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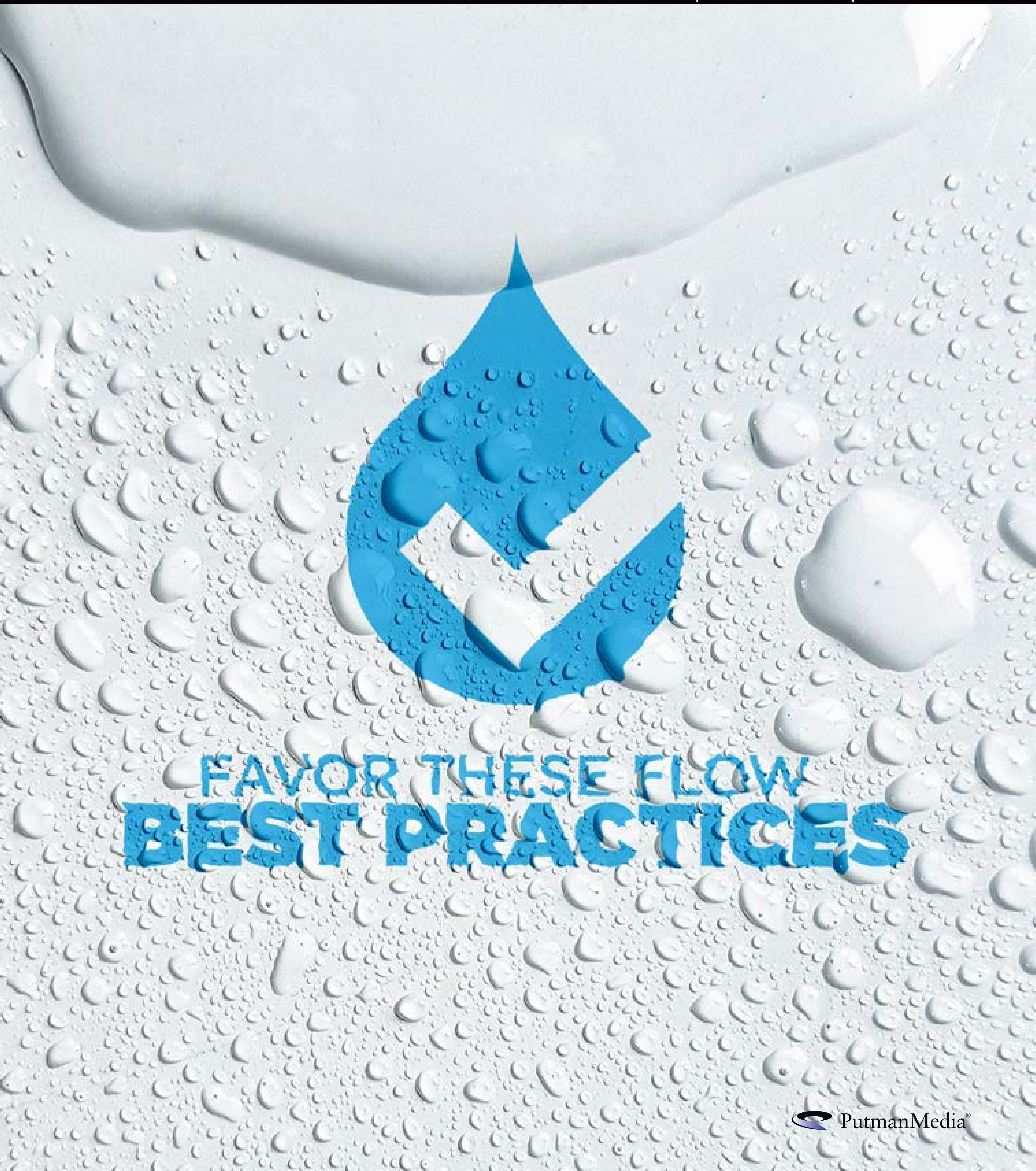

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Mind Piping System Mechanics

Ensure your layout can handle anticipated stresses

By Amin Almasi, rotating equipment consultant

Piping systems — pipes, fittings, valves and other items — not only must convey fluids (liquids and gases) from one location to another but also must cope with mechanical stresses. So, it is essential to check a system's mechanical behavior under regular loads (internal pressure, thermal stresses, dynamic forces, etc.) as well as under occasional and intermittent loading cases such as special vibration or pulsation. This evaluation usually relies upon commonly used rules and guidelines or involves review by an expert; sometimes specialized software performs the piping stress analysis. Typically, pipe stress engineers verify that the routing, nozzle loads, hangers and supports are appropriate and adequate to ensure allowable pipe stress isn't exceeded during situations such as sustained operations, pressure testing, etc.

