Tutorial for Steam Hammer Analysis using CAEPIPE

The following are the Steps for performing the Steam Hammer Analysis using CAEPIPE.

General

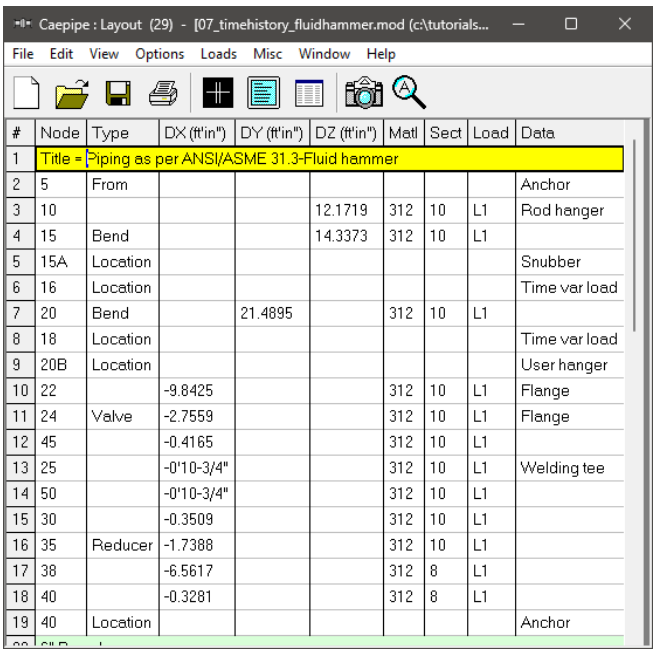
- Fluid Transient analysis is first carried out on the piping system using the Computational Fluid Dynamics (CFD) software such as “PipeNet”, “RELAP”, "ROLAST", etc.
- Most of the CFD software are capable of producing the output (force as a function of time at piping nodes where direction of flow changes such as at bends) in ASCII file format, which then can be read directly into CAEPIPE using the option "Read Time Functions" available in CAEPIPE Layout window > Misc > Time Functions.
- The resulting output thus imported into CAEPIPE are then applied at the corresponding nodes of the pipe stress model where direction of flow changes using “Time Varying Load” data type available in CAEPIPE.
- Specify various parameters for time history analysis in the Time History Analysis Control dialog under CAEPIPE Layout window > Loads > Time History.
- Perform analysis using CAEPIPE and make changes to piping layout and/or changes to support types and their locations, if required, to meet pipe stress analysis requirements.

Tutorial

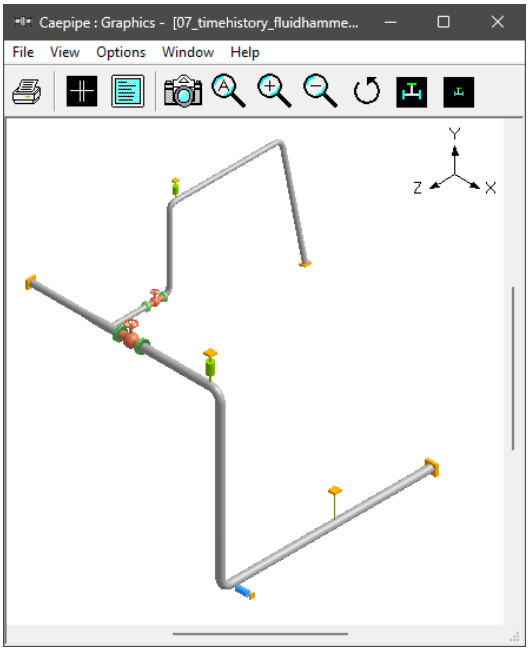
Step 1:

Attached is a sample CAEPIPE model for Steam Hammer System. For the attached model, let us assume the following.

1. Node 5 is connected to the Discharge Nozzle of a Pump.
2. Node 40 is connected to a Turbine Inlet Nozzle.
3. A valve is located between Nodes 22 and 24 to protect the turbine nozzle during tripping.



