# Release Notes: Plate-Frame Module

INSTED Ver. 9.0

**TTC TECHNOLOGIES, INC.**

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# Release Features

## INSTED Ver. 9.0

The most recent version of INSTED (Ver. 9.0) includes significant re-design, enhancements, and changes to the Plate-Frame module in INSTED. The new features include the following:

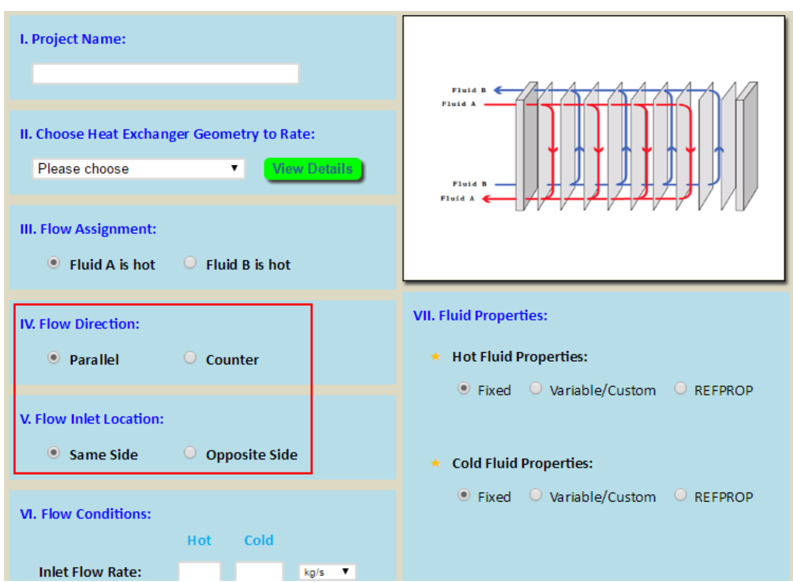
### *Improved Support for Multi-Pass Plate-Frame Calculations*

In INSTED 9.0, a new parameter "Flow Inlet Location" has been added to help define the different configurations of multi-pass flows in a plate frame heat exchanger (PHE). Together with the "Flow Inlet Direction," different multi-pass configurations can be defined. Details can be found in the Appendix of this Release Notes. The definition of these parameters is as follows.

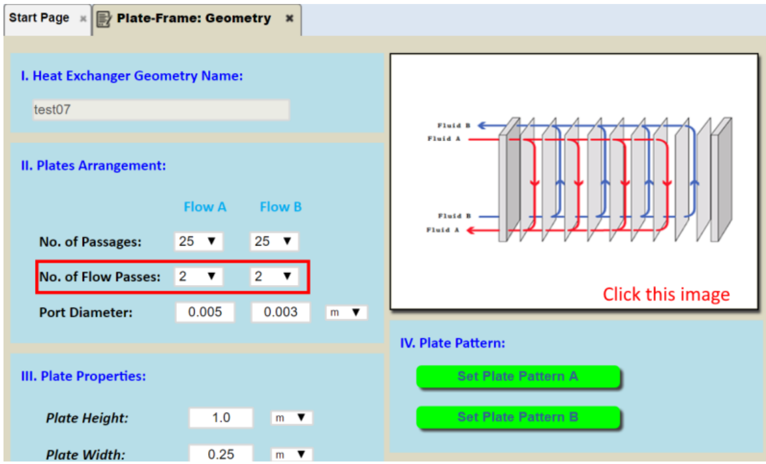
| | | |
|---|---|---|
| **Flow Inlet Direction** | ***Parallel*** | Stream inlets are both located at the top or bottom of the heat exchanger |
| | ***Counter*** | One stream inlet is located at the top and the other at the bottom of the heat exchanger |
| **Flow Inlet Location** | ***Same Side*** | Stream inlets are both located at the left or at the right side of the heat exchanger |
| | ***Opposite Sides*** | One stream inlet is located at the left side and the other at the right side of the heat exchanger |

Note that the PHE module currently does not support flow maldistribution from port to channel. Therefore, some configurations are mathematically identical and will return the same calculation results.

