM ANSYS
  set _nx [ans_getvalue PARM,_nx,VALUE]
  # CREATE ENTRY BOX
  entry $parent.e_nx -textvariable simple::_nx -bg white
  pack $parent.e_nx
  # CREATE THE OK BUTTON
  button $parent.btnOK -text OK -bg grey -command \
         [namespace code [list dlgOK ]]
  pack $parent.btnOK -fill x
  proc dlgOK {} {
     ans_sendcommand *set, _nx, $simple::_nx
     ans_sendcommand *SET,_BUTTON,2
     set simple::exitDialog 1
  }
  #SET UP WINDOW TO EXIT WHEN OK BUTTON IS PRESSED
  tkwait variable simple::exitDialog
  destroy $parent
}
```

(RP Success Stories, continued from pg 2...)
ogy to its fullest is a project that PADT is conducting for the US Army Research Office. While developing a custom pumping system for an application that demanded very high efficiencies, it became obvious that the friction between components was driving the performance of the system. A quick review of the available literature showed that there was no source for reliable friction data for the materials being considered. The only solution was to test the material at PADT.

However, a review of available testing devices showed that they either did not perform the type of tests that PADT needed or that their cost was prohibitive. As a result the development team decided to design and fabricate their own test system using in-house capabilities.

The team quickly created a 3D assembly model and verified the design using PADT's CAE technologies to make sure it would work. They then passed the geometry to the manufacturing team, where the bulk of the parts were created using Selective Laser Sintering. In just less then three days, the device went from concept to assembly and was ready to begin testing. Neither drawings nor NC programming were required. The critical components were created directly from the solid model.



(CAE Trends, continued from first page...)
are now carried out in a more traditional way within ANSYS®. Again, this should result in better simulation in less time.

The final area of development that effects the mechanical engineer is "THE WEB". The technologies that can be grouped under this heading are diverse, but they are already causing a revolution in almost every area of modern life, and CAE is no exception. Because this is such a new development, it is difficult to predict how it will actually impact the mechanical engineer, but PADT feels that two changes are certain.

The first change is the replacement of traditional software programs with "web based" client/server tools. This will result in greater platform independence, a consistent "look and feel" between programs, and the ability to interact on one machine while doing heavy computing on another, regardless of geographic location. It should also reduce the development time of new software and result in lower costs to end users.

How engineering teams store and share information will be the second important change. PADT has always felt that what engineers do is gather, create and evaluate information, and the web will prove to be a significant part of how this is done in the future. Collaboration and the sharing of information between teams or between customer and vendor will probably be carried out primarily through the web. Future improvements in bandwidth, encryption and compression technology should, if used correctly, allow engineers to work together much more efficiently and should remove the problems that are caused by miscommunication.

It is difficult to predict the future in this area, because there will certainly be new technologies that no one has even thought of. However, if these changes are watched closely, and evaluated properly, they can be adopted quickly and can easily result in significant productivity improvements. PADT has built a reputation for itself as a company that combines good people with good CAE tools, and we are confident that we will continue to do so in the future. The staff is excited and exhilarated about what will happen in the next 25 years and we hope that you will join us in the journey.

Industry Experience Leads to Vacuum Systems Team

As PADT grows, the company has identified key technical areas in which it provides focused and experienced engineering support. This tradition is continued with the creation of the new Vacuum Systems team. Successful projects for several customers that produce high vacuum systems for the semi-conductor manufacturing and related industries have led to the creation of this new area. With the addition of Rob Rowan, the former Director of Development Engineering at Tokyo Electron Arizona, PADT now has the experience and the leadership necessary to provide dedicated services to this important industry. More information can be found PADT's web site or in next quarters' issue of PADT News.

Heat Transfer & Hot Dogs

When asked to help a customer redesign a new consumer product, the analysis staff did not expect a free lunch. However, the job involved the analysis of heat shielding for a portable Bar-B-Q grill that can be attached to a trailer hitch. The initial design of the aptly named "TailGator" was used to obtain the temperature over time of a bed of "quicklite" coals. The test apparatus consisted of an accurate thermocouple probe, twelve hot dogs, 12 buns, ample beverages, our administrative assistant's Suburban, and a nice sunny day.

Some staff members requested repetitive testing to insure data quality, but one test proved sufficient to conduct a radiation driven heat transfer analysis of the new design. Who said you can't have your analysis and eat it too?

Comments?

We would love to receive feedback. If you have comments, please give us a call or drop us an e-mail.

Questions?

More detailed information can be found on our web site. Also, PADT's staff is always available to talk about your engineering issues and needs.

(480) 813-4884 • 1-800-293-PADT
www.padtinc.com • padt@padtinc.com

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Edited by ..... Jean Loutzenheiser, Ward Rand
Asst. Editor ..... Julie Canepa
Layout ..... Eric Miller
Contributors ..... Terry Santiago
Kou-Rey Chu
Eric Miller
Dr. Mark Johnson

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What's in this Issue?

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- Non-linear Dynamic Analysis with LS-DYNA
- Testing with PADT & Dynamic Labs
- More...

Phoenix Analysis & Design Technologies
1465 N Fiesta Blvd.
Suite 107
Gilbert AZ, 85233
Tel: 480 813-4884
Fax: 480 813-4807
www.padtinc.com