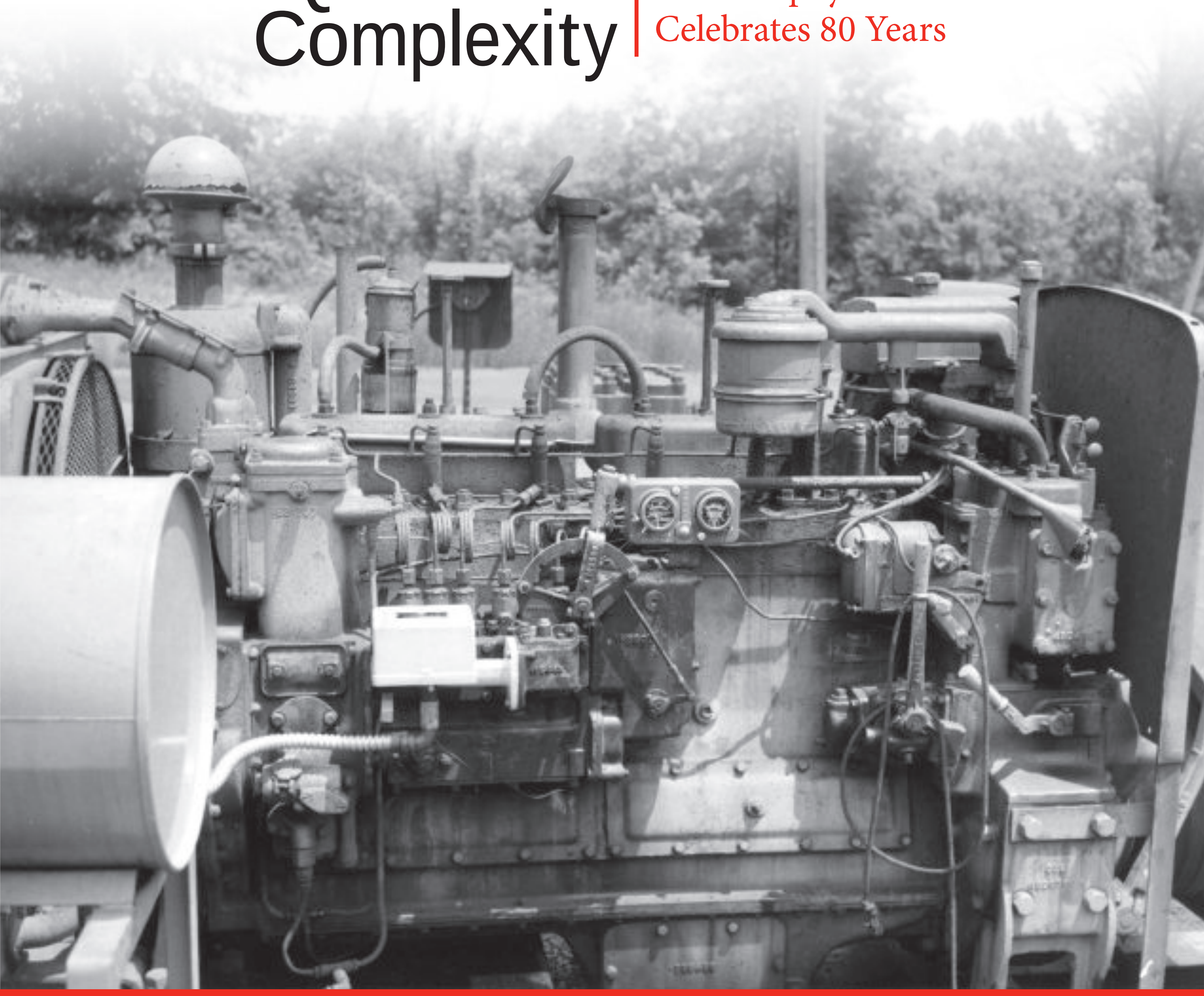
GAS COMPRESSION
magazine

JANUARY 2020

CONQUERING Complexity

FW Murphy Celebrates 80 Years



FLUID DYNAMIC SIMULATION

AUTOMATED NETWORK SIZING ADD-ON MODULE FOR CALCULATING COMPRESSIBLE FLOW

BY DANIEL FOELBER

Software that accurately calculates compressible flow is in high demand as engineers look for a solution that can model heat transfer and simulate pipe networks. For 25 years, Applied Flow Technology (AFT) has offered a fluid dynamic simulation tool for the gas compression industry — the AFT Arrow. Earlier this year, AFT introduced an add-on module for its AFT Arrow called Automated Network Sizing (ANS) as an option for design engineers to reduce installation or operational cost of the system, either by reducing the energy cost or the weight.

