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Training Plant Staff About Energy Efficiency

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Energy Saver – Educate Your Peers

Train your technical specialist on energy efficiency.

By Gary Faagau, Energy Columnist

"Increasing energy efficiency doesn't mean reducing product quality or unit capacity."

TECHNICAL SPECIALISTS concentrate on the health of your process. Your specialist can be a process engineer, corporate technology person or inside or outside consultant. This person has received extra training on the technology, whether on-the-job or through additional classes and seminars, and therefore can advise how the unit should perform. Because of this status, your technical specialist should also understand how the process uses energy and be aware of energy consumption and conservation when giving advice.

Training your specialist requires that you also understand how energy is used in the process. This will help when you talk to the specialist. However, you don't need to know all the nitty-gritty details.

Send a note to your expert and explain that you would like to talk about energy efficiency. Set an agenda to cover: feed preparation; reaction/process; feed effluent and products; and utility and equipment efficiency.

Feed preparation involves the steps to bring feed to the right temperature, pressure and quality for the unit's main function to work properly. It extends from the unit boundary to the reactor inlet. This is where energy is consumed to heat or cool or pressurize or depressurize material. Because these steps involve some heat input, I typically look at: how much energy is needed to get to the right conditions and how much energy is recovered from effluent or product streams. Stress to your process specialist that preparation steps are vital to energy efficiency.

The reaction section involves exothermic or endothermic reactions. Feed conditions are set to optimize the process, but you should ask if the same result can be accomplished at a lower energy input. As an example, pressure may be a hydraulic constraint. Sometimes lower pressure separation requires less energy but product requirements demand higher pressure. Pressure also can be temperature related when trying to condense a gas, which may set limitations. So, feed conditions may be a variable that can lead to lower energy cost without product sacrifice.

The expert should understand using recycle or slopping. Recycle occurs when a stream contains unconverted or undesirable products or if minimum capacity of equipment is unsatisfied. Recycle always increases the process' energy requirements; controlling or minimizing recycle typically saves energy. Energy consumption must be part of the equation when determining recycle rates or the need to recycle.

Slop is created when products don't meet specification and the stream must be reprocessed. This typically happens on start-ups and shut downs, but can occur in finished product tanks. Such situations can and should be controlled and minimized. On stream analyzers tend to reduce slop effects by limiting the time material needs to be slopped. Start-up and shut down procedures also need to be reviewed to reduce the time material needs to be slopped. Slop production should always be a key performance indicator on any unit.

The feed effluent and products section runs from the reactor section outlet to the unit boundaries. It typically recovers energy or prepares streams for their next destination. In general the idea is to recover as much useful heat as possible without increasing another unit's requirement. One of my pet peeves is use of storage as an intermediate between process units. Typically, a stream needs to be cooled and depressured to enter storage. Storage preparation usually involves air or water cooling as the final step. The stream is then reheated and repressured before further processing. This is one hidden energy waster that can kill profitability. The more it's eliminated, the more efficient your process becomes. The process specialist must be made aware of this and work with you to reduce or eliminate this practice.

Utility and equipment efficiency involves operating heaters, pumps, steam, air and other utility equipment at the best performance. Previous columns have covered these items and I encourage constant monitoring of these systems by your specialist.

The important reminder to your specialist is that energy efficiency doesn't mean reducing product quality or unit capacity. In some cases, it can help increase improve the product or increase unit capacity. Educating the specialist on the key areas and economics can lead to major savings.

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Train Your Operators on Energy Efficiency

Provide them with the right information and listen to their ideas.

By Gary Faagau, Energy Columnist

THE TWO most important parts of running an energy efficient unit are designing it properly and operating it well. For most of us, the equipment is already there and we can't control the inherent efficiency. However, correct operation of that equipment to maximize energy savings is something we can control. To do this, we must first properly train our operators.

Most places instruct operators based on the "need to know" principle. Basically, you just tell the operator what's required to do the job safely and properly. The purpose of this approach is to achieve consistent operation of the unit without too much deviation. The operator is instructed to prioritize actions and events - putting safety first, followed by reliability, rates, quality, yield and energy. There's nothing wrong with this progression; in fact it always should be enforced. However, to maximize unit profitability, you must ensure your operators make it to energy.

So, the first thing you must do is to automate as many of the other duties as possible. Freed from chasing down a hundred lab samples and checking a thousand field gauges, the operator can get to the point of trimming excess air from the furnace and monitoring steam traps for leaks. Now, with operator workload reduced, you can start the energy training. For each energy area, you need a key performance indicator (KPI). The KPIs you use for operators aren't necessarily those that you'll be using for reports. All KPIs for operators must relate to items they can control. They should be able to access these KPIs 24 hours a day. I try to put the KPIs in their distributed control system or all their reports so that the numbers always are in front of them.