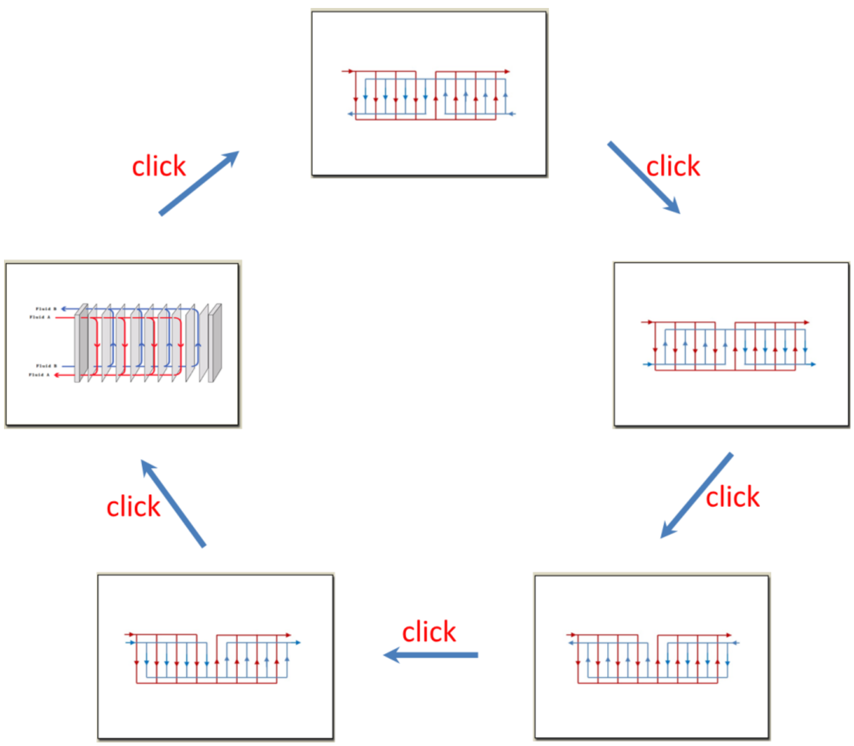
The GUI looks like the one below:



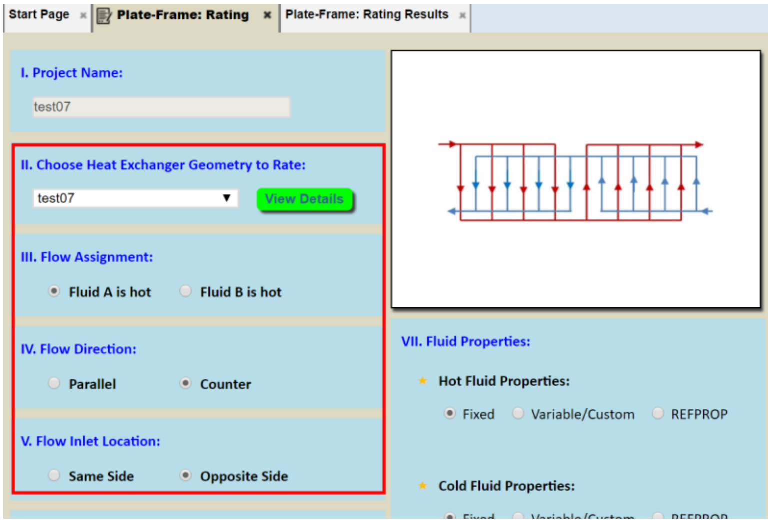
When defining the heat exchanger geometry, the number of flow passes can be defined:



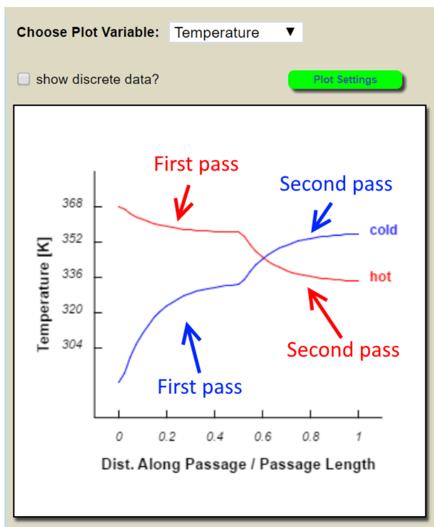

By repeatedly clicking the heat exchanger image in the GUI, all the supported multi-pass PHE configurations will be shown:




When rating a PHE, after choosing particular heat exchanger geometry, the GUI for entering the parameters required for the configuration will be shown (below).




In the results for the Rating task, the effects of having a multi-pass configuration can be observed in the plots of the distribution of certain variables, such as temperature, along the flow passage. This is evident in the figure below.