Localized stresses in piping systems and their supports demand attention because they can lead to different types of failures. Such high stresses in steel structures and piping components can arise, for example, from sharp corners in the design or inclusions in a material.

Another area of concern is operating temperature range; piping and its supports for high or very low operating temperatures require special designs. High temperature poses issues of strength of materials, thermal expansion and thermal stress. Low temperature brings its own set of rules and guides; for instance, most ordinary steels become more brittle as the temperature decreases from normal operating conditions. So, it's necessary to know the temperature distribution for these applications and select materials accordingly.

PIPING DESIGN AND LAYOUT

An elbow provides a change in direction in a piping system. This adds pressure losses to the system due to impact, friction and re-acceleration. As fluid enters the inlet of an elbow, it typically continues moving straight ahead to the first (or primary) impact zone; the fluid then is deflected at an angle toward the outlet of the elbow. Many different factors, such as the elbow design and the fluid's characteristics and velocity, determine the deflection angle. In many designs, the fluid will hit one or more secondary impact zones before exiting the elbow.

Elbows and bends are available in a variety of angles and types. For instance, 90° elbows come in short and long radius versions. Short radius elbows have a center-to-face dimension of 1 × diameter and typically are used in tight areas where clearance or space is an issue. Long radius elbows have a center-to-face dimension of 1.5 × diameter; they are the more common type and are used when space is available and flow is more critical.

Reducers provide a change in pipe diameter. They are either concentric (Figure 1) or eccentric. Concentric reducers retain the existing pipe centerline, while eccentric ones shift the centerline. Eccentric

REDUCERS
Figure 1. This piping system uses a number of concentric reducers.

reducers are useful, for example, to maintain elevation bottom-of-piping (BOP) in a piping system or with flat-side-up (FSU) in a pump suction to avoid problems such as gas pockets.

The design of piping branch connections is a critical task; poor arrangements have caused numerous failures. Coming up with a proper design requires a great deal of effort; many issues, such as fluid dynamics, mechanical robustness and localized stresses, come into play. The general rule (with some exceptions) is to use a top-side branch connection when the fluid is a gas, and a usually a bottom-side branch connection when it is a liquid. However, many factors, including application and fluid details, influence the selection. For example, a low temperature service (whether liquid or gas) typically should have a top-side

SUPPORTS
Figure 2. It's good practice to have supports near valves and other heavy items attached to piping.

branch connection to cope with the possibility of ice formation within the pipe during normal operation; the ice, which would flow at the bottom of the pipe, could block a bottom-side connection.

Fluid hammer is an important consideration for many piping system designs. When the flow through a system is suddenly halted at one point, because of a valve closure, machinery trip (such as a pump trip) or another reason, the fluid in the remainder of the system doesn't stop instantaneously. As fluid continues to flow into the area of stoppage (upstream of the valve or machinery), it compresses, causing a high pressure situation at that point. Likewise, on the other side of the restriction, the fluid moves away from the stoppage point, creating a low pressure (vacuum) situation at that location. The fluid at the next elbow or closure along the piping system is still at the original operating pressure, resulting in an unbalanced pressure force acting on the valve seat, the elbow or the stoppage location. The fluid continues to flow, compressing (or decompressing) fluid further away from the point of flow stoppage, thus causing the leading edge of the pressure pulse to move through the piping. As the pulse passes the first elbow, the pressure now is equalized at each end of the pipe run, leading to a more-or-less balanced pressure load on the first piping leg. However, the unbalanced pressure now has shifted to the second leg. The unbalanced pressure load will continue to rise and fall in sequential legs as the pressure pulse travels back to the source (or forward to the sink). The ramp-up time of the profile roughly coincides with the elapsed time from full flow to low flow, such as the closing time of the valve or trip time of the machinery. Because the leading edge of the pressure pulse shouldn't change as the pulse travels through the system, the ramp-down time is more or less the same; the duration of the load from initiation through the beginning of the ramp-down approximately equals the time required for the pressure pulse to travel the length of the piping leg. Piping design must consider these issues as well as other operating parameters such as how fast a change (such as closing of a valve) could be.

