

Painting "Happy" Thermal Barriers

By Doug Oatis

After Rod's in-depth analysis of structural shells to solid connections, I figured it was time to write about the thermal shell-solid capabilities within ANSYS. We all know that many features are omitted from the CAD model that's given to an analyst, but few are as important as a thermal barrier. This thin layer would be just about impossible to create as a solid (unless you're really good at using your CAD package), that's why ANSYS introduced SHELL131/132.

It isn't everyday that you come across an extremely useful, powerful, yet simple to use element. By default, thermal shells have DOFs at the top (TTOP), bottom

(TBOT), and at the internal layers (TEx). This makes it problematic when connecting it to thermal solids, which only have a TEMP DOF. Luckily, with a simple flip of a keyoption, you can replace TTOP or TBOT with the TEMP DOF, rather than writing your own constraint

equations to tie together the shells to underlying solids.

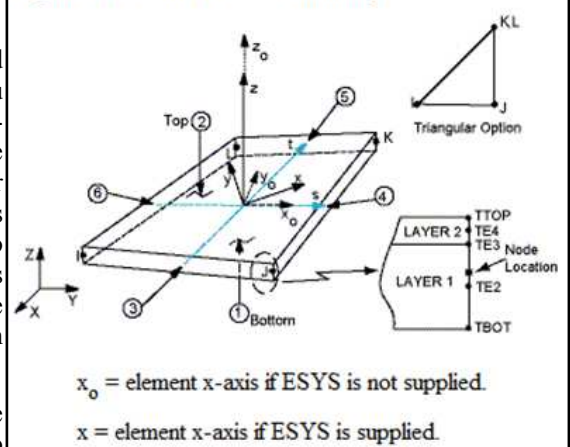
So, by setting KEYOPT(6)=1 and using the ESURF command, you can do your best Bob Ross impression and paint some happy little shells wherever you want in your model! After you paint the shells on, you can then apply convection to the top (face 2). Bob's painting was creating by plotting shells with the section properties turned on (/ESHAPE,1).

To properly define the SHELL131/132, you will need to

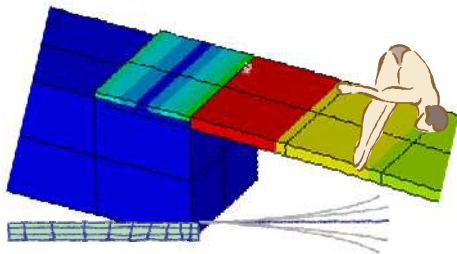
use sections (rather than a real constant). This will allow you to specify multiple layers/materials, integration points, and section offset (should be SECOFFSET,BOT when using the paint option).

Now you're probably wondering how to use this in Simulation. All you need is a named

Figure 131.1 SHELL131 Geometry



(Cont. on pg. 7)



By Rod Scholl

Continuing from last month's article ([link](#))

we explore the various methods of attaching shell element to solid element regions. First we explored sharing nodes, especially using a "painted on region" or overlap region to transfer the moments.

Shell To Solid Interfaces: Using Constraint Equations

Then we looked at using contact (CONTA17x) technology. This time we will look at constraint equations.

Then to complicate matters, and close out the series of articles, we will look at cases of mis-matched mesh between the solids and shell elements and compare our developed methodologies.

We defined our test case previously ([link](#)), and showed a theoretical equivalent stress of 100 in the shells at the interface, and 4.00 at the base of the solid.

Coupled Connection

It is not that uncommon to couple/constraint equation (CP, CE, or CERIG/CEINTF) the solid elements to the shells. We have to keep in mind that the equations do not update for large deflection (as they do when using the contact method with MPC)

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equations, or using the MPC184 elements). Also, it is possible to unintentionally create an infinitely stiff corner, giving quite altered results. The real difficulty with this approach is apparent with the butt joint. However, let us look at the magnitude of the error, compared to the other approaches.

The Overlap Joint

For the overlap joint, I'm not sure why we wouldn't just share nodes with the overlapping shell elements if the mesh matches, but for argument's sake, we show that coupled nodes at the interface (Figure 1) matches the shared nodes result (Figure 2) from the previous article ([link](#)).