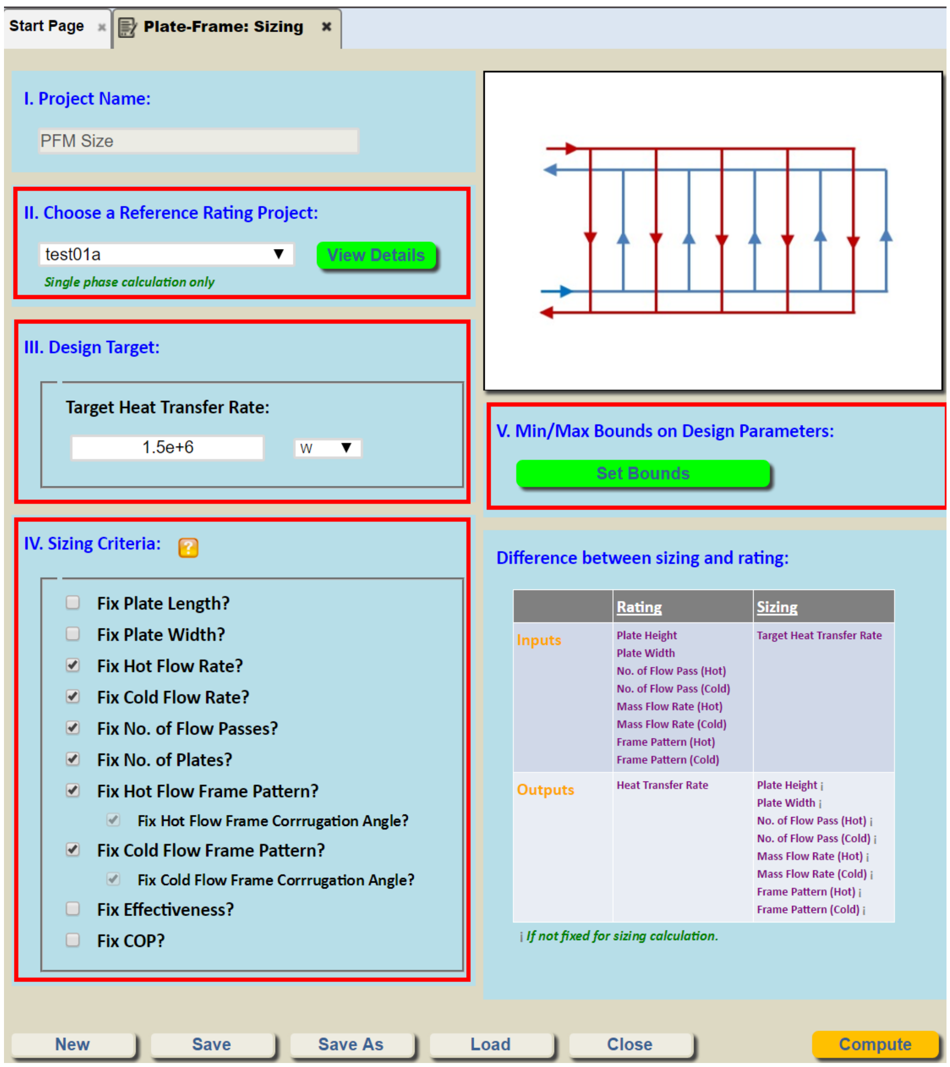


## *Sizing & Optimization using the Genetic Algorithm*

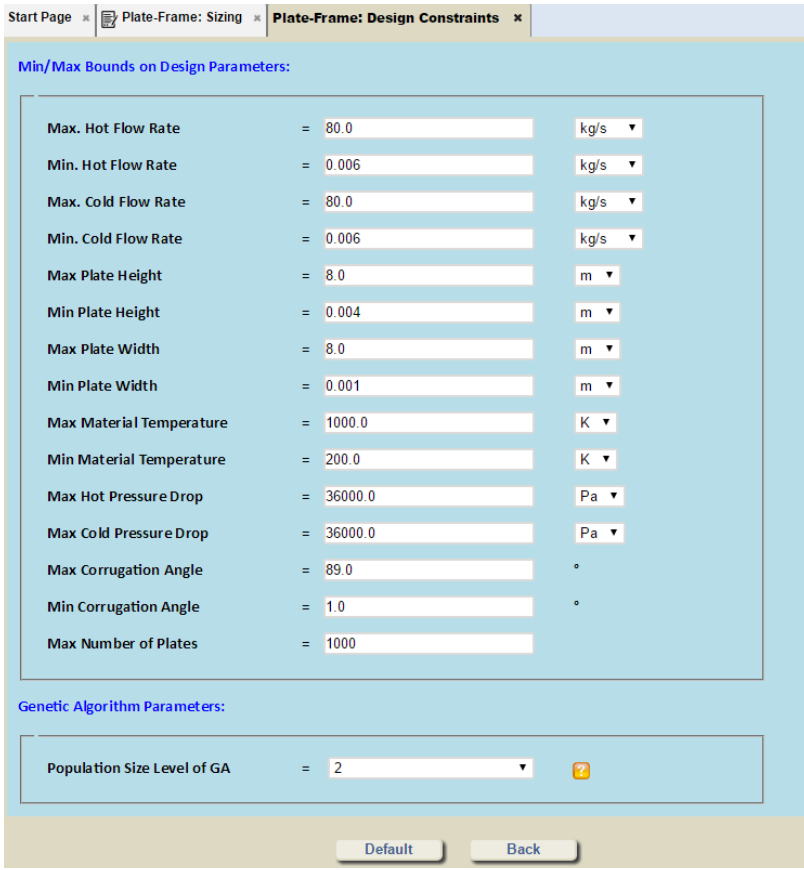
In INSTED 9.0, Sizing and Optimization functionalities have been added to the PHE module. Similar to the Plate-Fin module, both the Sizing and Optimization solvers are based on the generic algorithm. During calculation, design realizations will be suggested to you by the code based on your specified design targets and bounds.