#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Piping as per ANSI/ASME 31.3-Fluid hammer								
2	5	From							Anchor
3	10				12.1719	312	10	L1	Rod hanger
4	15	Bend			14.3373	312	10	L1	
5	15A	Location							Snubber
6	16	Location							Time var load
7	20	Bend		21.4895		312	10	L1	
8	18	Location							Time var load
9	20B	Location							User hanger
10	22		-9.8425			312	10	L1	Flange
11	24	Valve	-2.7559			312	10	L1	Flange
12	45		-0.4165			312	10	L1	
13	25		-0'10-3/4"			312	10	L1	Welding tee
14	50		-0'10-3/4"			312	10	L1	
15	30		-0.3509			312	10	L1	
16	35	Reducer	-1.7388			312	10	L1	
17	38		-6.5617			312	8	L1	
18	40		-0.3281			312	8	L1	
19	40	Location							Anchor



Caepipe : Materials (1) - [07_timehistory_fluidhammer.mod (c:\tutorials\steam hammer analysis)]

File Edit View Options Misc Window Help

#	Name	Description	Type	Density (lb/in3)	Nu	Joint factor	Yield (psi)	Tensile (psi)
1	312	A312 TP316 (16Cr-12Ni-2Mo)	AS	0.289	0.3	1.00		
2								

#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
1	-325	30.3E+6	8.15E-6	20000
2	-200	29.7E+6	8.47E-6	20000
3	-100	29.0E+6	8.75E-6	20000
4	70	28.3E+6	9.11E-6	20000
5	200	27.6E+6	9.34E-6	20000
6	300	27.0E+6	9.47E-6	20000
7	400	26.5E+6	9.59E-6	19300
8	500	25.8E+6	9.70E-6	17900
9	600	25.3E+6	9.82E-6	17000
10	650	25.1E+6	9.87E-6	16700

Caepipe : Pipe Sections (3) - [07_timehistory_fluidhammer.mod (c:\tutorials\stea...

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#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	6	6"	STD	6.6248	0.28			11	2.5591			
2	8	8"	STD	8.6248	0.322							
3	10	10"	STD	10.75	0.365							

Caepipe : Loads (2) - [07_timehistory_fluidhammer.mod (c:\tutorials\steam ham...

File Edit View Options Misc Window Help

#	Name	T1 (F)	P1 (psi)	Desg.T (F)	Desg.Pr. (psi)	Specific gravity	Add.Wgt. (lb/ft)	Wind Load 1	Wind Load 2	Wind Load 3	Wind Load 4
1	L1	365	145	365	145	0.1					
2	L2	500	464	500	464	0.1					
3											

Step 2:

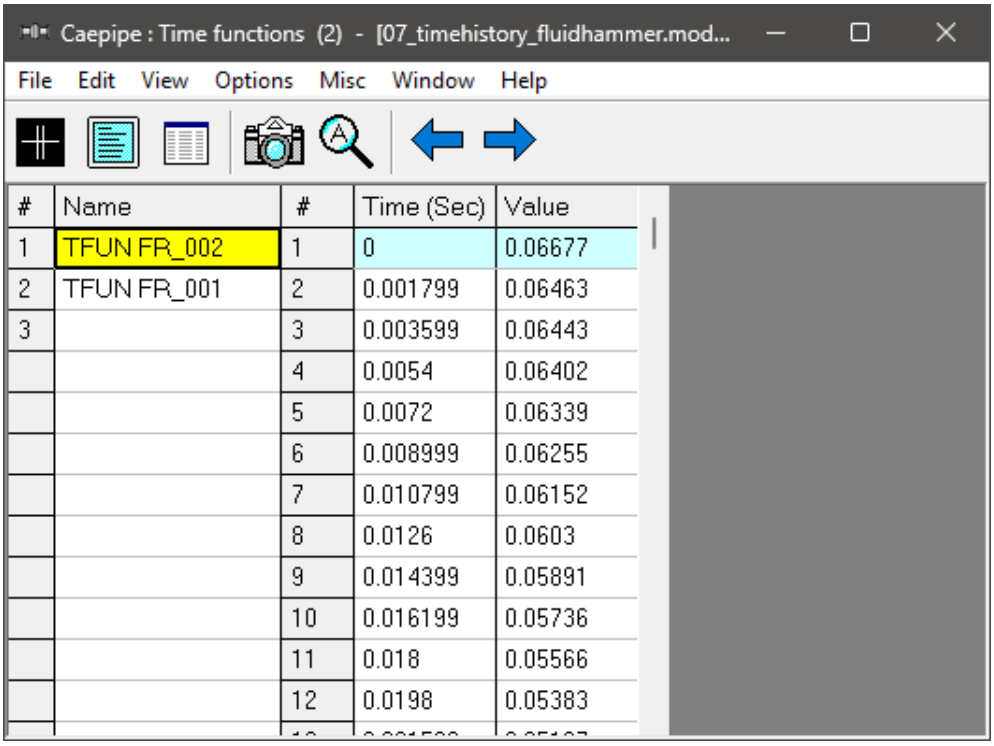
For the sample layout described above, let us assume that the CFD analysis is carried out using the software “ROLAST”. As a result of this simulation, the forces are obtained as a function of time at Bend center nodes 16 and 18 in Global Z direction and Global Y direction respectively.