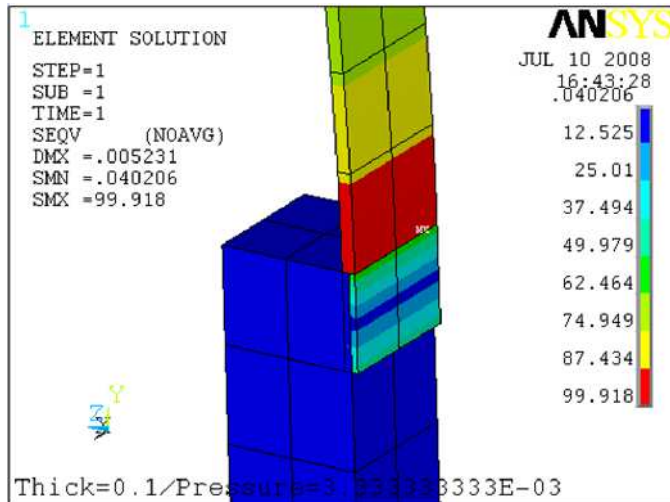


Figure 1: Coupled Nodes

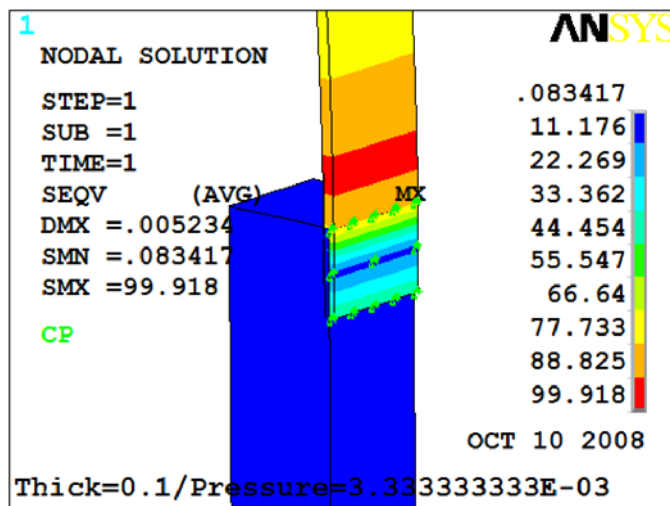


Figure 2: Shared Nodes

Angle Butt Joint

I confess, I might just like saying "angle steel butt joint"... but I digress. Similar to the overlap joint above, the coupled result (Figure 3) matches the shared result (Figure 4) from the previous article ([link](#)).

Butt Joint

Note that couples (CP's) can only couple together active DOF's - and given that we need to restrain the rotational DOF's (Rotx, roty, rotz) on the shell elements, we remember that the solid elements

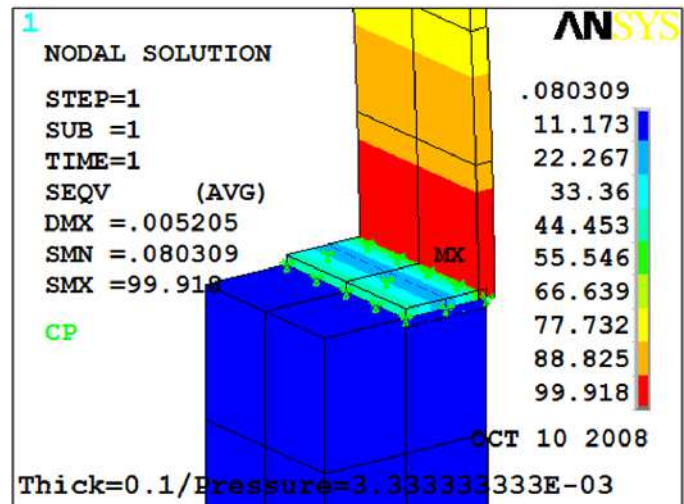


Figure 3: Coupled Nodes

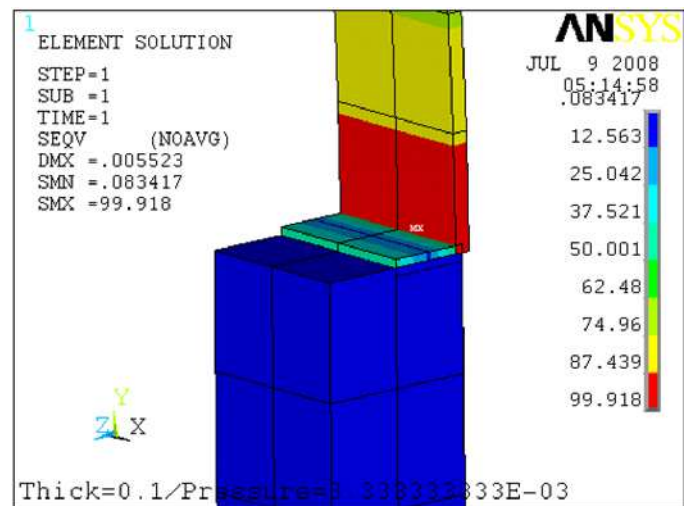


Figure 4: Shared Nodes

do not have these types of DOF's active (they only have UX, UY, UZ). This is why we will use constraint equations (CE's) rather than couples to join this type of interface. These CE's will tie the different DOF's together by grabbing nodes an element length away from the shell-solid interface.

