UCRL-ID-125097

New HYDRA Option: Time Histories of Element Pressure with THUG

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September 26, 1996

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Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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1.0 Introduction

The incompressible Navier-Stokes flow code HYDRA (Christon 1995) has been modified to produce pressure time history databases for both two-dimensional (2D) and three-dimensional (3D) simulations. This report describes the control parameters needed to activate this option in HYDRA. A detailed description of the actual code modifications are included in Appendix A. The generated pressure time history data is formatted for postprocessing with the code THUG (Speck 1996). A brief description of how to produce pressure time history plots is included here for completeness.

2.0 Background

HYDRA uses the Q1P0 element formulation which provides bilinear velocity support in 2D and trilinear support in 3D with piecewise constant pressure. Thus, the solution produces nodal velocities and element centered pressures for evaluation. Originally only nodal velocities were part of the time history edit. We have added the option to produce element pressure time histories in order to enhance data analysis capabilities. Thus, this addition provides a time history edit of element quantities. Further expansion to include the editing of other element quantities (e.g., vorticity, turbulent eddy viscosity) should be fairly straightforward in the future.

3.0 Pressure Time History Control Parameters in HYDRA

The control parameters for activating the pressure (element) time history option are patterned after the parameters for the velocity (nodal) time history option (see page 36, Figure 4.1, and page 47 in HYDRA manual or copy of pages included here in Appendix B). The format is

C The elhist-end block defines the time-history elements

elhist *number of element blocks*

nstep *edit interval*

st *starting number* **en** *end number*

...

end

In the current setup, the edit interval for the element histories (nstep) **must** be the same as that for the nodal time histories.

4.0 Plotting Results with THUG

To accommodate both 2D and 3D simulation data with the same postprocessing tools, THUG traditionally plots 2D results as shell element data. (For output format information see Procassini 1995.) Fortunately, a flag is written to the output file by HYDRA to signal the THUG code that only a limited number of the shell output parameters are written to the time history file (7 instead of the standard 33) so that the 2D time history output is comparable to that in 3D. Another flag signals THUG that nodal data is excluded. (Nodal data is normally included with each element time history to support strain calculations in solid mechanics problems.) Excluding nodal data further reduces the output by 56 parameters per element for hexahedron data and 28 parameters per element for shell data. In 3D and 2D, the parameter to plot with THUG is 'pressure'.

The steps in plotting pressure time histories with THUG are the following

thug -i [<path>]<time history root name>	to run THUG
gather s *starting number-ending number*	for shells (2D pressure elements)
gather h *starting number-ending number*	for hexahedrons (3D pressure elements)
plot press s *starting number-ending number*	for shells
plot press h *starting number-ending number*	for hexahedrons

For a more general description of THUG command syntax, refer to the THUG manual.

References

Christon, M.A. 1995, "HYDRA: A Finite Element Computational Fluid Dynamics Code User Manual", LLNL UCRL-MA-121344.

Procassini, R.J. 1995, "Description of the Plot and Time History Data Bases Currently Used in the MDG Finite Element Codes", LLNL internal document.

Speck, D.E. 1996, "THUG: Time Histories from Unstructured Grids User Manual", UCRL-MA-124586.

Appendix A
Details of Coding Changes

The following is a list of modified files with a detailed description of the code changes.

STORAGE	•	pointer 57 identified for storage of time history element blocks *inls*(2, *nbknl*).
	•	pointer 35 in array *icntl* identified for control variable *nbknl* which is the number of element time history blocks.
	•	pointer 36 in array *icntl* identified for variable *nwnlth* which is the number of words for element time history blocks.
pointers.h	•	*inls* added to common block *ptrs*, dimension statement, and pointer statement.
chkpnt.F	•	subroutine *ckpnt*: included element blocks *inls* in restart file.
	•	subroutine *rstart:* reads *inls* from restart file and allocates memory.
drv2d.F	•	subroutines *fe2d, fead2a, imad2a, p22d, p22dorg,* and *p22dab*: added *inls*, *p*, *rho*, and *nbknl* to call *thnd2d.*
drv3d.F	•	subroutine *fe3d, p23d, p23dorg,* and *p23e*: added *inls*, *p*, *rho*, and *nbknl* to call *thnd3d.*
io.F	•	subroutine *cntlin*: added *nbknl.*
	•	subroutine *ekoctl*: added *nbknl.*
	•	subroutine *getctl*: set default for *nbknl*=0 and added parse of element time history blocks.
	•	subroutine *getmod*: added parse of element time histories, changed call *getthb* to *getthbnd*, and added call *getthbel.*
	•	subroutine *getthbel*: added parse of control file for element time histories.
	•	subroutine *getthbnd*: name of subroutine change from *getthb*
	•	subroutine *modctl*: added write for element time histories.
	•	subroutine *nsinpt*: added output of element time histories as shell elements for 2D and brick elements for 3D.
	•	subroutine *thnd2d*: added write of element data.
	•	subroutine *thnd3d*: added write of element data.
	•	subroutine *wrthnd*: added element data.

Appendix B
Pages from HYDRA Manual Describing Input Format

```
Analysis Title {80 characters or less}
C A "C" followed by a blank space starts a comment line
{Comments may be enclosed in braces as well}
C The mesh-end block describes the mesh parameters
mesh
...
end
C The analyze-end block describes the analysis
parameters
analyze
...
end
C The momsol-end block defines the momentum equation
solver
momsol
...
end
C The ppesol-end block defines the PPE equation solver
ppesol
...
end
C The ndhist-end block defines the time-history nodes
ndhist
...
end            elhist
<-----------      :
end            end
```

Figure 4.1: A Sample HYDRA Control File

4.1.5 Time History Blocks

Time history nodes may be defined to track primitive nodal variables at a small number of nodes where the interval that the data is recorded at is much smaller than for state data. This type of data is useful for detecting steady-state conditions, and for the evaluation of periodic behavior.

Time History Blocks

Keyword	Variable & Meaning
ndhist *n*	Specify n time history nodes (*default*: **n=0**).
st	Starting node number in block.
en	Ending node number in block.
nstep	Time history output interval (*default:* **nstep=1**).
end	Terminate time history block

New input:

elhist *n*	Specify *n* time history elements (*default*: **n=0**).
st	Starting element number in block.
en	Ending element number in block.
nstep	Time history output interval (must be the same as that for nodal time histories).
end	Terminate time history block.