Step 3:

The forces thus obtained as a function of time at Nodes 16 and 18 are then exported to an ASCII file “SampleSteamHammerLoad.txt” attached herewith. In the attached ASCII file, the value in the first column is time in seconds, while the second column is the force in lbs.

Step 4:

Import this ASCII file into CAEPIPE through Layout window > Misc > Time Functions > File > Read Time Functions. See snap shots below for details.



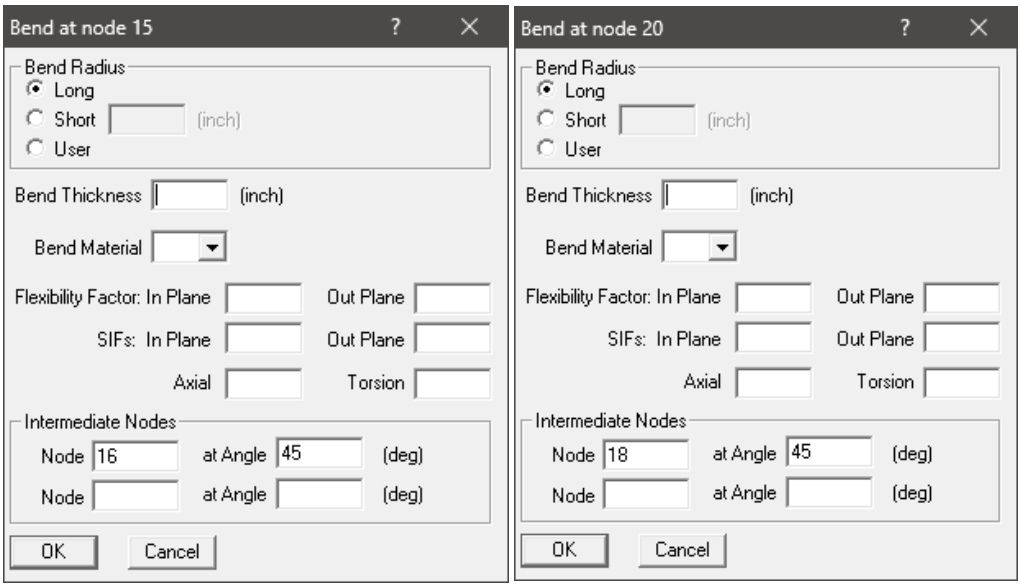
#	Name	#	Time (Sec)	Value
1	TFUN FR_002	1	0	0.06677
2	TFUN FR_001	2	0.001799	0.06463
3		3	0.003599	0.06443
		4	0.0054	0.06402
		5	0.0072	0.06339
		6	0.008999	0.06255
		7	0.010799	0.06152
		8	0.0126	0.0603
		9	0.014399	0.05891
		10	0.016199	0.05736
		11	0.018	0.05566
		12	0.0198	0.05383

Step 5:

Now create Bend Center Node 16 by editing the “Bend at node 15” as shown below.

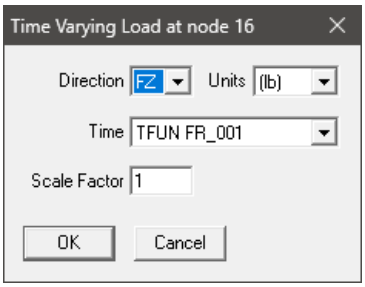
Step 6:

Similarly, create the Bend Center Node 18 by editing the “Bend at node 20” as shown below.



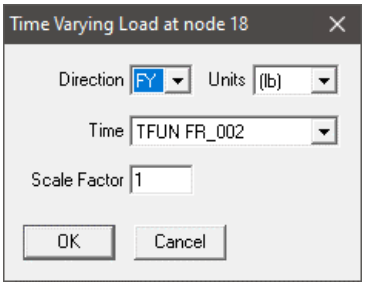
Step 7:

Insert a new row after node “15A” and define a “Location” card with node number as “16”. Add a “Time Varying Load” under data column for node 16 and fill/select the details as shown below.