To generate the CE's we have a few options.

- 1) Use CEINTF with nodes selected from the shells
- 2) Use CEINTF with nodes selected from the solid
- 3) Use CERIG
- 4) Write our own CE's

Option 1), can give the CEINTF macro problems as you see in Figures 5. Using a different selection tolerance, we arrive at Figure 6 results. Here we get some odd results (Figure 7) at the interface (but by now we're used to that).

Option 2) also confuses the CEINTF macro (not really intended for this sort of thing) and results in problems as seen in Figure 8

(Cont. on pg. 3)

(Shell-Solid cont...)

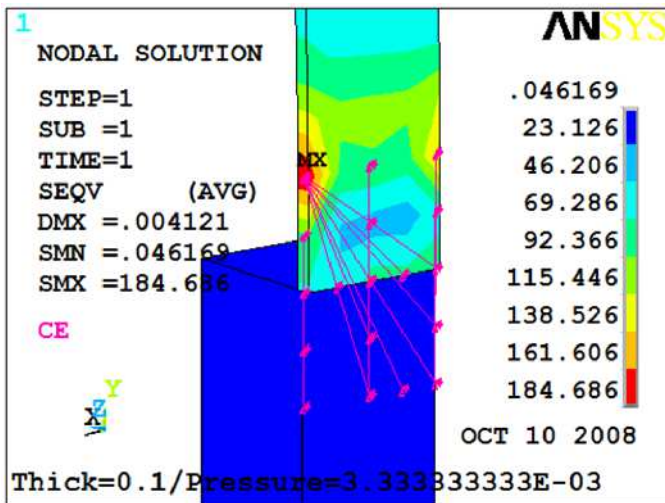


Figure 5: CEINTF With First Tolerance

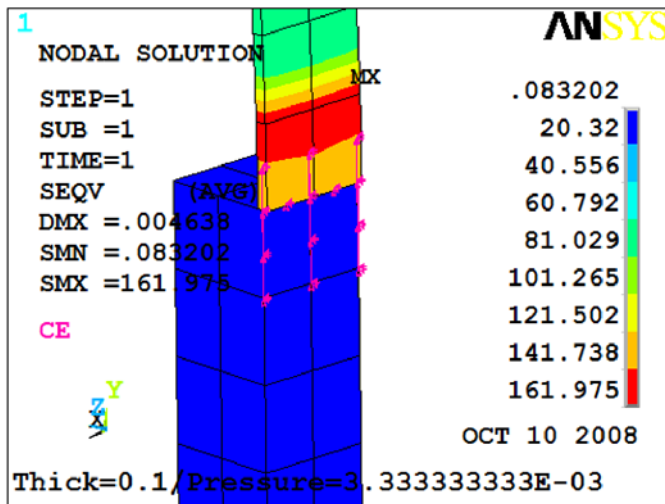


Figure 6: CEINTF With Second Tolerance

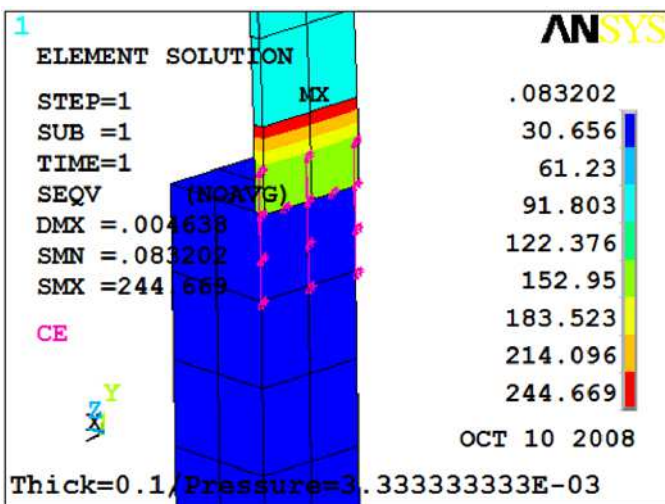


Figure 7: Odd Results from CEINTF

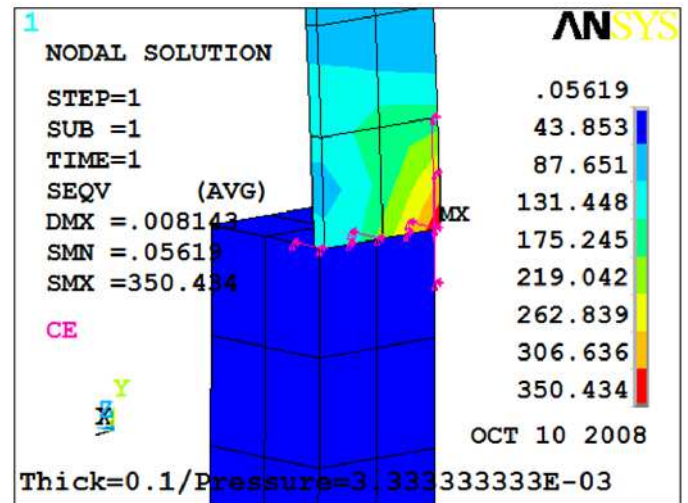


Figure 8: CEINTF Generated Connections

our desired interface, and came up empty handed. Best I can tell there's no way to take advantage of the CERIG generated equations for this non-standard usage.

So Option 4), writing our own CE's is really our only hope for the couple/constraint equation approach for the butt joint. We have lots of choices on how to write these.

Remember that we have been using contact elements, with the MPC algorithm (and small deformation) and it is equivalent to using constraint equations (note you can list the internally generated constraint equations via command CELIST,,,INTE) as shown in Figure 9.

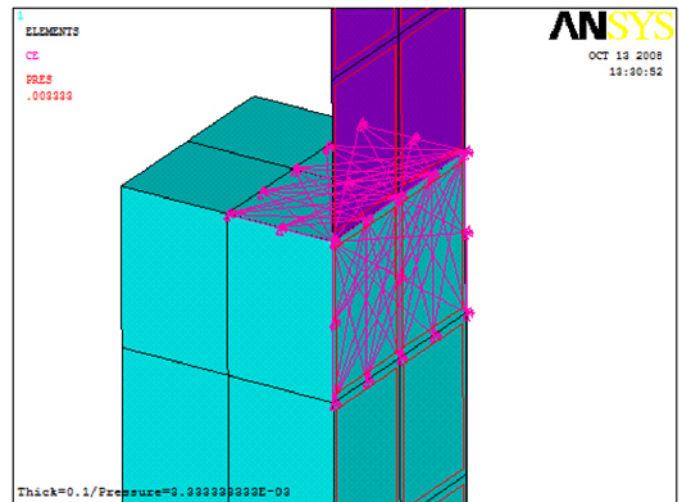


Figure 9: MPC Constraints