ANS builds on AFT Arrow's capabilities, which is specifically designed for compressible flow systems containing steam, compressed air, chemical and petrochemical process gases, natural gas transport, and more. Typical applications of AFT Arrow include sizing and selection of pipe or duct sizing, relief valve sizing and system calculations, as well as compressor, fan, and control valve sizing and selection. Additionally, it can simulate system operation and component interaction, detect and calculate choked flow, evaluate pipe insulation and heat transfer in pipes and heat exchangers, and troubleshoot existing systems.

The ANS add-on module includes the company's IntelliFlow technology. Developed in 2001, IntelliFlow allows the program to search for cost reduction opportunities in pipe systems. In 2003, ANS followed up with a version for gas piping systems. "We knew this technology was advanced, and we 100% know this technology can help advance engineering design," said Reinaldo Pinto, technical sales director at AFT.

AFT then took the proven IntelliFlow technology and wrapped it into a program that is more easily accessible for engineers who can use AFT's existing base product, start the module, and follow the navigation panel. Within the technology, engineers can choose a path to evaluate the system for weight, or to evaluate the operational cost.

"This new software program will typically help engineers design systems with 10 to 15% savings on piping costs and energy costs," said Pinto.

According to Pinto, ANS has three primary advantages — it is available as an add-on module for an existing product; AFT works with 38 channel partners and is used in more than 80 countries, exposing the company to a broad set of use cases to continually improve upon the existing technology; and the technology is a brand-new concept with the capability to improve the design process.

"ANS can accurately size the system from the beginning to meet the design requirements," said Nick Vastine, AFT business applications engineer. "Engineers will be able to apply a safety margin on the system to consider the wear on components and adhere to the expected system life. The intelligent internal numerical searching algorithms can be used on existing system designs, or new designs, to evaluate the complex interaction of variables in system design, revealing combinations of parameters that minimize cost."

The ANS module uses IntelliFlow technology to inform sizing iterations. Using an existing steady-state hydraulic model, users can activate the ANS add-on module and follow the navigation panel to enter the necessary information to size their system automatically.

According to Pinto, the required input begins with the sizing objective. This can include minimizing initial costs, such as pipe weight or monetary cost, or considering long-term energy costs over the life of the system. Following the sizing objective is the size assignment, which identifies what components of the system will be varied. Specifying candidate sets restrict the available pipe sizes and will be used to report a

Continued on page 18

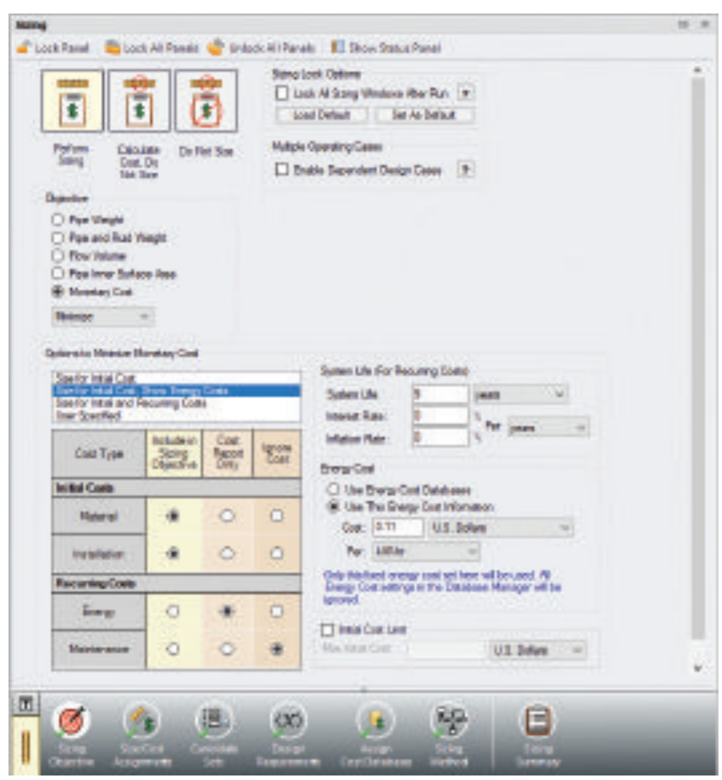


Figure 1. Setting the Sizing Objective in the ANS module can minimize initial costs and energy costs over a five-year life cycle. Options are also available to simplify input by minimizing cost indirectly using parameters such as pipe weight.

discrete pipe size such as ANSI Steel 3-in. (76-mm) SCH 40. The final user input comes from design requirements. These can include requirements specific to a compressor (such as maximum power or required pressure rise) or to pipes in the system (such as maximum temperatures or minimum delivery pressures). These adaptable design requirements enable the user to test different operating conditions, making sure the single system is properly sized in each design case.