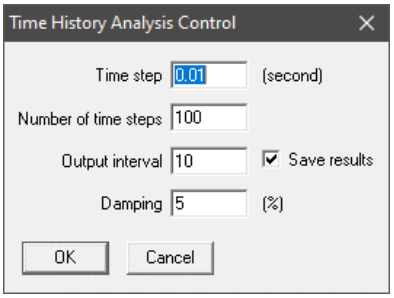
Step 8:

Similarly, insert another row after bend node “20” and define a “Location” card with node number as “18”. Add a “Time Varying Load” under data column and fill/select the details as shown below.



Step 9:

Specify various parameters for time history analysis in the Time History Analysis Control dialog under menu Loads > Time History. See Snap shot below.



Time step

The time step (time interval) at which the analysis is performed should be typically no more than 10% (smaller the better) of the period of the highest frequency of interest, i.e., higher the frequency, smaller the time step, e.g., for a 33 Hz maximum frequency, the time step would be less than 0.003 seconds.

Number of time steps

The time history response is calculated for a total time (seconds) of Time step × Number of time steps. This is how long you want to study system response. The total time may exceed the range of available data in the time function. The time function is only a forcing function. But, CAEPIPE can compute system

response to it well after the forcing function ceases. For example, the effect of a heavy steam hammer could linger on for a minute while your forcing function data could span only 8s (seconds).

Output interval

The output interval is a multiple of time step at which you want CAEPIPE to save (and later display) results. For example, assuming a time step of 0.001s, if you wanted to see results at every 100th time step (0.1s, 0.2s, 0.3s, and so on), enter 100 for output interval. You need to check the "Save Results" checkbox to see these time varying results which are saved in the file <modelname>.rth. If the "Save Results" checkbox is not checked, only the enveloped results are available but not their variation in time. The .RTH files may be big for large models with many time steps (so ensure that you have adequate storage and permission settings).

Damping

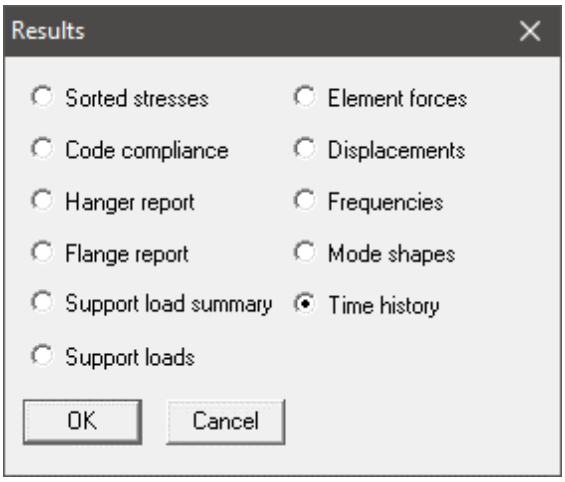
Express the damping factor as a percentage (not as a fraction). Enter 5, not 0.05, for 5% damping.

Step 10:

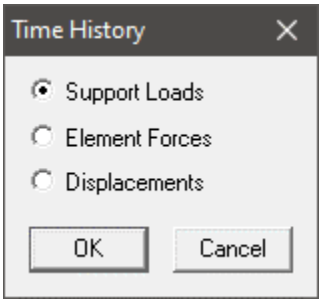
Save the model and perform the analysis through Layout window > File > Analyze. CAEPIPE will apply these loads to compute the response of the piping system by performing a time history analysis along with other load cases defined in the piping system.

Step 11:

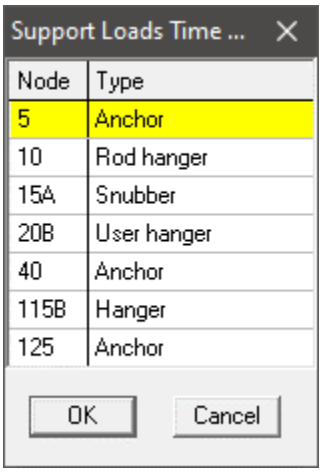
Upon successful analysis, CAEPIPE will now show a new item "Time history" in results dialog as shown below.