### *Sizing*

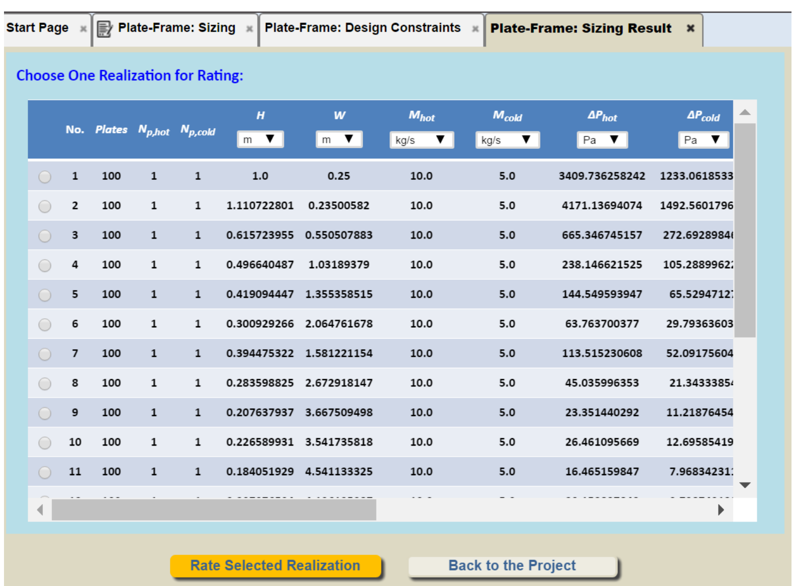
For Sizing, after choosing a reference Rating Project which provides a template for the problem to be sized, you can specify a target heat transfer rate with some additional design criteria. The GUI for this is shown below.




You can specify the bounds on the design parameters by clicking the “Set Bounds” button. The GUI is shown below.




After you have clicked on “Compute” button, the code will begin execution, and, upon completion, will list all the possible design realizations that satisfy the design target. The dialog box containing the list of realizations is shown below.




You can choose any design realization from this table and click the “Rate the Selected Realization” button in order to rate the selected realization.


You may save the selected realization into a regular Rating project by clicking the "Save to a Regular Rating Project" button. The results of rating may be exported into a downloadable Excel file by clicking on the "Download Realization Data" button.

