EngineeredSoftware, Inc.

Using Fluid Flow Software in Plant Operations

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Introduction

Fluid flow software provides a clear picture of how a piping system operates by calculating the flow rates and pressures in the system. Initially this software was mainly used to design the piping system, but recently more plant personnel are using this type of software to simulate the operation of existing fluid piping systems.

To become more useful for plant personnel, the software has to be easy to use while showing the interaction of the pipelines, pumps, components, and control valves in the system. In addition, the information has to be easy to share with others and provide access to information needed to operate and maintain the fluid piping system.

This white paper describes how PIPE-FLO, a fluid flow computer program developed by Engineered Software, provides owners and operators of piping systems with the tools they need to gain a clear picture of their system operation. Examples are presented that show how this software is currently meeting the needs of the plant operating market.

Total Picture

To be effective in the plant operating market, the piping software must provide the user with sufficient information to design, build, operate, and maintain the system through the plant life. The total picture provides the user with information he or she needs to fully understand the operation of the system.

To provide this total picture, PIPE-FLO includes the following features:

- A piping schematic showing how the items in the system are connected.
- A calculation engine capable of showing the flow rates and pressures within the piping system and highlighting problem areas.
- The ability to easily communicate with others as to how the system operates.
- Access to information needed to design, build, operate, and maintain the piping system.

Other programs can provide the user with one or more of the necessary features, but the value of PIPE-FLO is the integration of these tasks into a single application.

Visualization

The first step is providing the user with a clear picture of how the items in a piping system are connected. Piping schematics show the location of tanks, pumps, components, control valves, and pipelines and how they are connected. A piping schematic identifies each item in the system using the project's equipment naming convention.

Piping schematic drawings can be created using CAD software, providing the user with the ability to easily maintain these design documents. General-purpose CAD software has a long list of features making it useful for other types of drawings as well. But the large feature set of CAD software results in a steep learning curve one must overcome to effectively utilize the software.

During PIPE-FLO's development, the drawing features were limited to those needed to develop a 2-D piping schematic. This approach makes it much easier to learn how to use the software.

PIPE-FLO's drawing feature set includes the ability to:

- Place pre-defined piping system objects (tanks, pumps, components, control valves, and pipelines) on the schematic drawing.
- Name items on the schematic drawing using the plant customer's naming convention.
- Insert text and call out boxes on the piping schematic providing greater presentation value to the schematic drawing.
- Incorporate typical CAD features such as zoom, pan, snap, edit, object copy, and group copy to make it easier to create and update the piping schematic.

PIPE-FLO uses the piping schematic in each stage of the process such as selecting the object to enter or edit data, viewing piping system information and displaying calculated results.

Calculation

PIPE-FLO calculates the balanced flow rates and pressures in piping systems. It can handle open or closed loop systems, as well as series, branching, and parallel flow paths.

The following features are included in PIPE-FLO's calculation engine:

- The piping schematic drawing is used to automatically set up the equations necessary to calculate the balanced flow rates and pressures.
- Engineering data tables store pipe, valve, and fluid properties needed to calculate the balanced flow rates and pressures.
- Sizing rules and design limits assist the user in optimizing individual pipelines during the design process.
- The software uses the calculated results to assist in selecting and inserting pump and control valves from manufacturer supplied Electronic Catalogs.
- The ability to set up and save various operating scenarios or lineups so the user can see how the system operates under a variety of expected operating conditions.

This approach also allows the user to optimize the piping system as it is being built, providing a better final design. Using these calculation techniques, the user is able to quickly build the piping system model without having to get involved with the program's inner workings.

Communications

Communication is necessary to insure the various groups involved in the project have a clear understanding of how the piping system is to be built and operated.

To insure a system is built to meet the requirements of the end user, specification documents are developed outlining the methods for each item's design, construction, and testing.

During the design process the information must be checked and reviewed by other members of the design team. After the system design is completed, the owner of the piping system must review the information.

To accomplish these various communication tasks, PIPE-FLO:

- Uses pipe specifications to outline the pipe material and valve tables for various piping applications.
- Saves pipe specifications in design files which can be used as templates when creating a new system.
- Engineering data tables can be modified to provide further design control.
- All program reports can be printed to Portable Document Format (PDF) files and e-mailed directly from PIPE-FLO.
- Projects can be shared with others in a Piping System View (PSV) file format; using the free PIPE-FLO Viewer program, the PSV file can be opened and the recipient can see how the system operates.

The ability to communicate with others insures everyone involved with the project has access to all the information needed to design, build, operate, and maintain a fluid piping system.

Access

Many of the documents required to design, build, operate and maintain a fluid piping systems are available in electronic format. Using the program's FLO-Link feature, hypertext links can be created within the FLO-Sheet to design documents located on the Internet or on a network. For example, a pipeline on the FLO-Sheet can have a FLO-Link to the piping isometric drawing done under a CAD program. Links can be created to maintenance manuals, spare parts lists, and dimensional drawings.