Once the piping layout is complete, attention should turn to piping support design and stress analysis.

PIPING SUPPORT DESIGN

Sustained loads on supports mainly consist of internal pressure and deadweight — i.e., the weight of pipes, fittings, components such as valves, operating or test fluid, insulation, cladding, lining, etc. The first step in piping support design is to determine the allowable span between supports; this span depends on many details, such as piping material and wall thickness (pipe schedule), and generally includes a conservative safety factor. As a very rough indication, allowable spans between supports for 2-in., 6-in., 10-in. and 20-in. piping could be 3 m, 5 m, 7 m and 9 m, respectively. As another rough indication, you can conservatively estimate the allowable span as $2 \times D^{0.5}$ where D is the pipe diameter in inches and the resulting allowable span is in meters. Some tables and charts give spans between supports 20–30% greater than these values but I encourage more conservative numbers. Wherever a valve, fitting, strainer, flange connection, instrument or other heavy object is in the piping system, reduce the allowable span accordingly. Adding extra piping supports near valves and flange connections always is a good idea (Figure 2).

Movement of the piping must be controlled. A fixed-point anchor restricts all axial and rotational movements whereas a cross guide constrains displacements of piping along the axis perpendicular to its centerline. Support design should consider many details, such as the type of machinery connected to the piping, details of the machinery package, nearby equipment and other items attached to the piping. For example, machinery packages that include shell-and-tube heat exchangers (e.g., oil and water coolers, inter/after coolers, etc.) should have an anchor support on the side from which the tube bundle will be pulled out for maintenance work and also should consider the thermal expansion of piping connected to the exchanger(s).

Typical vertical supports to carry deadweight are:

- support hangers;

Undesirable movements can occur due to many phenomena.

- rod hangers;
- resting steel supports; and
- variable and constant spring hangers (which should be used where other options aren't effective).

Rod hangers and resting steel supports fully restrain downward pipe movement but permit pipe to lift up. Variable spring hangers usually use coiled springs to support a load and allow piping movement; the resistance of the coiled springs to a load changes during compression. In contrast, a constant spring hanger provides consistent support force by having two moment arms pivoted about a common point. The load is suspended from one of these arms and a spring is attached to the other. An appropriate choice of moment arms and spring properties can provide a resisting force nearly independent of position. Constant support hangers principally are used to support pipes and equipment subject to vertical movement due to thermal expansion (or contraction) at locations where transfer of load/stress to other supports or equipment can be critical. As an indication, the maximum recommended variation from the operating load is around 25–30% for variable spring hangers. If the variation exceeds 30%, a constant support hanger might be used.

Undesirable movements can occur due to many phenomena, such as sympathetic vibration, rapid valve closure, relief valve opening and two-phase flow. It may be necessary to limit this type of deflection to prevent generation of unacceptable stresses and high loads on equipment nozzles. A sway brace, which essentially is a double-acting spring housed in a canister, is a cost-effective means of restricting pipework deflection. It isn't intended to carry the weight of piping systems but only to limit undesirable movements. It acts like a rigid strut until a small preload is reached, then the restraining force increases in proportion to the applied deflection. A sway brace does provide some resistance to the thermal movement of a piping system; so specifying it requires care. Installation of a sway brace raises the fundamental frequency of vibration of a pipework system, which likely will reduce undesirable deflections. The devices often are used to solve unforeseen problems of resonant vibration.

Piping systems also may face loads imposed by occasional events such as severe wind, earthquake or a fluid hammer. To protect piping from wind or earthquake (which usually occur in a horizontal plane), normal practice is to attach lateral supports (instead of axial restraints) to piping systems. Protecting piping from fluid hammer loads may call for both lateral supports and axial restraints.

To carry sustained loads, vertical supports normally are required. For thermal loads, having no supports gives zero stresses — so, the fewer the number of supports, the lower the thermal stresses. Only use axial restraints and intermediate anchors to direct thermal growth away from equipment nozzles.

PIPE STRESS ANALYSIS

Such an evaluation is an important step for machinery piping designs as well as many piping systems. In simple terms, it is used to:

- Ensure the stresses in all piping components (including piping supports) in machinery package(s) and connected systems are within allowable limits;
- Solve dynamic problems developed due to mechanical vibration, pulsation, etc.; and
- Address issues, such as displacement stress range, nozzle loading, etc., due to higher or lower operating temperatures.