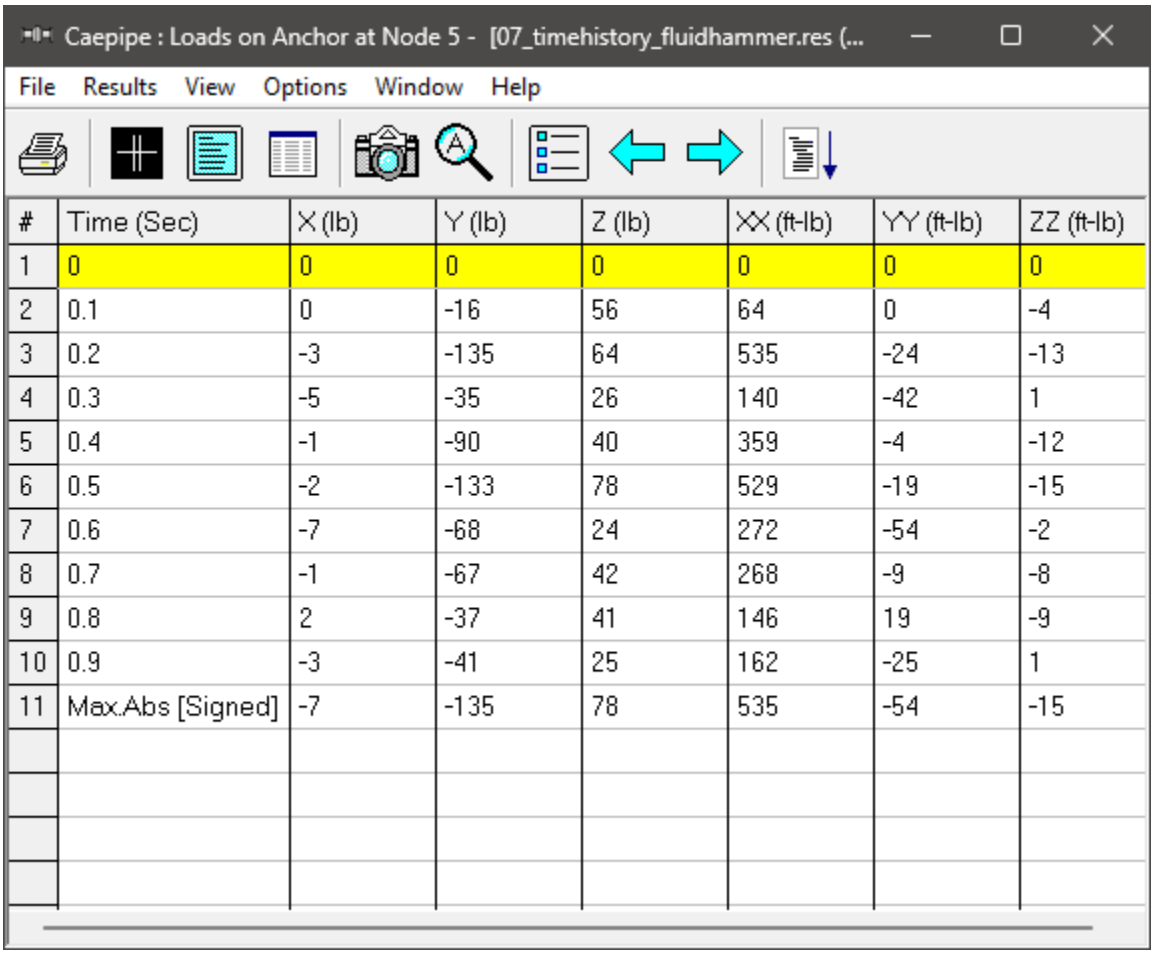
For time history results, you are shown the following dialog from which you need to select an item.



Then, you are shown a list of supports in the model from which you need to select one.



Once you select a support from the list, then you are shown the time history at that location.



#	Time (Sec)	X (lb)	Y (lb)	Z (lb)	XX (ft-lb)	YY (ft-lb)	ZZ (ft-lb)
1	0	0	0	0	0	0	0
2	0.1	0	-16	56	64	0	-4
3	0.2	-3	-135	64	535	-24	-13
4	0.3	-5	-35	26	140	-42	1
5	0.4	-1	-90	40	359	-4	-12
6	0.5	-2	-133	78	529	-19	-15
7	0.6	-7	-68	24	272	-54	-2
8	0.7	-1	-67	42	268	-9	-8
9	0.8	2	-37	41	146	19	-9
10	0.9	-3	-41	25	162	-25	1
11	Max.Abs [Signed]	-7	-135	78	535	-54	-15

While viewing these results, you can export time history results to a comma separated values (.csv) file that can be read by a spreadsheet program such as MS-Excel (see menu File > Export) for further processing.