The ANS module utilizes the user input to inform sizing iterations. According to Vastine, engineers are generally familiar with applying sensitivity analysis to find the minimum for a particular operating parameter. "This is great for one variable but becomes exponentially more complex as more variables are concurrently considered," said Vastine. "This means engineers could sift through millions of design combinations to find a system cost minimum, but there are much better ways to spend their time.

"The ANS module replaces potentially overwhelming iterations by changing pipe sizes and uses the resulting improvement to inform the next iteration. Rather than blanket testing combinations, each iteration informs the next, navigating a few hundred options rather than the possible millions," added Vastine. "It looks at variables and sizes networks on a macro-level to ensure that design requirements are met at the lowest system cost. A smaller pipe can cost less upfront but will require a larger compressor, while the opposite is equally valid."

APPLICATIONS FOR ANS WITHIN THE COMPRESSOR STATION

The ANS module is designed to minimize system costs by sizing a network based on design requirements, said Pinto. Rather than manually iterating to garner diminishing returns, the ANS module lets numerical methods guide the sizing process to design "intelligently" for better results. The ANS module can design a single system to meet requirements in many different operating conditions. "These different conditions can include low flow, changes in composition, or selectively running compressors in parallel," said Pinto. "The module can also take an existing compressor station design and adapt it to meet new design requirements. This removes the overhead of starting each design from scratch."

The ANS module can perform several functions for the design requirements specific to a compressor, including power, pressure rise, pressure static (delivery pressure), and speed. The ANS module can set the upper limit on power to a compressor when sizing for weight. The module can also provide a range of necessary pressure rises as well as specifying a range of minimum and maximum delivery pressures. For speed, the module can limit the overclocking of an existing compressor to see if it is possible to retain an existing compressor in a system.

Design requirements incorporated into the system can also inform how the compressor operates. For example, requirements can be specified at many points in a pipe to ensure enthalpy, mass flow, velocity, temperature, and other quantities are met.

SIZING OBJECTIVES AND COST SAVINGS

There are many potential sizing objectives for a system. According to Vastine, it is possible to minimize initial system cost based on factors such as weight, volume, and surface area.

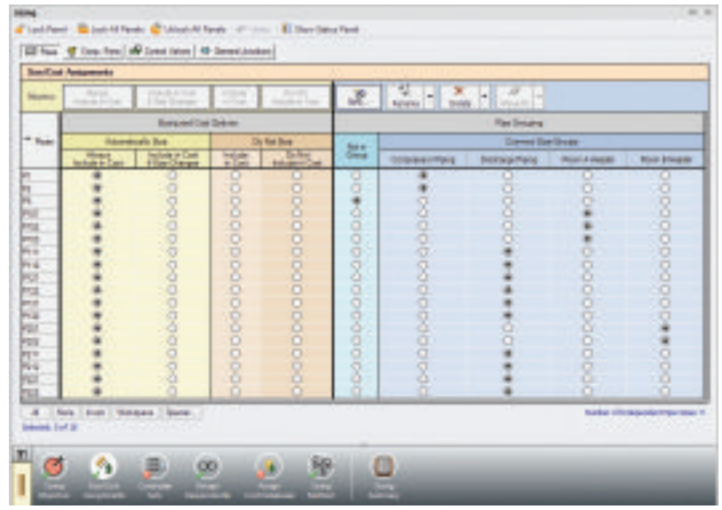


Figure 2. Pipes can be grouped in the ANS module to maintain a group of pipes at the same size, such as for pipes at the inlet and outlet of a control valve. These common size groups are also indicated by color in Figure 5 of the Workspace.

