Tutorial for Jacketed Piping Modeling and Analysis using CAEPIPE

The following are the Steps to perform Jacketed Piping Modeling and Analysis using CAEPIPE.

General

Jacketed piping is used when the primary state of the pipe contents (fuel, chemicals such as resins, etc.) needs to be maintained at a specific temperature during transport. An outer (jacket) pipe surrounds the inner (core) pipe that contains the operating fluid or the chemical. The jacket provides external heating or cooling as required along the length of the core pipe. The terminology used here is as follows:

- **Jacketed** piping refers to the entire assembly, i.e., a core pipe with a jacket on the outside.
- **Jacket** pipe refers only to the outside pipe.
- **Core pipe** refers only to the inside pipe that contains the operating fluid.

In CAEPIPE, jacketed piping need only be modeled once, not twice (as in some other programs). CAEPIPE models the outer jacket pipe along with the inner core pipe on the Layout window. Each row defines a jacketed piping element. The jacket and the core pipes may have different materials, sections and loads (pressures and temperatures).

Tutorial

Snap shot shown below is a sample model for Jacketed Piping Modeling and Analysis. CAEPIPE model file (.mod) and results file (.res) are saved in the .zip file, which can be downloaded from this Tutorial.
Step 1:
First define materials, sections and loads required for Jacket and Core elements through Layout window > Misc > Materials/Sections/Loads. Snap shots shown below for section and load names ending with “J” refer to the sections and loads defined for Jacket elements.

Step 2:
While modeling the stress system with jacketed piping, use the element types “JPIPE” and “JBEND” instead of PIPE and BEND. The details for Jacket Pipe and Jacket Bend are given below.

Jacket Pipe
A Jacketed pipe is input by typing “JP” under Type or selecting “Jacketed pipe” from the Element types dialog. The material, section and load specified in the Jacketed Pipe dialog apply to the jacket pipe, while the corresponding ones mentioned on the layout row (next to offsets) apply to the core pipe.
The jacket’s material, section, and load names are input here (CS, 10J and L1J as shown). CAEPIPE retains the properties of a jacket pipe until changed so there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

In case you are analyzing for wind, it may be more accurate to specify a different load for the core pipe alone that does not specify the Wind load since most of the core pipe is not exposed to Wind load. Same applies to the core pipe insulation if the core pipe does not have insulation.

**Jacketed Bend**

A Jacketed bend consists of a core bend (with a straight portion of core pipe) surrounded by a jacket bend (with a straight portion of jacket pipe).

A Jacketed bend is input by typing “JB” in the Type column or by selecting “Jacketed bend” from the Element types dialog.
**Jacket (properties)**

The jacket’s material, section, and load names are input here. The properties of a jacketed pipe are retained until changed. So, there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

**Core (properties)**

Presently these properties are disabled. You need to enter them on the layout row under Material, Section and Load.

**Bend radius**

Separate bend radii may be specified for the core and the jacket pipes. Note that CAEPIPE does not check for interference between the core and the jacket arising out of differently specified bend radii. The bend radius for the core pipe is generally the same as that of the jacket pipe, since the two bends are generally concentric. Use the Render feature in the Graphics window to check visually for interference between the core and the jacket.

**Bend thickness**

Separate bend thicknesses may be specified for the core and the jacket bends, if they are not the same as the default jacket and core section thicknesses.

**Intermediate nodes**

You can define additional nodes on the outside jacket of a jacketed bend for locating supports. You may also use internal nodes generated by CAEPIPE to locate Data items such as supports, spiders, etc.

**Internal nodes**

CAEPIPE generates a “J” node for jacket pipes. For example, from node 20 to 25, CAEPIPE generates 20J and a 25J as (internal) jacket nodes (that may be referenced on the layout screen).

Similarly, CAEPIPE generates “C” and “D” nodes for the Jacketed bend on the jacket at the near and far ends of the bend. The core pipe bend has its own “A” and “B” nodes. Example: When you define a Jacketed bend from node 78 to the Tangent Intersection node 80, 80A, 80B (nodes on core bend), 80C and 80D (nodes on jacket) are automatically generated. Nodes (80A, 80C) and (80B and 80D) are coincident only if the core and the jacket pipes have the same bend radii.

The “C” and “D” nodes may be used to specify Data items such as supports, forces, etc. on the jacket.

**Step 3:**

At nodes where the jacket terminates, the ends of the jacket and core pipes need to be rigidly connected using the "Jacket end cap" data type. See Node 530 as an example in the attached model.