I keep each KPI simple so there's no question about what should be done. For a furnace, the KPI should be percent oxygen instead of excess air or furnace efficiency. By concentrating on oxygen, the operator understands that reducing the oxygen number to a target range decreases the cost of operating the unit, which increases profitability. Steam isn't an easy KPI. I try to find something on the unit that is controllable, like letdown valves or vents. One of my favorite KPIs is product slop or recycle. It not only looks at energy but also at the capacity and effectiveness of the unit. If the unit runs with an energy management system (EMS), your KPI can include time for response or percentage of time the system is online. I like using an energy-lost dollar calculation on my EMS system and keeping track by shift (see: http://www.ChemicalProcessing.com/articles/2009/164.html). It creates a lot of controversy and gets people more involved in making sure the EMS is working properly.

"All KPIs for operators must relate to items they can control."

Now, once you have your KPIs, you must gather your operators in a training room. First, give them all the basics about what energy is used, how much is used, and how this compares to similar units in your company or in the industry. Then, present each KPI; tell them what's being measured and how to control it. They need to know what valves to turn or who to call.

Next, introduce them to the dollar figure and set an initial goal. If you've an incentive program, it would be perfect to tie energy savings into that program. What I like doing is bringing in outside experts. Your steam vendor, furnace specialist, rotating equipment person and process technologist can help you out. After providing the operators with all this knowledge, it's your turn to listen. Hold an idea-generation or brainstorming session where they can present ideas on how to reduce energy or to do their job better. This last point is very important because operators know best what's preventing them from doing a better job.

Typically you'll see results almost immediately but they'll taper off after a while. So, it's important to keep communicating the importance of energy. I usually ask the operations manager or plant manager to give a pep talk about keeping energy efficiency at a high level. But at least once every six months, you must bring operators together to refresh their memories and review results from the past six months. This is a good time for another idea-generation or brainstorming session to look at ways to improve operator performance.

Training operators in energy efficiency means providing them with the right information and listening to their ideas of how they can do their job better. Do this and you'll see real savings in your fuel bill.

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Train Your Project Manager on Energy Efficiency

Treating energy saving measures as project add-ons can help.

By Gary Faagau, Energy Columnist

IN THE second part of this series, "Train Your Operators on Energy Efficiency," I said the two most important parts of running an energy efficient unit are designing it properly and operating it well. So it's essential to get your inputs to the project manager early and often.

"Energy projects usually have a lower threshold, or return requirement."

Project management is the discipline of planning, organizing and managing resources to bring about the successful completion of a specific project. Project management starts when the concept is first conceived. Regardless of whether a project involves a revamp or a grassroots unit, the project manager's job is to complete it on time and on budget. To do this, the project must be conceived and then designed to meet the goals. Energy typically isn't an initial part of project management unless the project is specifically meant to reduce energy costs. However, energy is a variable — so, the energy manager should make sure the project managers understand the importance of energy efficiency and how it affects a project.

My favorite example relates to a process heater. At the time, I was a corporate energy director and had to sign off on every project the company was doing. We had implemented energy codes for our projects. The codes required an energy balance for every project and that plant energy efficiency couldn't decrease after completion of a project. The idea was that if your project made the plant less energy efficient you'd have to do additional work to restore the efficiency. In this case, a project team planned to install a process heater with a 750°F stack. The heater manufacturer gave the project manager the option of not recovering heat to cut the overall cost of the heater. The project manager was trying to save money and decided against installing a heat recovery system. So, I had to have a long talk with the project team about energy management. It was frustrating for them because they had thought the project was ready to go. As it turns out, adding the recovery system reduced steam requirements and the changes to the design paid for themselves while improving the overall efficiency. The return on investment (ROI) of the project also increased.

One way to make it easier on project managers is to provide capital for energy add-ons. Basically, a project is designed "bareboned" and then energy efficiency measures are added. Teaching project managers to think in this fashion gives them greater flexibility and leads to more energy savings. Separating the energy capital also gives management a better sense of energy costs. In addition, in most companies, energy projects have a lower threshold, or return requirement, because the savings are more predictable. Basically, the difference between products and feed can vary and thus pose a larger chance of fluctuation in a project's return — but the cost of energy is always positive and rarely decreases.

Training the project manager to understand the difference between energy projects and other capital projects also leads to management's understanding of energy improvements. Very rarely are any projects done purely because of energy but the energy component can be very important. The two areas that this is most true in are environmental compliance and utility projects.

Environmental compliance projects are those required by law. In most cases, companies like to minimize the cost of these projects because they don't have a monetary investment return. Environmental projects often relate to energy consumption or production. One example would be to add selective catalytic reduction to a heater stack to reduce NOx. Because this offers no return, project management usually would involve minimizing the cost of the system. However, adding an air preheater can make this project a money-maker. If you run a return on investment (ROI) analysis on the whole project, it may not reach the minimum required for your company — but separating the environmental project and then adding the energy project, with the ROI only on the energy project, would make this a clear winner. Such separation also works well for utility projects. By splitting the sustainable and energy savings parts of a project, the energy portion has a better chance of being added.

If you can train your project managers to understand the importance of energy, the different thresholds between energy and other capital projects, and the value of handling energy projects as add-ons, you'll not only be able to trace energy projects better, but also will be better able to defend those projects and convince your plant manager that they're worth doing.

So, the next step is training your plant manager on energy efficiency. That will be the fourth and final part of this series.