Internal pressure, whether design or operating, usually causes uniform circumferential stresses in the pipe wall; pressure/temperature ratings enable determining the appropriate pipe wall thickness. Internal pressure also gives rise to axial stresses in the pipe wall. These axial pressure stresses depend upon pressure, pipe diameter and wall thickness. Because all three are set at initial stages of design, the axial stresses can be determined at that point; changing the piping layout or the support scheme usually can't alter these stresses. A pipe's deadweight causes it to bend (generally downward) between supports and nozzles. This produces in the pipe wall so-called bending stresses, which vary more-or-less linearly across the pipe cross-section — being tensile at either the top or bottom surface and compressive at the other surface. If the piping system isn't supported in the vertical direction (i.e., in the direction of gravity) except for equipment nozzles, pipe bending due to deadweight may create excessive stresses in the pipe and impose large loads on equipment nozzles, thereby increasing susceptibility to "failure by collapse." Various international piping standards and codes impose stress limits on these axial stresses generated by deadweight and pressure to avoid problems; to keep calculated actual stresses below such allowable stresses for sustained loads may require provision of more supports for the piping system.

Thermal loads (expansion and contraction loads) are important forces in piping

Thermal loads (expansion and contraction loads) are important forces in piping design.

design; Piping will expand or contract as it goes from one thermal state to another, e.g., from ambient conditions (while idle) to normal operating temperature and then back to ambient. If the piping system isn't restrained in the thermal growth (or contraction) directions — for example, in the axial direction of pipe — then, for such cyclic thermal loads, the piping system expands or contracts freely. In this case, no significant internal forces, moments and resulting stresses and strains result. If, on the other hand, the piping system is restrained in the directions it wants to thermally deform, such as at equipment nozzles and pipe supports, cyclic thermal stresses and strains develop throughout the system as it goes from one thermal state to another. When such calculated thermal stress ranges exceed the allowable thermal stress range specified by various international piping standards or codes, then the system is susceptible to "failure by fatigue" or other modes of failure.

To avoid such failures due to cyclic thermal loads, the piping system should be made flexible. This often involves introducing bends or elbows into the layout to add flexibility. Having connected equipment nozzles offset from each other provides one avenue for this. If the two nozzles are in line, then the straight pipe connecting these nozzles will be very stiff. In contrast, offset nozzles will require piping with a bend or elbow; such an "L-shaped" piping layout is much more flexible. Another option is to use expansion loops (with each loop usually consisting of four bends or elbows) to absorb thermal growth or contraction. If these options aren't feasible, alternatives such as expansion joints (bellows, slip joints, etc.) might make sense. However, expansion joints are expensive and require some attention by maintenance and operations.

Cyclic thermal loads also impose loads on nozzles of rotating equipment and machines. Some of these units are sensitive to nozzle loads, with excessive loads impairing operation and even causing damage. So, reduction in nozzle loads is an important topic for the piping-in of such packages. A number of methods can help keep nozzle loads within limits:

- Adding elbows or using other techniques to increase the flexibility of the piping connected to machinery and, consequently, reduce the nozzle loads;
- Putting in axial restraints, which constrain piping in its axial direction, at appropriate locations to direct thermal growth (or contraction) away from nozzles; and,
- Installing intermediate anchors, which restrain piping movement in the three or four translational and three or four rotational directions, at appropriate locations so regions (such as expansion loops) away from equipment nozzles absorb thermal deformation. ●

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Stop Inconsistent Mixing

A range of factors can contribute to erratic performance

By David S. Dickey, MixTech, Inc.

Varying results from seemingly repetitive processes afflict many plants. Indeed, as a consultant for mixing processes and equipment, I find that a large proportion of my projects involve tackling such issues.

Companies call upon me because they think that at least part of their problems relate to mixing. In most cases, the difficulties result from not paying enough attention to the process and, sometimes, just from inadequate attention to the details. Some inconsistencies become obvious with careful observation of the entire process from the raw materials to the product and even packaging. However, some mixing problems may be more difficult to assess and correct.

Everyone knows something about mixing. After all, it plays a role in preparing meals in the kitchen and in performing some do-it-yourself household projects like painting. However, this familiarity sometimes hinders rather than helps. For instance, duplicating what happens in a kitchen mixing bowl or a laboratory beaker can be difficult on an industrial scale just because of size. Indeed, some industrial mixing problems develop simply because of the increased batch size. Mixing several thousand gallons or pounds of material is tougher than a similar operation in a kitchen mixing bowl. In other cases, the products being mixed may have different components, some with unusual physical properties. Even food ingredients can cause process problems on the industrial scale.