Also we could try the CEINTF command, and get results similar to above depending on what elements we include. My first few trials didn't produce anything that looked superior to the contact generated ones, or any different from the CEINTF generated in the above cases of the lap joint and angle butt joint.

So, if we are to write our own CE's, by adjusting coefficients we can pretty much distribute the load in any fashion we'd like. I suppose for this article, if we have in mind to disregard local

(Cont. on pg. 4)

(Shell-Solid cont...)

results, and prioritize results at removed locations, we would attach rigidly to the closest nodes only. This numerically makes an infinitely stiff corner from the mid-side nodes inward. We will couple in UX, UY, UZ at the coincident nodes at the interface.

And we'll look at three cases of tying rotation about X, by coupling

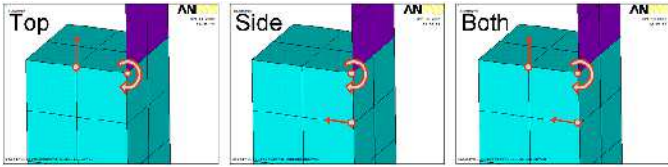


Figure 10: Tying Rotations about X

the side and top midside nodes' deflection with the shell node's rotation. Figure 10.

Looking at the first two, CE's Option 1 and 2 (in yellow) created using the CEINTF algorithm, we can find nothing really redeeming about that approach.

For the manually created set (in grey), we see that the stress in the solid at the interface is quite low - but as always we will forgo that accuracy knowing it is anti-conservative and will be handled separately in our design. We see the nice benefit of the nodal solution matching the element solution which is always nice.

However, we see the accuracy at the base is still around 1% error. This isn't great, but maybe is tolerable. Add in the difficulty of loading scenarios which are not as simple as our case (rotation only about X) and I don't see any reason to write the CE's manually. There seems to be no advantage over the overlapping shell or the 175's (Nodal Contact) approaches.

