

## Advanced Simulation Pressure-Flow Solver (MYNAH Technologies MiMiC v3.3 )

### Brief description

The pressure-flow (P-F) solver is a generalized object that operates at the level of the simulation process flow sheet of the Mimic model. The solver acts on the objects of one process flow sheet, providing calculation of the pressure values for the objects in the simulation flow sheet. The calculated pressure values are applied then for evaluation of the flow rates between the objects of the flow sheet.

The number of the P-F solver generalized objects in the MiMiC model is limited only by the intended extent of advanced simulation in the model and computational resources of the simulator. In this way, we can provide flexibility of the model fidelity levels, by combining in one simulation the model segments that need the advanced objects and P-F solver with more simple segments that need just basic balance simulations.

In the P-F solver the process flow sheet is considered (represented) as a local **flow network** that includes the **Nodes** and **Transport Units**, connecting these nodes. The advanced objects of the simulation flow sheet are mapped to the flow network as follows.

The nodes of the flow network are defined as **Active** and **Passive** nodes. The active nodes include the accumulation objects that have their own models for the pressure calculation (such as **Separator** and **Vessel** objects, containing the vapor holdup, the **Distillation Column** objects). The active nodes include also the compressors and pumps that calculate head and outlet pressures depending on its state (ON/OFF) and flow demand at the outlet of this unit. The passive nodes include the **Stream Tee** objects, serving for connections (junction and branching of the streams) of the advanced unit operations.

The transport units are the directed edges of the flow network graph. The P-F solver uses the transport units for calculation of the pressure values at the passive nodes and flow rates between the nodes. The transport units include the **Stream object** with specified **conductance Cv** (represents the pipe segment, connecting two nodes) and/or the combination of **two Stream objects** and **Valve object**, representing the serial connection Stream - Valve – Stream.

The main challenges in development of the P-F solvers that are being addressed:

**Handling the flow network integrity.** The entire network can be broken into the several subnets due to dynamically (on-line) changing conditions

- the conductance of some of the transport units become zeroes (the valve is closed or the pipe is plugged)
- switching ON and OFF the pumps and compressors

- Check valves in the situations when the downstream pressure of the valve becomes higher than upstream one
- Dead End and Isolated nodes, resulting from dynamically changing topology of the flow network

The above situations can lead to singularity of the original flow network structure that results in incorrect calculations of the pressures and flow rates or even a crash of the P-F solver.

**Initialization of the flow network.** The calculation of the flow network should be able to start from any arbitrary initial state. The P-F solver should correctly initialize the given process flow sheet in the situations when the other flow sheets are already running dynamically and/or some changes were made only for some object of the given flow sheet. The cold start initialization (when the pumps/compressors have not started yet and most of the valves are closed) should also be provided.

**Handling integrity/continuity of the multicomponent streams.** The P-F solver should be able to provide a correct calculation of the phase change for the multicomponent streams along the network that occur due to the pressure drop at the transport units and/or due to mixing of the stream at the nodes. Therefore, the system should include the reliable on-line vapor fraction calculation of the stream vapor fraction, i.e. the reliable and fast flash calculations.

A remark on the use of the valve characteristics:

In the MiMiC P-F solver the valve nonlinearities are not handled directly. These nonlinearities along with the valve position are located in the stream conductance, which combines the current values of the valve position and valve flow coefficients. The last values, in turn, can depend on the current valve position, pressure drop, stream media, and other factors. In this way, we can separate the different effects impacting the flow and allow the user to control the simulation fidelity he/she needs for the given application.