Most mixing inconsistencies stem from one underlying misconception. Mixing isn't just one process and can't always be done successfully in one way or by one type of equipment. Creating an oil-in-water emulsion requires different mixing functions than those for suspending solids. Heat transfer varies considerably depending on the service, e.g., blending versus gas dispersion. Correctly identifying the type of mixing process and the most appropriate equipment is an essential step in creating a consistently successful mixing process.

DIFFERENT MIXING PROCESSES

To succeed, at a minimum a mixing process must ensure that all the vessel contents are moving. Whether the process is low viscosity blending, high viscosity turnover, solids suspension or gas dispersion, everything must be in motion to achieve a practical degree of uniformity. Increased uniformity is the most common characteristic that defines mixing, regardless of process details or the phases present. Even dry powder blending has greater uniformity as its primary objective. A sufficient degree of uniformity for powders is a random or chaotic distribution of different particles.

Liquid blending often is the simplest and easiest mixing process to define and monitor. Whether combining large quantities of a few materials or adding many ingredients to create a batch, mixing usually is measured both by the degree of uniformity and the time required to achieve that result. When two or more components have similar physical properties achieving a uniform combination generally doesn't pose great difficulty. However, if one component differs significantly in a physical property, e.g., viscosity, even miscible liquid blending can take a long time and require intense mixing. Adding the more viscous liquid to the less viscous one almost always works better than doing the opposite. The lower viscosity liquid is easier to move and even may be turbulent enough to help disperse the higher viscosity addition. Putting a low viscosity liquid into a high viscosity fluid can be extremely difficult. The flow pattern in a high viscosity liquid often is laminar with stretching flow that only creates streaks or sheets of the low viscosity fluid. It may take a considerable amount of time to divide and stretch the low viscosity liquid well enough to achieve an acceptable blend.

RAW MATERIALS

A mixer often is the main piece of equipment that helps transform raw materials into a product. The success of that process step depends on both the raw materials and the equipment. First, to have any hope of making a quality product, sufficiently consistent raw materials are essential. The raw materials most likely to cause problems are natural ones, whether minerals or agricultural products. Minerals taken from the ground can differ in physical or chemical properties depending upon their origin,

Even when measurement of ingredients is accurate, order of addition or rate of addition can significantly affect process results.

even within a single deposit or mine. When the minerals are refined before use, differences in properties still may exist; these can change the ability of a mixer to produce the desired product. Agricultural products also may vary in properties because of moisture content, growing conditions or other factors. Manufactured compounds typically are less variable.

Eliminating differences in batches of raw materials obviously is important to avoid product inconsistencies. At the most fundamental level, a plant must purchase components to the same specifications and test them to ensure compliance with those specifications. For some ingredients, achieving consistent processing and product quality requires meeting tight specifications. In other cases, a relatively wide range of physical and chemical parameters may be acceptable. If material specifications can't be assured, the site must have a mixing process sufficiently robust to handle the variability.

Depending on the type of process, everything from chemical purity to particle size or viscosity may be an important property. One of the more common problems is an inconsistent starting temperature. If a process doesn't begin at the same temperature for each run, the fluid viscosity or reaction rate may differ. Unfortunately, initial temperature often varies highly depending on time of day, day of the week, operator observation, ambient temperature, etc. In one case I encountered, a plant always heated a batch of polymer before starting the process but gave its operators no instructions as to how high or low the temperature should be. The process began when the operator was ready — so, the temperature differed from batch to batch.

Even when measurement of ingredients is accurate, order of addition or rate of addition can significantly affect process results. Operator training or other methods can minimize addition variability. One way to regulate the rate of addition is to put in a measured quantity of an ingredient and then mix for a certain period before making another addition. The amount of time between additions must be long enough to avoid large differences in local concentrations.

Another problem area, not directly related to mixing, is post-processing and packaging. For instance, the plant that had difficulties with initial batch temperature also incurred issues because it processed the finished polymer on different pieces of equipment. Although the final products looked the same, the actual processing differed with respect to the steps in the rolling and cutting operations.