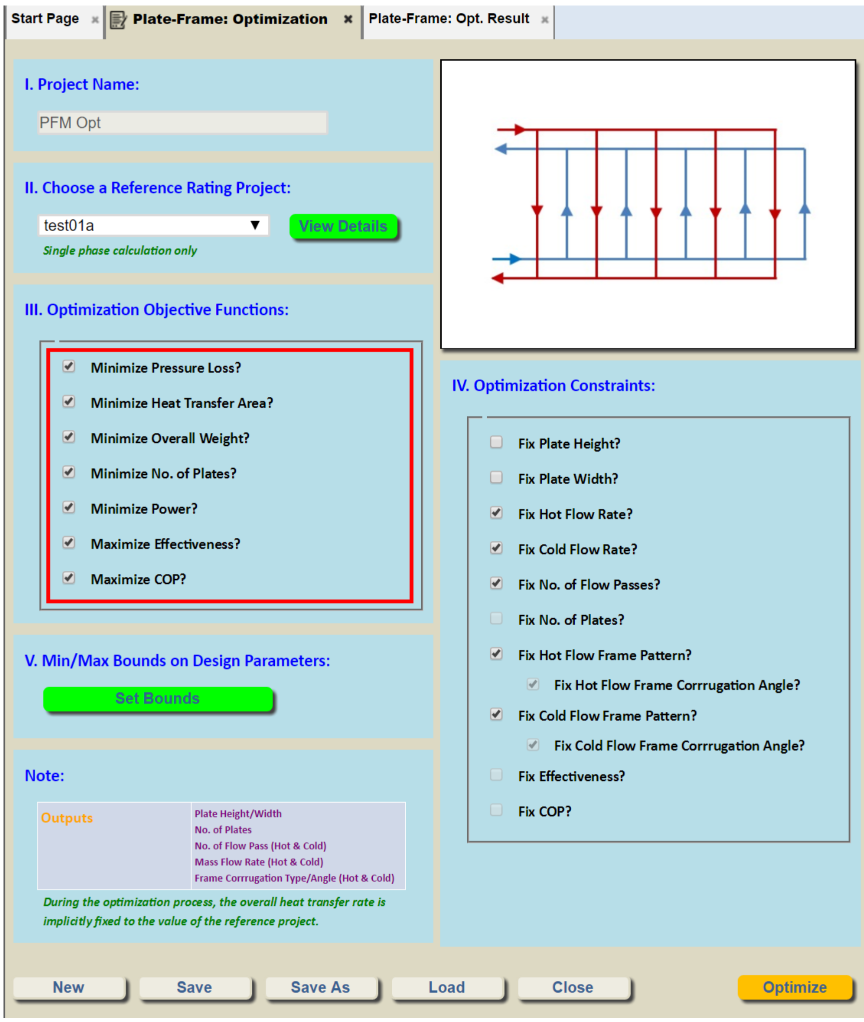
| HX Problem Statement | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Operating Conditions -Hot | | | | Operating Conditions -Cold | | | | HX Core Design Input | | | | HX Core Dimensions | | | | | |
| Fluid Type | Flow Rate | Tin | Pin | Fluid Type | Flow Rate | Tin | Pin | t-sp | t-ep | port-dia-hot | port-dia-cold | P-L | P-W | L-NF/S | Np-h | Np-c | W |
| [-] | [kg/s] | [K] | [Pa] | [-] | [kg/s] | [K] | [Pa] | [m] | [m] | [m] | [m] | [m] | [m] | [m] | [-] | [-] | [kg] |
| | 10 | 368.16 | 0 | | 5 | 288.16 | 0 | 3E-09 | 0 | 0.005 | 0.005 | 1.1107 | 0.25 | 0.5 | 50 | 50 | 0.0002 |

## *Optimization*

The procedure for optimization in INSTED PHE is in general similar to that for sizing, However, the former also attempts to find design realizations can achieve the same heat transfer rate as in the reference project, as well as achieving one or more of the following optimization targets:

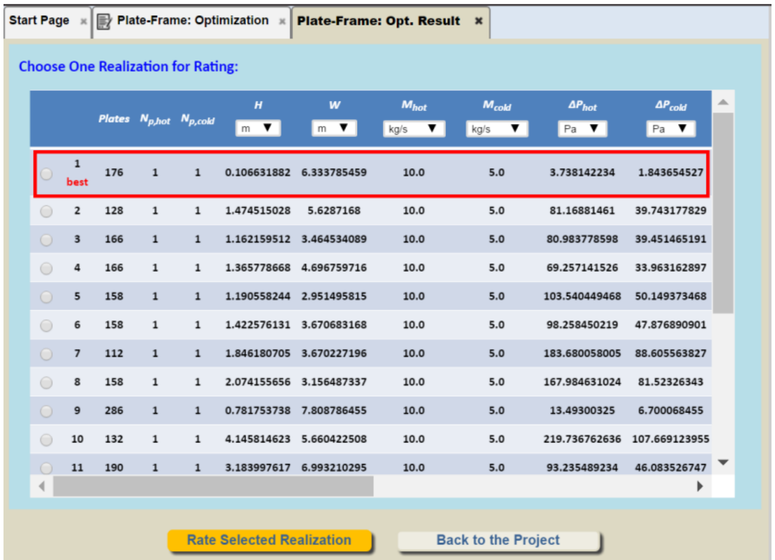
- Minimize Pressure Loss
- Minimize Heat Transfer Area
- Minimize Overall Weight
- Minimize No. of Plates
- Minimize Power
- Maximize Effectiveness
- Maximize Cop

The relevant GUI for this setting is shown below.




Similar to the Sizing module, after specifying the bounds on the design parameters and chosing the design constraints, you can click the “Compute” button to start the Optimization calculations. When the calculations have been completed, all possible design realizations that satisfy the design target will be listed in a table. The list of the realizations is sorted based on how well the realizations satisfy the optimization targets. The best one is placed at the top of the table.

The dialog box containing the list of realizations is shown below.