FLO-Links can also be used to start other programs. For example, a FLO-Link associated with a pump on the FLO-Sheet can start up the plant's maintenance management software and display the maintenance history for the selected pump.

Building the System Model

Building the system model involves entering the details about each item in the piping system. Much of the information needed to build the model is obtained during the design process. It is always best to create the model during the design process and keep the model current through construction and startup. This allows you to turn over a completed piping system model to the client as part of the required design package.

Design document

The PIPE-FLO project file provides the user with the ability to store and update piping system design details as they become available. For example, when doing a preliminary design the pipe diameter and number of isolation and check valves is determined. The length of pipe and number of elbows is approximated. Once the pipe routing is completed, the exact length of pipe and number of elbows is known, and the piping system model can be updated.

As the various design and equipment document packages become available, FLO-Links can be added to the PIPE-FLO model. By creating the FLO-Links when the information becomes available, the piping system model is always current and can be used to quickly access information about each item in the piping system.

At the end of the design phase, the engineering documents can be turned over to construction for use in building the system.

Construction document

During the construction process, the design documents are used to build and test the system.

In this phase of the project, field changes are often necessary to accommodate changes in pipe routing or changes in the system design. If the modifications involve adding pipe length, elbows, or changes to the pipe sizes, the piping system model can be quickly updated and calculations performed to show the effect these changes have on the piping system operation.

During plant startup and testing, the PIPE-FLO model provides the plant startup engineers with a model that shows how the system will operate. This information is very useful during startup because much of the equipment testing is done with the equipment running in abnormal operating conditions. Using PIPE-FLO, a copy of the design model can be created and the operating conditions can be adjusted to reflect how the test will be run.

PIPE-FLO can also be used while flushing the piping system to remove construction debris. A copy of the piping system model can be created and the startup engineer can insert the strainers, filters and piping jumpers needed to flush the system. PIPE-FLO can then calculate the flush velocities for each flush path. In addition, PIPE-FLO can calculate if a pump is operating off of its pump curve due to abnormal operating conditions encountered during the flushing operations.

The PIPE-FLO model also shows how the system should operate under various pre-operational test conditions. Many of these tests are performed at off-normal operating conditions and a piping system model provides indication of how the system will operate during these tests.

Finally, the program can calculate the valve positions needed to balance the flow rates in the piping system.

Validating the model

After the system is built and while it is put into operation, the piping model should be validated. The PIPE-FLO model shows how the system is designed to operate. The plant instrumentation shows how the plant is actually operating. If the PIPE-FLO model matches the observed plant operating conditions, the model accurately reflects the actual system operation and it is a valid model.

Once the validation is performed for a variety of operating conditions, the model can be used to predict system operation under any possible set of operating conditions.

Troubleshooting System Operations

After the system has been turned over to the operating plant, the PIPE-FLO model can be used to troubleshoot system operation. If the predicted results of the piping system model do not agree with the observed plant operating data, then either the model is incorrect, or something in the piping system is not operating as designed.

This information can be valuable in troubleshooting a piping system. For example if the flow rate through a system is low, the problem could be caused by a:

- Valve out of position
- System blockage
- Pump problem
- Control valve problem

A piping system lineup can be created so the model is set up exactly like the real system is operating. By comparing the observed values of the operating system with the piping system model, one can quickly isolate the problem and, more importantly, determine what can be done to return the system to normal operation.

Plant Improvements & Modifications

During the life of the plant, changes will be made to system because of process changes, the addition of new loads, or the need to increase capacity. Using the existing piping system model, the project engineer can see how the required changes will affect the operation of the system. For example, an engineer in a chemical plant in Deer Park Texas was faced with the need to increase the capacity of a service water system. It was determined that an additional pump in parallel should be added to increase the system capacity.

After the plant engineer evaluated the piping system with PIPE-FLO, he noticed that over 1/3 of the system losses occurred in a 90 ft section of the 36-inch pump discharge header. Using the PIPE-FLO, model he determined that if the 36-inch discharge header was replaced with a 48-inch header, the existing pump could handle the additional system load. The resulting reduction in pipeline loss in the discharge header eliminated the need to add a third pump, resulting in a savings in capital cost of over $100,000. This modification also reduced the system headloss, resulting in lower pumping costs.

Training & Operations

Plant operating personnel need to know how the plant will operate during a variety of conditions. They can either gain that experiencing by actually putting the plant into that condition, or they can simulate the operation using piping analysis software.

In many cases, the piping system is infrequently operated at given conditions, such as startup or shutdown, making it difficult for operating personnel to obtain necessary experience. In other cases the system cannot be operated in that condition due to operational requirements.

Using PIPE-FLO, an operator can safely simulate the operation of the piping system in these infrequent or potentially dangerous system operating conditions, allowing a plant operator to gain experience in system operation without affecting the operation of the physical plant.

Conclusion

PIPE-FLO provides a clear picture of the operation of a fluid piping system; as a result, the model is a valuable design document for anyone involved with the system. If the model is started during the design phase, updated during construction, and maintained for the life of the plant, a clear picture of the piping system operation is always available.