Regardless of the methods used to regulate a process, one of the best controls is accurate recordkeeping. Proper batch records not only promote good operating procedures but also can serve as a key tool for tracing possible causes of variations. Some inconsistencies are as basic as differences in operator training or experience. Certain operators can improve a process while others seem to introduce new problems in every batch they make. The same plant that didn't monitor starting temperatures or post-processing equipment also lumped daily production into a single lot number. Each day, it produced five to ten batches, most at slightly different conditions. Lack of individual lot numbers for these batches significantly hampered finding a cause and solution to inconsistency problems.

Another common misconception is that good mixing requires a deep surface vortex. In most cases, a deep vortex actually results in poor mixing because all the flow is around in a circle with little vertical or radial motion. Baffles help convert some rotational motion created by a center-mounted mixer into both vertical or radial flow. (For more on baffles, see "Don't Let Baffles Baffle You," http://bit.ly/2HLVUua.) Vertical recirculation usually is the most effective means for creating a uniform blend or suspending solids. Without adequate vertical motion, ingredients added on the surface may take a long time to reach the impeller and circulate throughout the entire tank.

Even when a surface vortex may aid in liquid or powder addition, the vortex never should extend all the way to the impeller. Once the impeller begins to draw air into the liquid, pumping dies and mechanical loads on the mixer increase. A deep vortex in a laboratory beaker may work because of short distances and times — but still isn't efficient.

PROCESS EVALUATION

Observation is key to quantifying and understanding mixing. That's because all mixing results are empirical. While correlations permit accurately estimating impeller power and pumping, these correlations come from data obtained in experimental studies. Other characteristics of mixer performance require more direct monitoring. Indeed, determining suitable process improvements depends on good observations of existing conditions. Mixing sometimes gets blamed for process problems because it's the least well understood operation. Almost anyone can identify good mixing in the kitchen and other household projects. The problems in industrial mixing are much more difficult to observe. Factors like tank size, metal construction and opaque fluids sometimes make direct monitoring nearly impossible.

The first step in making process observations is to quantify product quality. Focusing on product quality directs the critical observations of the process at what the customer sees. Quality control tests should exist both for the product and the raw materials. The basic observations before and after the mixing operations must be quantified and verified. To the extent practical, seek laboratory or pilot plant data, even if from previous testing. A process or test failure may provide the most important information; unfortunately, such mishaps often don't get recorded and evaluated. In many mixing applications, simply avoiding previous mistakes or unsuccessful operating conditions can solve process problems. Identifying changes in the process or ingredients that correspond to the product inconsistency problems may require documented conditions over a period of time. A key step in making process improvements or avoiding problems is obtaining objective data about the problem.

Whenever possible, delve into the type of mixing necessary for success of the operation. Simple blending always is necessary — but may be needed primarily for batch uniformity of composition, viscosity, temperature or other chemical and physical properties. Mixing has been around for a long time and studied extensively. Numerous books and papers present useful information about solving mixing problems. A lot of practical advice appears in the mixing section of *CP*'s online Ask the Experts Forum (www.ChemicalProcessing.com/experts/mixing/). Even a basic Internet search may lead to a source of information that can provide guidance about possible improvements.

In the absence of a clear connection between the process and result, the next option may be to select an adjustment to the process with a high likelihood of success and a low probably of failure. A reduction in batch volume of 10% to 15% should raise mixing "intensity" for an existing process. If increasing the mixing intensity doesn't change blending and possibly other results, then mixing may not be the primary problem. Making changes to mixing based on subjective information rather than on an understanding of how mixing is likely to affect both the process and the results is risky.

Always remember that you can't solve inconsistency problems without making changes — but that the appropriate alterations may not necessarily involve just mixing.

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Make the Case for Vacuum Boosters

Reduce costs while increasing flow and improving energy efficiency

By Mike Gaines, Tuthill Vacuum & Blower Systems

Vacuum boosters are positive-displacement dry pumps that provide an easy way to increase your flow — your cfm — and get deeper vacuum. Vacuum boosters use two-lobe rotors spinning in opposite directions to remove gas. This provides a quick way to get more cfm in the deep end with considerable money saving on equipment and horsepower requirements.

The booster increases the vacuum system's cfm, therefore reducing the evacuation time while increasing ultimate vacuum of the backing pump by as much as eight times. When used separately to discharge atmosphere, they typically are limited to inlet pressures of half an atmosphere.

The vacuum booster's advantage is evident when it's placed in series with another vacuum pump. The booster then provides higher pumping capacity and lower pressures typically at lower cost and power consumption. The backing pump can be an oil-sealed piston or vane pump; a liquid ring pump utilizing a variety of different sealants from water, solvents or oil; or a dry vacuum pump.