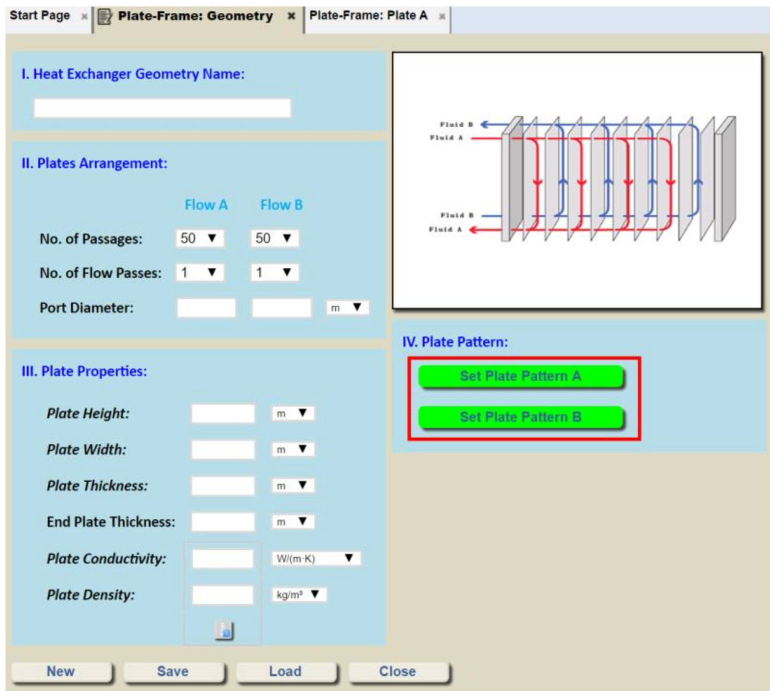


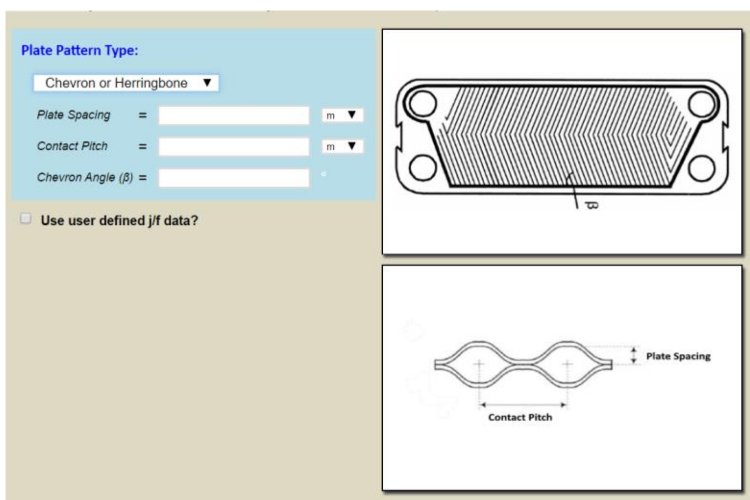

| | Plates | $N_{p,hot}$ | $N_{p,cold}$ | H (m) | W (m) | $M_{hot}$ (kg/s) | $M_{cold}$ (kg/s) | $\Delta P_{hot}$ (Pa) | $\Delta P_{cold}$ (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| 1 best | 176 | 1 | 1 | 0.106631882 | 6.333785459 | 10.0 | 5.0 | 3.738142234 | 1.843654527 |
| 2 | 128 | 1 | 1 | 1.474515028 | 5.6287168 | 10.0 | 5.0 | 81.16881461 | 39.743177829 |
| 3 | 166 | 1 | 1 | 1.162159512 | 3.464534089 | 10.0 | 5.0 | 80.983778598 | 39.451465191 |
| 4 | 166 | 1 | 1 | 1.365778668 | 4.696759716 | 10.0 | 5.0 | 69.257141526 | 33.963162897 |
| 5 | 158 | 1 | 1 | 1.190558244 | 2.951495815 | 10.0 | 5.0 | 103.540449468 | 50.149373468 |
| 6 | 158 | 1 | 1 | 1.422576131 | 3.670683168 | 10.0 | 5.0 | 98.258450219 | 47.876890901 |
| 7 | 112 | 1 | 1 | 1.846180705 | 3.670227196 | 10.0 | 5.0 | 183.680058005 | 88.605563827 |
| 8 | 158 | 1 | 1 | 2.074155656 | 3.156487337 | 10.0 | 5.0 | 167.984631024 | 81.52326343 |
| 9 | 286 | 1 | 1 | 0.781753738 | 7.808786455 | 10.0 | 5.0 | 13.49300325 | 6.700068455 |
| 10 | 132 | 1 | 1 | 4.145814623 | 5.660422508 | 10.0 | 5.0 | 219.736762636 | 107.669123955 |
| 11 | 190 | 1 | 1 | 3.183997617 | 6.993210295 | 10.0 | 5.0 | 93.235489234 | 46.083526747 |

## Improvements to Chevron Corrugations

In INSTED 9.0, for the PHE with chevron-type corrugation, the following improvements have been made:

1) In the previous version of INSTED, the chevron corrugation must be identical for both streams. In INSTED 9.0, different corrugation parameters, such as the corrugation angle and contact pitch, can be set for each side of the streams. The GUI is shown below.