By specifying “Jacket end cap” at a node, CAEPIPE only considers that the core pipe and the jacket are “tied” at that node and NOTHING more. Weld SIF at that node, if desired, should be explicitly added using “Location” type and the Data item “Weld”. If your weld type is not listed there, you could specify the weld SIF for that node using the “User SIF” Data item. See Node 135 as an example in the attached model.

Also, “Spiders” need to be input at locations found in the physical assembly. You may have to break up the piping into smaller elements to insert spiders at appropriate locations. For example, see Nodes 76 and 78 from the attached model.

Locations where the “Jacket End Caps” and “Spiders” used in the stress system can be viewed through Layout window > View > List > Jacket connections.
Step 4:

Specify Data items such as a Limit Stops, Flanges, Restraints, etc. on the jacket/core at appropriate locations as required.

Step 5:

At the Branch Nodes 30, 110 and 120, both core pipe and jacket are having an “Unreinforced fabricated tee”. Then, the “Unreinforced fabricated tees” on core pipe are to be input at Nodes 30, 110 and 120 using the Data item “Branch SIF”, while the jacket “Unreinforced fabricated tees” have to be specified at Nodes 30J, 110J and 120J using “Location” type and the Data item “Branch SIF”. At all these nodes (30, 30J, 110, 110J, 120 and 120J), you can also add the weld SIFs, again using the “Location” type and the Data item “Weld” or “User SIF”. Please note that CAEPIPE will consider only the higher of the two SIF values (first SIF due to branch and the second SIF due to weld) at these nodes in computing stresses.

Any SIF value specified in the “User SIF” Data item will always overwrite any other SIF value calculated/determined at that node using any other method(s).
**Step 6:**

Save and Analyze the model through File > Analyze. Upon successful analysis, CAEPIPE display Stresses, Displacements, Element forces, Support loads and Support load summary.

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**Jacketed Piping Stresses/Ratios**

The default stress contour is for the core piping. CAEPIPE provides an option for you to display the color-coded stress/ratio contour for jacketed piping in the graphics window context menu. Upon selecting the command, Jacket stresses can be seen as shown below:
### Displacements (global)

<table>
<thead>
<tr>
<th>#</th>
<th>Node</th>
<th>X (inch)</th>
<th>Y (inch)</th>
<th>Z (inch)</th>
<th>XX (deg)</th>
<th>YY (deg)</th>
<th>ZZ (deg)</th>
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<td>0.000</td>
<td>0.000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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<tr>
<td>2</td>
<td>20</td>
<td>0.016</td>
<td>-0.000</td>
<td>-0.001</td>
<td>-0.0067</td>
<td>0.0048</td>
<td>-0.0033</td>
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<tr>
<td>3</td>
<td>20J</td>
<td>0.016</td>
<td>0.000</td>
<td>0.001</td>
<td>-0.0067</td>
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<td>-0.0033</td>
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<tr>
<td>4</td>
<td>25</td>
<td>0.039</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.0168</td>
<td>0.0045</td>
<td>-0.0097</td>
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<tr>
<td>5</td>
<td>25J</td>
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<td>6</td>
<td>30</td>
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<td>0.0231</td>
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<td>7</td>
<td>30J</td>
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<td>8</td>
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<td>-0.002</td>
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<tr>
<td>9</td>
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<td>-0.001</td>
<td>-0.0209</td>
<td>0.0053</td>
<td>-0.0159</td>
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<tr>
<td>10</td>
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<td>0.000</td>
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<tr>
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### Loads on Anchors: Operating (W+P1+T1)

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<tr>
<th>#</th>
<th>Node</th>
<th>FX (lb)</th>
<th>FY (lb)</th>
<th>FZ (lb)</th>
<th>MX (ft-lb)</th>
<th>MY (ft-lb)</th>
<th>MZ (ft-lb)</th>
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<tr>
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<td>3</td>
<td>530</td>
<td>32</td>
<td>-54</td>
<td>-61</td>
<td>-78</td>
<td>-73</td>
<td>-134</td>
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<td>-9</td>
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<tr>
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### Support load summary for anchor at node 10

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<th>Load combination</th>
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<th>FY (lb)</th>
<th>FZ (lb)</th>
<th>MX (ft-lb)</th>
<th>MY (ft-lb)</th>
<th>MZ (ft-lb)</th>
<th>Displacements (global)</th>
<th>X (inch)</th>
<th>Y (inch)</th>
<th>Z (inch)</th>
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<td>498</td>
<td>506</td>
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<td>Minimum</td>
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