VACUUM BOOSTER USE IN INDUSTRY

According to Phil Vibert, senior engineer at Tuthill Vacuum & Blower Systems, vacuum boosters have a reputation in industry for simplicity and reliability. "If you take a booster and put a backing pump behind it, you can run the booster at low pressures and derive the needed pumping capacity with lower overall horsepower, compared to opting for a larger backing pump alone," he says.

C-FACED BOOSTER
Figure 1. The Tuthill M-D Pneumatics 2700 C-Faced Vacuum Booster can be paired with a variable frequency drive for further energy savings.

Vibert adds that most industrial applications for vacuum boosters require a deeper vacuum and increased volumetric flow. Typical pressures can vary from 0.1 to 100 mmHg. Typical industrial sectors are chemical, pharmaceutical, vacuum furnace and steel degassing with applications that include degassing, distillation, drying, freeze drying, transformer drying, metallurgical treatment and CVD.

He cites as an example higher-capacity pumping of solvent vapors for recovery purposes: "Vacuum boosters enhance the performance of a dry vacuum pump when used in combination and provide a lower cost alternative compared to a larger dry pump." He says this can be an advantage in the chemical processing industry when dealing with multiple volatile solvent vapor loads in which the dry vacuum system with after-condenser can transport the solvent vapor and selectively condense it in the exhaust condenser.

Peter Rescsanski, Tuthill's Northeast regional sales manager, explains that customers often rely on booster pumps for their unique performance characteristics and for an optimized blend of cost, reliability and quiet operation. He notes that units with helical gears on the boosters — as well as units with a five-bearing booster — provide smoother, quieter, and more reliable operation than the industry-standard straight-cut gears.

Rescsanski explains that boosters also allow users to pump down to the required vacuum more quickly while minimizing pump and motor size. He describes the experience of a customer that recently retrofitted nine vacuum furnaces with new 5-in. gear boosters with 24-in. rotors in tandem with the company's rotary-piston vacuum pumps.

"Those boosters are rated to 1,600 cfm, provide vertical flow, are left-hand drive and have labyrinth slinger-style seals," he says. "The furnaces, used to dry calcium, are large box-style units measuring 20 ft. by 8 ft. by 6 ft., and the customer had been pumping them down with stand-alone oil-vapor diffusion pumps. Pump down (from 10 torr to 0.05 torr) took four hours, while our solution reduced that to three hours. That dramatic time savings resulted in a return on investment in just two to three months."

VACUUM BOOSTERS IN CHEMICAL INDUSTRY APPLICATIONS

Boosters are offered in various metallurgy, including 304 and 316 stainless steel, for additional corrosion resistance, as well as a coating as a lower-cost corrosion resistant alternative.

Vibert says, "Manufacturers can offer mechanical face seals for their vacuum boosters that deliver positive pressure with low gas leak rates of 1X10 -4 cc/sec per mechanical seal, or noncontacting slinger seals that don't produce heat and commonly are used in vacuum booster applications in which there are no gases that affect the oil or in certain heat (furnace) applications.

He points out that the recent improved carbon composition of face seals lasts significantly longer and withstands higher operating temperatures over previous face seal generations.

Rescsanski believes it's important that customers in multiple segments of chemical, petrochemical and others select vacuum boosters designed with engineering acumen. "We sell more than just equipment; we sell solutions," he notes.

Many companies have cut back on their engineering staffs and maintenance departments and so have come to rely on vacuum booster manufacturers as technical experts and for applications support, he says.

"Customers see how durable and high-performing vacuum boosters are as a way to optimize reliability, while driving down operating costs and reducing the number of service calls needed to keep the systems running," he adds.

ENERGY EFFICIENCY, BOOSTERS AND VFDS

For increased energy savings, Vibert suggests using variable-frequency drives (VFDs) with vacuum boosters, as well as for faster evacuations in which the booster runs continuously with its backing pump.

C-FLANGE SETUP
Figure 2. A C-flange setup allows for a direct-drive motor to be connected, and saves space while eliminating belt and sheave issues.

"A constant-torque VFD with current feedback allows you to adjust motor speed and prevent it from overloading," he explains. "We can start the booster at atmospheric pressure and the motor will operate at a very low rpm to minimize the pressure differential across the booster. As the pressure is reduced, the booster then speeds up to maintain power demand on the motor (because hp ≈ torque x rpm) until it reaches the motor's full-load rpm."