Conclusions

It probably isn't wise to take my word for it, but for all of our reference, let me distill the last three articles into some rough conclusions:

Lap Joint:

For lap joints, the nodal contact (CONTA175) approach is best, remembering that the solid stresses at the interface are greatly non-conservative, and must be handled differently if they drive the design.

Angle Steel Butt Joint:

For angle butt joints, the nodal contact (CONTA175) approach is best, remembering that the solid stresses at the interface are greatly non-conservative, and must be handled differently if they drive the design.

Butt Joint:

We probably can breathe a sigh of relief knowing we do not have to write our own CE's, nor is it worthwhile to bias the mesh at the joint.

Also, with meshes that do not match at the interface, we should proceed with the CONTA175 approach - it is suitably accurate, and waaaaaay easier than writing our own CE's.

But for matched meshes, I have to side with the overlapping shells on the top surface, rather than contact technology (CONTA175) because of the better stress results at removed locations, and higher (more accurate) stress in the solid region near the shell to solid interface (although still quite non-conservative). The nodal contact is a close runner up, and is likely sufficient for the bulk of analyses.

Configuration	Included Surfaces	Shell Stress (Nodal)	Shell Stress (Element)	Base Stress (Nodal)	Solid Interface Stress
CE's, Option 1	NA	162.0	244.7	3.95	10.20
CE's, Option 2	NA	350.4	350.4	2.30	34.90
CE's, Manual Top	Top	99.9	99.9	3.95	3.57
CE's, Manual Side	Side	99.9	99.9	3.95	2.22
CE's, Manual Both	Both	99.9	99.9	3.95	2.30
175's (Nodal Contact)	Top	100.0	100.0	3.95	4.01
175's (Nodal Contact)	Side	100.1	100.1	3.95	2.70
175's (Nodal Contact)	Top & Side	100.0	100.0	3.95	1.59
177's (Edge Contact)	Top	224.7	239.0	3.95	3.82
177's (Edge Contact)	Side	224.6	238.9	3.95	2.80
177's (Edge Contact)	Top & Side	224.6	239.0	3.95	1.69
Overlap Shells	Top	99.9	99.9	4.01	9.59
Overlap Shells	Side	93.0	99.9	3.87	7.24
Overlap Shells	Top & Side	99.9	99.9	4.01	4.13

Table 1: Summary of Results

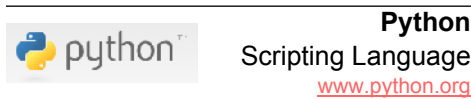
Free Tools Every Analyst Should Have

Compiled by Eric Miller

Engineers like clever tools, and they like free stuff. So free and useful software tools are always of interest. Over the years everyone here at PADT has built up a library of free software programs that they use on a regular basis. So we thought it would be a good idea to get a list of them and share it with the user community.

Some are pretty major (Python, OpenOffice) and some are small. They are all free to download and most have been around for a while and are robust and well supported by the community or author.

If you have one of your favorite tools to add, e-mail us at focus@padtinc.com. We'll publish a list of links next month.

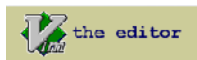


Python

Scripting Language

www.python.org

Python is **the** productivity scripting language. No ifs, ands or buts about it. For those of us that are older, the object oriented nature of the language takes a little getting used to, but beyond that it is simple to learn, very concise and very powerful. It is also very widely accepted, has a huge library of pre-written routines, and has been linked to tons of tools out there. It can be run in batch or be used to make a graphical user interface. If you are automating processes for any engineering task, it would be hard to find a better tool to do it in than python.



Vim:Vi Improved

Text Editor

www.vim.org

There are two kinds of text editor users, those who fumble around with a mouse and those who use Vi. For writing code or managing input and output files nothing beats Vi for speed, once you have memorized the archaic key strokes. And Vim is the leading Vi editor for Windows. It works like Vi on *nix with some extra GUI type functions that are useful. It also has text highlighting for most scripting languages, including APDL.



OpenOffice

Office Software

www.openoffice.org

Beyond text editing, and for free, there is only OpenOffice. This incredibly powerful Office suite offers 80%-90% of what MS

Office does, but is open and free. And it reads and writes MS file formats. And, if you are a Linux user, this is the best office suite for that OS. We find that it is not compatible enough with MS Office to make it our primary tool, but for the type of things that an FEA/CFD guy does, it is plenty powerful.



LaTeX

Batch Typesetting

www.latex-project.org

Have you ever wanted to be able to create professional looking documents in batch mode or with a script? LaTeX has been around a long time and is an incredibly powerful way to automate the formatting of your document in-line with the document. It actually started life as a typesetting language before WYSIWYG editors. We often use it with python or APDL to automatically create nicely formatted documents on the fly. It is also useful for formatting nasty math equations, and outputs to PDF.