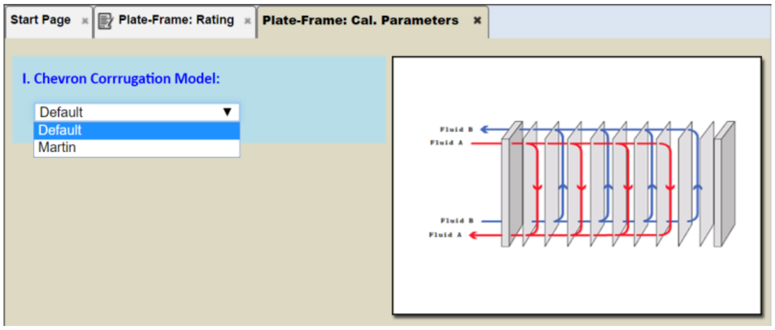



2) Martin's new j/f correlation model is now supported in the solver.

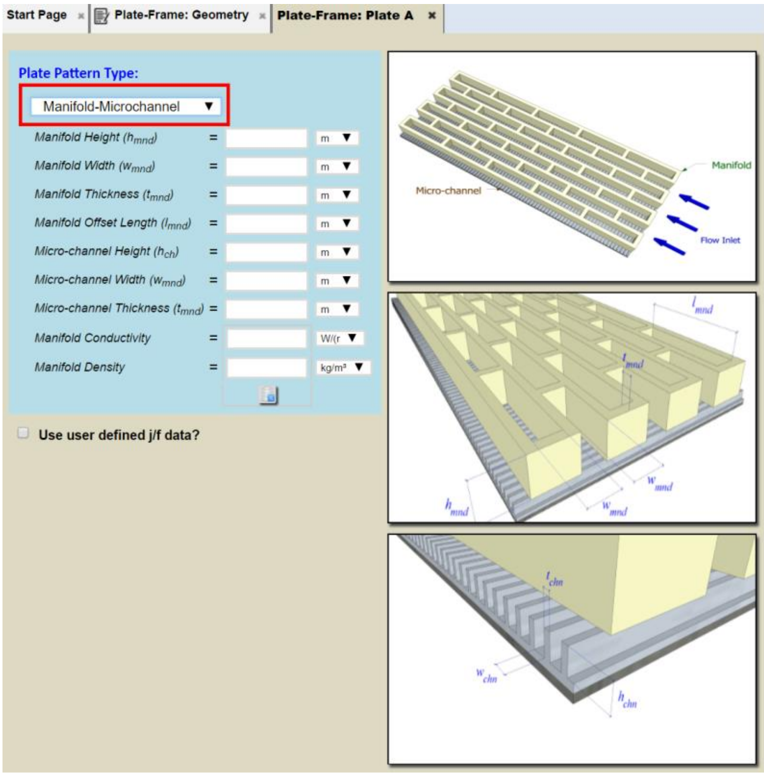
Reference: Martin, Holger, "A theoretical approach to predict the performance of chevron-type plate heat exchangers." Chemical Engineering and Processing: Process Intensification 35, no. 4 (1996), pp. 301-310.

You can choose the j/f correlation model to use from the “Set Calculation Parameters” button in the rating project.



## Support for Manifold-Microchannel Fins Model

In INSTED 9.0, a new type of plate heat exchanger: Manifolds-Microchannel PHE exchanger is now supported for rating, multiple rating, sizing, and optimization calculations. The GUI where you define the manifolds-microchannel is shown below.