The VFD can even be used to set the limit on both the maximum and minimum rpm so that C-face motors (Figure 1) can be used to direct drive boosters at nonsynchronous motor speeds.

Rescsanski points out that pressure sensors can be added in the vacuum line and send the signal to the VFD controller, constantly monitoring the vacuum level and adjusting motor speed accordingly. "This can dramatically reduce energy consumption, anywhere from 30% to 80%," he says.

VACUUM BOOSTER SELECTION

Booster models range from 3.25- to 12-in. gear diameter and 2.5- to 48-in. rotor length. The standard construction materials are cast-iron for the housing, end plates, end covers and port fittings and ductile iron for the rotors and shafts. Also offered are stainless steel components

Vacuum Booster Vent Terminology and Uses

A **vent** is an empty space between the process chamber and the oil sump. It typically is isolated by the oil seal and a labyrinth seal.

A **condensable gas** will change state (liquid) with a change in gas temperature or pressure.

Vent to drain is a valve connected to the bottom of the vent that may be opened to drain liquids from the vent to an atmospheric drain — the principal being that any liquids that might accumulate in the vacuum booster vent will be drained out of the unit to a sealed container.

Standard lip/lab seals have a wide application in pneumatic conveying, wastewater treatment and general process industries that require high-pressure, high-volume air. The seal areas are vented to atmosphere to relieve process pressure against the internal lip seals.

Single-envelope gas service designs are used in such applications as closed-loop pneumatic conveying, process gas handling or elevated pressure applications up to 100 psig discharge. In this scenario the vent openings are tapped and plugged to prevent gas leakage. These fittings also can accept an inert gas purge for positive containment of the process gas.

Double-envelope gas service designs are special units built to laboratory standards in which almost complete sealing is required. In addition to the features shown on the single-envelope series, the drive shaft is sealed mechanically and the oil sumps are plugged to provide an even higher degree of leakage protection.

for more severe duty. The boosters are designed to operate at 82 dB(A) or less at blank-off (open field; motor and background noise excluded) and are supplied with a heavy-duty driveshaft for either direct-coupled or belt-driven applications.

Match the booster to the application by selecting a model that operates within a performance range of 50 to 12,700 cfm. To help select the right vacuum booster for a specific application, look into testing services, including special testing available to ASME PTC-9 (1 psig slip method), hydrostatic testing to 150 psig (10.35 bar g), pressure gas testing to 100 psig (6.9 bar g) and seal leakage and noise testing.

Many vacuum boosters also are offered with a C-flange setup (Figure 2) that allows for a direct-drive motor to be connected, which saves space while eliminating belt and sheave issues.

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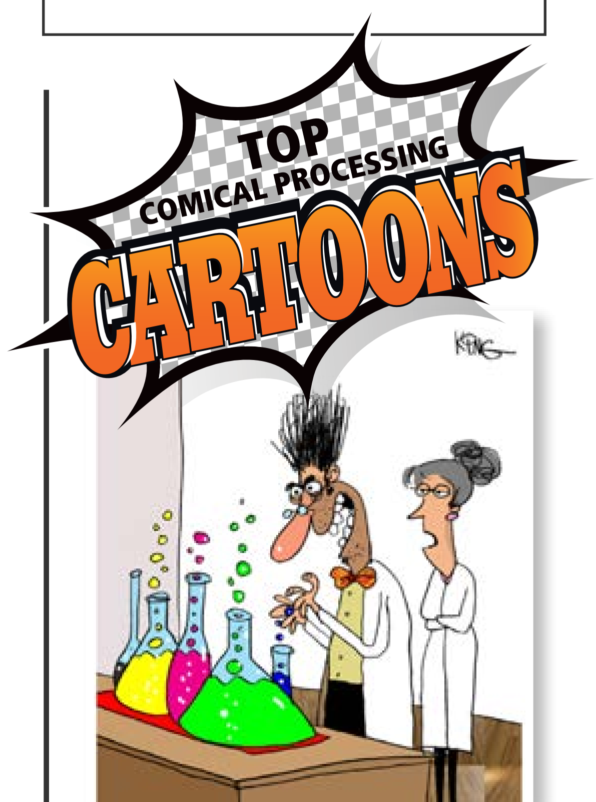

Visit the lighter side, featuring drawings by award-winning cartoonist Jerry King. Click on an image and you will arrive at a page with the winning caption and all submissions for that particular cartoon.