CutePDF Writer

PDF Writer

www.cutepdf.com

Although Office 2007 now saves as PDF (yea!) you still often need a good PDF creator. CutePDF seems to be the best free "print-to-pdf" tool out there. We find it works pretty well.



GSView

PDF Viewer

www.cs.wisc.edu/~ghost/gsview

Ghostscript is the opensource clone of Postscript, and GSView is a tool for looking at ghostscript and Postscript files. If you produce raw *.ps or *.gs files, you need this tool.



Movietogif

Animation Converter

www.evanolds.com/movtogifsimple.html

Ever make an AVI of an animated result and then struggle to get it into a PowerPoint or on a web site. Movie to Gif is a simple little tool that converts from MPEG or AVI into GIF. And once in GIF you can imbed in your PowerPoint or put it on a web site.



Irfanview

Image Viewer

www.irfanview.com

Simple, super fast, and compact tool for looking at images and movies. It has some simple editing tools as well. Instead of firing up a big

graphics program, for windows this is the fastest way to view almost any format. Sorry *NOT FREE, small fee for commercial use.*



ImageMagick

Image Converter

www.imagemagick.org

Command line based tool for modifying, translating and converting images. This is "the tool" for batch conversion, cropping and filtering of images. We use it to automate the creation and editing of results plots, including stuff like cropping, adding logos and converting formats.



AnyDWG

Image Converter

anydwg.com

This is actually a suite of tools for converting to and from Autocad formats. If you don't have a program that reads DWG/DXF, then DWG to PDF is a great way to convert to PDF. If you have a PDF of a part you want to model but need to get it into CAD, PDF to DXF will do that conversion for you. Simple but a big time saver.

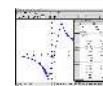


TheGimp

Image Editor

www.gimp.org

OK, the name is really bad. But if you can get beyond that you will find an image editing tool that is incredibly powerful. It runs on Linux and Windows and provides all the tools that even hard-core Photoshop users like. If you need to clean up plots, add annotation or crop things a lot, this is the best free tool out there, and better than most commercial tools. This is a must have if you don't want to pay for Photoshop or PaintShopPro.



Engauge

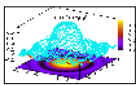
Graph Digitizer

digitizer.sourceforge.net

Don't you hate it when you ask for material properties and you get a graph printed on paper? Instead of breaking out the ruler try Engauge. This simple program takes an image and automatically finds the axis and the curves. It has tools for cleaning up the image and setting stuff up if the automatic stuff doesn't work 100%. This program has saved us dozens of hours and a lot of frustration.

(Cont. on pg. 6)

(Free tools cont...)



Gnuplot Graphing

www.gnuplot.info

Let's be honest, most of us make graphs in ANSYS or Excel, and both programs kind of suck at making graphs. Gnuplot has been around forever and produces high quality graphs, in batch mode, in 2D and 3D with all the bells and whistles you could ask for. Using APDL, python or by creating simple input files, you can take pretty much any simulation value and make nice graphs in the background. Next time you get frustrated trying to graph something, think Gnuplot.



GeoGebra Math Tool

www.geogebra.org

This program is amazing. If you ever find yourself doing algebra or calculus and you want to visualize your equations, GeoGebra is the right tool. Type in an equation and see it on the screen. Drag points around and watch the equations change. Very fast, very powerful. A great visualization tool.



SciLab Math Tool

www.scilab.org

SciLab is basically an OpenSource version of MatLab. They describe it as "a scientific software package for numerical computations providing a powerful open computing environment for engineering and scientific applications". It is extremely powerful and although not 100% as powerful as MatLab, it is pretty dang close and for most analysts probably close enough. There are other similar tools (Octave being one) but this seems to be the dominant one. Also, it has a Simulink system simulator similar to LabVIEW.



TightVNC Remote Desktop

www.tightvnc.com

Be honest, all of us are always logging on to our machines at work from home or while on vacation. Windows remote desktop is OK but it logs you off the remote machine. VNC lets you share your desktop and often works faster, and it works with Linux. It can also handle slow connections better (you can reduce color and such). There are many flavors, but we have found TightVNC to be reliable and compact.