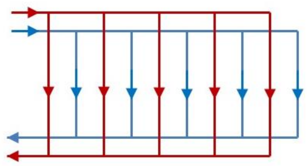
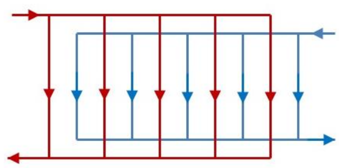
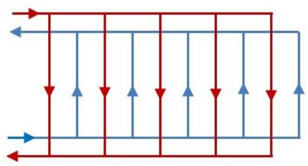
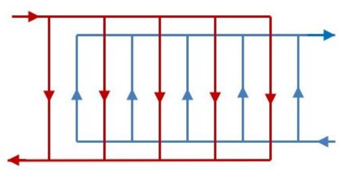


## *More Sample Validation Problems:*

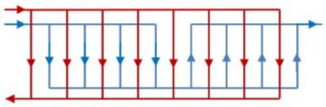
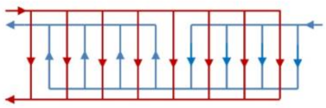
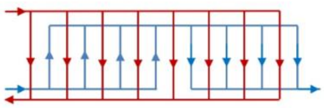
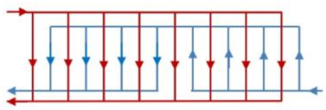
In INSTED 9.0, new sample problems have been added for plate-frame module. You may copy the sample problems into your account and run them to get familiar with the new plate-frame module in INSTED and validate the code.

## *Appendix: Illustration of Multi-Pass Configurations*

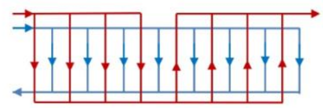
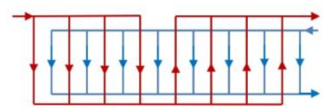
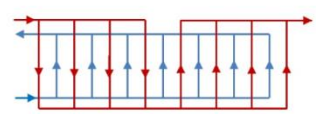
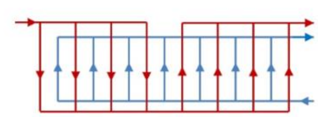
**1-by-1**

| | Hot Passes | Cold Passes | Inlet Flow Direction | Inlet Location | PHE Configuration |
|---|---|---|---|---|---|
| #1 | 1 | 1 | Parallel | Same side |  |
| #2 | 1 | 1 | Parallel | Opposite side |  |
| #3 | 1 | 1 | Counter | Same side |  |
| #4 | 1 | 1 | Counter | Opposite side |  |

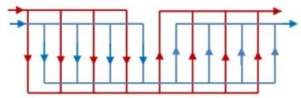
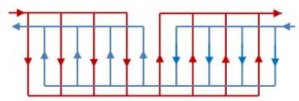
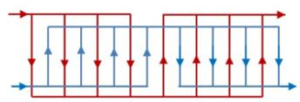
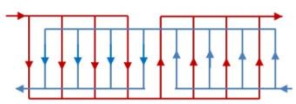
**1-by-2**

| | Hot Passes | Cold Passes | Inlet Flow Direction | Inlet Location | PHE Configuration |
|---|---|---|---|---|---|
| #1 | 1 | 2 | Parallel | Same side |  |
| #2 | 1 | 2 | Parallel | Opposite side |  |
| #3 | 1 | 2 | Counter | Same side |  |
| #4 | 1 | 2 | Counter | Opposite side |  |

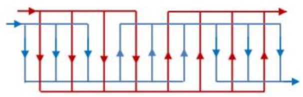
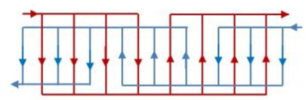
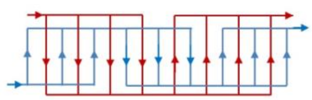
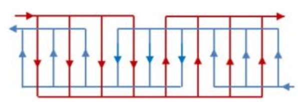
**2-by-1**

| | Hot Passes | Cold Passes | Inlet Flow Direction | Inlet Location | PHE Configuration |
|---|---|---|---|---|---|
| #1 | 2 | 1 | Parallel | Same side |  |
| #2 | 2 | 1 | Parallel | Opposite side |  |
| #3 | 2 | 1 | Counter | Same side |  |
| #4 | 2 | 1 | Counter | Opposite side |  |

**2-by-2**

| | Hot Passes | Cold Passes | Inlet Flow Direction | Inlet Location | PHE Configuration |
|---|---|---|---|---|---|
| #1 | 2 | 2 | Parallel | Same side |  |
| #2 | 2 | 2 | Parallel | Opposite side |  |
| #3 | 2 | 2 | Counter | Same side |  |
| #4 | 2 | 2 | Counter | Opposite side |  |

**M-by-N**

| | Hot Passes | Cold Passes | Inlet Flow Direction | Inlet Location | PHE Configuration |
|---|---|---|---|---|---|
| #1 | 2 | 3 | Parallel | Same side |  |
| #2 | 2 | 3 | Parallel | Opposite side |  |
| #3 | 2 | 3 | Counter | Same side |  |
| #4 | 2 | 3 | Counter | Opposite side |  |