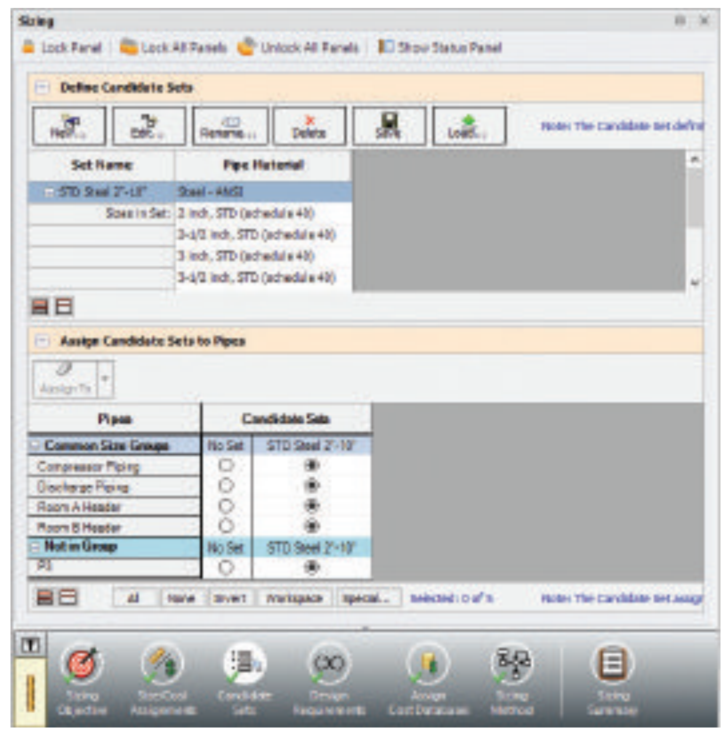


Figure 3. A selection of possible pipe sizes can be defined for the ANS module to consider during the sizing.

However, since the cost of the compressor is likely the most significant cost in a compressor station, it is best to size an initial system based on monetary cost.

"With significant energy costs to operate compressors, it may also be beneficial to investigate the additional upfront investment to justify long-term savings," said Vastine. "For projects with a maximum budget, optionally size is a feature that allows minimal energy expenses to ensure the project is executed under budget. This will result in the most efficient compressor to meet design requirements.

"The ANS module can also consider variable costs that will change over time, such as maintenance schedules and increasing costs of energy," added Vastine. "These future costs can

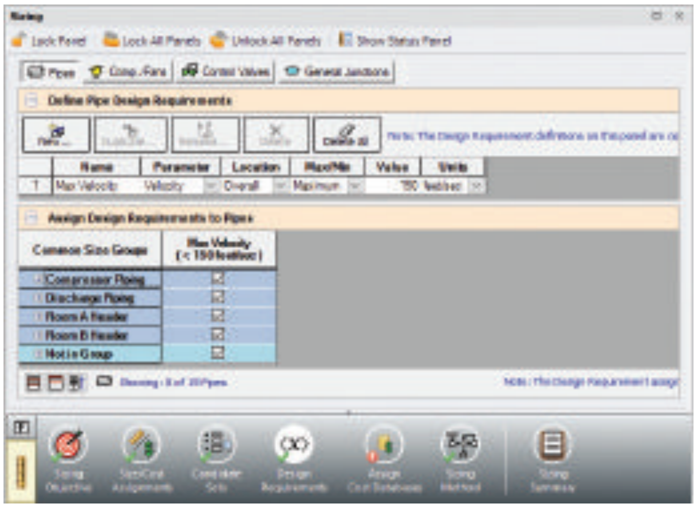


Figure 4. Design Requirements, such as for a maximum velocity, can be defined in the ANS module as shown above. This prevents the final design from violating any safety or operational standards.

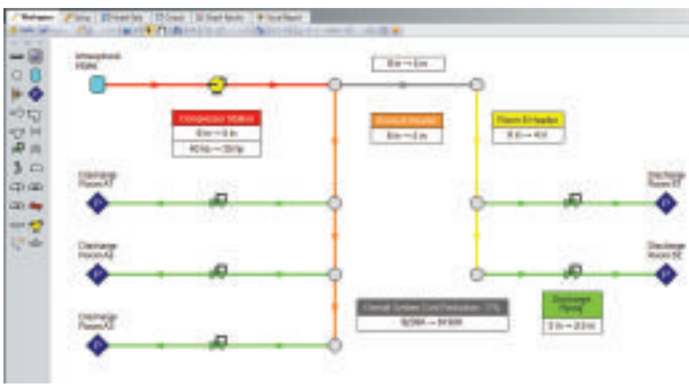


Figure 5. According to AFT, the ANS module was able to reduce system costs by 17% over the system's five-year lifecycle. Design requirements, such as maximum velocities and maximum compressor power, were maintained during sizing.

then be discounted to adjust for the time value of money so the project retains its positive net present value. Engineers can consider inflation, discount rates, and plant lifecycles all within the ANS module itself."

The ANS module will build a system surrounding a chosen compressor. "It can adapt how the chosen compressor operates; however, it will not actively change compressors during sizing," said Pinto. "This adaptation will include moving along the compressor's operating curve but can also include adjusting compressor speed to adapt the curve itself.

The module can be used to create different scenarios for different compressors and compare across these scenarios to find the best combination. According to Pinto, by saving manufacturer information into a database, data are easily accessible in subsequent projects or new projects that recycle previous design assets. "Using manufacturer data early in the sizing process is essential to reduce the uncertainty of the final built project. For components as significant as a compressor, it is especially important to replicate the final physical system as closely as possible," said Pinto. "Every slight uncertainty can compound over the lifecycle of a design." GCM