Putty SSH Tool

www.putty.org

Another silly name. These OpenSource Linux guys! If you work on a bunch of machines and want to manage SSH connections to them, Putty is the way to go. It is also a good way to add SSH to a Windows box. If you don't know what SSH is, you probably don't need Putty.



cygwin Linux Emulator

www.cygwin.com

You either love cygwin or you hate it. We love it. Cygwin is a Linux and X-Windows environment that runs on windows. If you have a windows desktop and you use remote Linux or Unix machines, cygwin is the free way to connect to them and view graphics. Also, if you are a big Linux/Unix fan and can't function outside of that environment, but you are forced to have a windows box, you can have your cake and eat it too with cygwin. This is a must have for those with Linux compute servers.



CP16 Calculator

www.hpcalc.org/hp48/pc/emulators

Long for reverse polish notation? This web site has a whole slew of HP calculator emulators. The CP16 seems to be the best of the lot.



Dropbox File Sharing

www.getdropbox.com

This is a program and a web service that some of us have found very useful and a big time saver. You load the software on all of your computers, and it syncs the files in a specified "dropbox" folder on all the machines. You can also access the files through a web interface. It is limited to 2GB but is a great way to keep a set of important files available across home, work, laptop and while you are on the road.



FileZilla FTP Utility

filezilla-project.org

For whatever reason, FTP isn't as simple as it used to be. FileZilla takes the difficult out of it and allows you to avoid trying to use your browser to get at files. Many of us have been using it for some time and a lot of our file transfer problems have gone away.



7-Zip File Compression

www.7-zip.org

WinZip has almost become synonymous with file zipping. And Windows now supports ZIP files. But WinZip is not free (didn't know that? Thief!) and every once in a while we would run across an archive format that we couldn't read. 7-Zip, silly name again, reads almost everything (#7z, ZIP, GZIP, BZIP2, TAR, RAR, CAB, ISO, ARJ, LZH, CHM, MSI, WIM, Z, CPIO, RPM, DEB and NSIS) and writes to 7z, ZIP, GZIP and TAR. It is fast and works really well in windows under the right mouse click.

New on XANSYS

The elves who keep XANSYS up and running have been very busy (so they can finish in time for us to rent them out to Santa) making some long needed changes to the site.

The most important is that XANSYS now runs as both an e-mail list (mailman listserver) and as a modern Web based forum. Experienced and seasoned users who prefer to interact through the more stable and robust e-mail method can continue to do so. Young and impatient adrenaline junkies can use the forum. An added bonus is that the forum also serves as the archive so searching is better than ever. Sometimes you can have your cake and eat it too.

www.xansys.org/forum

Forum	Search	Results	Pages	First Post
XANSYS	[Search] [Filter]	213 results found	10	1
XANSYS	[Search] [Filter]	213 results found	10	1
XANSYS	[Search] [Filter]	213 results found	10	1
XANSYS	[Search] [Filter]	213 results found	10	1

Secondly, we've added a blog. Nothing too fancy and so far not a lot of posts to it. But still, a place for key people on XANSYS to express more of an opinion than what is considered polite within the list (and now forum).

xansys.blogspot.com

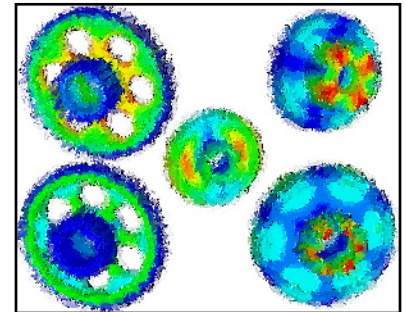
(Thermal Boundary, cont...)

selection (made of faces) and a command snippet. Here's a very basic one:

```
/prep7
max_type=elmigr(0,14)
shell_type=max_type+1          !Define scalar for shell type definition
max_secn=sectinqr(0,14)
shell_secn=max_secn+1          !Define scalar for shell section definition
max_mat=mpinqr(0,,14)
shell_mat=max_mat+1            !Define scalar for shell material definition

et,shell_type,132               !Define SHELL132 (midside nodes)
keyopt,shell_type,6,1          !Turn on paint option
mp,kxx,shell_type,5
sect,shell_secn,shell
secdata,.125,1
secoffset,BOT
seccontrol                      !Define material properties and section controls

cmsel,s,face                    !Replace with your named selection
type,shell_type
mat,shell_mat
secn,shell_secn
esurf                          !Paint Happy Surfaces!!!
allsel,all
/solu
```



So next time you need to do a thermal analysis that includes a thermal barrier/coating, look to SHELL131/132 for a very simple solution. Also remember to build your model in the spirit of Bob Ross, "We don't make mistakes, we just have happy accidents." Sorry, that's just my way of saying "happy debugging."

Confused again by Doug's pop culture references? Don't know who Bob Ross is? He was a painter who had a TV show on US Public Television that showed people how to paint. He was almost creepily calm and soft spoken and was fascinating to watch because he could create a complete forest of "happy trees" in a few minutes. Many of the "middle aged" generation would watch Bob early on Saturday mornings before cartoons came on. <[wPdja](#)>

News - Links - Info

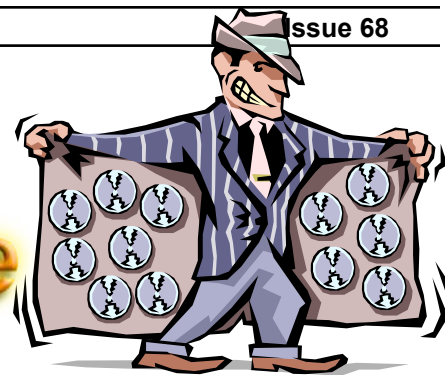
- The SWAU Report is now Snippets! PADT is broadening the scope of our other ANSYS related publication with a new name and more news and opinion: <[link](#)>
- Engineering Simulation Energy Conference, Houston, Texas, November 11-12, 2008. PADT will be there <[link](#)>
- Info on the ANSYS User conference and what a success it was can be found here: <[link](#)>
- PADT's 2009 Training Schedule is out. It includes some new classes and the schedule for the first half of 2009. <[link](#)>
- We recently stumbled across a new on-line resource called FEAdomain.com. It's a forum, it's a resource site, job listings, etc... It's a lot of stuff. It even has expensive advertising. Unlike a lot of such sites, it has some good ANSYS related information. Looking at the forum, it is still small but someone is adding a lot of content. Worth checking out. <[link](#)>

PADT's Training Schedule

Month	Start	End	#	Title	Location
Oct '08	10/27	10/27	411	WB Simulation Electromagnetics	Tempe, AZ
	10/28	10/28	206	WB Rigid & Flexible Dynamics	Tempe, AZ
Nov '08	11/5	11/7	101	Introduction to ANSYS, Part I	Tempe, AZ
	11/10	11/10	702	WB DesignXplorer	Tempe, AZ
	11/12	11/13	301	Heat Transfer	Tempe, AZ
	11/17	11/18	102	Introduction to ANSYS, Part II	Tempe, AZ
	11/19	11/20	204	Advanced Contact and Fasteners	Tempe, AZ
	11/24	11/25	604	Introduction to CFX	Tempe, AZ
Dec '08	12/1	12/2	104	WB Simulation – Intro	Tempe, AZ
	12/8	12/9	302	WB Simulation Heat Transfer	Tempe, AZ
	12/10	12/11	207	WB Simulation – Struct. Nonlin.	Tempe, AZ
	12/15	12/16	801	ANSYS Customization with APDL	Tempe, AZ
Jan '09	1/9	1/9	605	CFX for the Non-CFD Specialist	Tempe, AZ
	1/12	1/14	101	Introduction to ANSYS, Part I	Tempe, AZ
	1/15	1/16	100	Engineering with FEA	Tempe, AZ
	1/22	1/23	651	CFX Combustion and Radiation	Tempe, AZ
	1/26	1/27	104	WB Simulation – Intro	Albq, NM
	1/28	1/29	207	WB Simulation – Struct. Nonlin.	Albq, NM
Feb 09	1/30	1/30	107	WB DesignModeler	Tempe, AZ
	2/2	2/3	301	Heat Transfer	Tempe, AZ
	2/4	2/5	801	ANSYS Customization with APDL	Tempe, AZ
	2/6	2/6	411	WB Simulation Electromagnetics	Tempe, AZ
	2/9	2/10	205	WB Simulation Dynamics	Tempe, AZ
	2/12	2/13	652	CFX Multiphase Flows	Tempe, AZ
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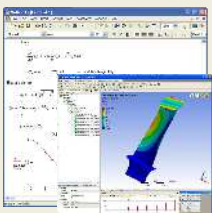
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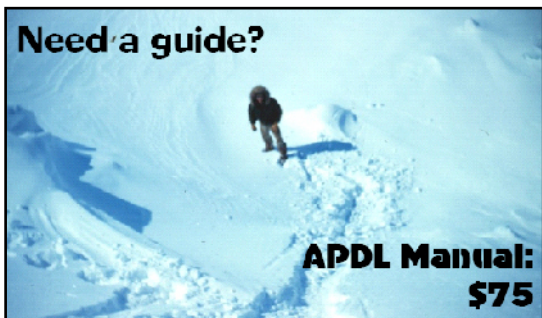
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