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Train Your Plant Manager on Energy Efficiency

Present your energy program in a way the plant manager can quickly comprehend.

By Gary Faagau, Energy Columnist

WE'VE ALREADY dealt with getting your process specialist, operators and project manager to contribute to energy efficiency. There's one last person you must get involved in the efforts — your plant manager.

I went to dinner recently with a refinery manager of a large gulf coast complex. The conversation ranged from safety issues, projects, personnel, budgets, and an assortment of problems and opportunities. He was a busy man — hundreds of things at the plant commanded his attention. However, I was mildly surprised when the conversation turned to energy. He knew exactly where his plant stood relative to the industry and was making strides in reducing energy use. "The plant efficiency has improved 3% versus last year," he boasted. I thought to myself, this is a well-trained manager.

To get maximum benefit from your energy program, you must present it in a way that captures the plant manager's attention while taking little or no time. Organizing the information in a repetitive fashion has benefits.

I find the best presentation method is to set up a system of information. The system is meant to give the plant manager the right dose at the right time.

Daily report: I would start first with the daily report your plant manager sees each morning. This report, which usually includes everything about the plant, should contain two numbers that summarize overall consumption of energy. These numbers must be something the manager is used to looking at. The first is straight energy units in a certain time period (BTU/year, Kcal/hr, MW, or kJ); the second is the relative number, based on product, feed or whatever the most common method you use (BTU/lb, MW/klb, etc.). Present these two numbers daily or weekly and display them with a reference number — either the goal for the plant or the budgeted amount.

Weekly progress report: Keep this to no more than two paragraphs so the plant manager can read it in less than 3 minutes. Follow energy consumption information with any explanation of why the number is what it is. Then tell the plant manager what energy-related items happened the last week and what should be expected next week.

Monthly progress report: Here, provide more detail about individual systems and include more information about projects, maintenance and energy concerns. If you have an energy team, put in items from team meetings. The report should never exceed one page. It doesn't have to break down each individual energy contributor but large groups (steam, electrical, furnace efficiencies, etc.). The monthly report is a look back of what was expected last month and what really happened. It also tells the plant manager what to expect in the daily and weekly reports for the next month.

Quarterly report: Hold a 60-to-90-minute meeting with the plant manager and other key staff. Include presentations by the energy team on implementations that took place during the quarter. Also mention any failures or setbacks, the reason they occurred, and how they will be fixed. Discuss new problems and pitch ideas for new projects. This is your chance to show any progress and get feedback. Use the meeting to discuss budget concerns and show that the energy team has spent capital well. Don't throw quarterly meetings together at the last minute. It may take time to compress material into less than 90 minutes. If you plan ahead, your report will be more concise and will keep the attention of the audience.

Fiscal year report: Here, show the entire program's accomplishments and outline how energy projects will be implemented during the new fiscal year. Include what you want to see in the next budget and your justification for that spending. Present problems that were found and resolved, projects that were implemented and whether they met expectations, and give individuals or teams time to present what they did to save energy.

By improving the way you present information, you stand to make your plant manager a better advocate for your energy program.

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"Quick and concise information can help get your plant manager on board."

Some training courses are worth the price

Learn to use energy tools to make your plant more efficient

By Gary Faagau, energy columnist

When you compare DOE's courses to others, you can't find a better value.

SOMETIMES SPECIALIZED training courses can be very costly. Even going to industry workshops and seminars have a huge price tag. This has caused many companies to limit training to keep cost down. While taking training classes can be an expensive proposition, the U.S. Department of Energy (DOE) has a great deal for you. Not only do they offer free useful tools, but also cheap training and the ability to be a qualified specialist in many different energy areas.

Through the Office of Industrial Technology, the DOE has been offering Internet, local and national training on a set of practical evaluation tools that can be used to create an energy efficiency program. Energy systems include steam, process heating, compressed air, motors, pumps, and fans — systems that are used throughout industry. Training can range from Internet introductory courses to one- to three-day courses.

One of the most useful courses is the Steam System Assessment training. The one-day course focuses on DOE's Best Practice Steam Tool that can be used to evaluate any steam system.

The Excel-based tool is actually extremely powerful and can evaluate steam traps, boilers and up to three different steam pressures. When used correctly, the evaluation can actually be stretched to do more complicated systems. The course is enough to start using the tool and probably monitoring your own system. Once you've learned to use the tool, you can then take the three-day Specialist Qualification course. Once qualified, you'll have enough knowledge to map most steam systems in most industries. The course is often used by steam equipment and services providers as a way to certify their engineers.

Another very useful training is for process heaters. The program used for this training is the Process Heating Analysis and Survey Tool (PHAST). This program can evaluate almost any type of process heater from kilns and smelters to box type furnaces. PHAST is amazingly versatile and does a great job evaluating all forms of losses that occur in a furnace. Just like the steam program, the one-day training is enough to evaluate your own system while the two-day training can get you qualified as a specialist to apply the program to other process heaters.

The other four training areas — fans, motors, compressed air and pumps — are geared a little more toward maintenance engineers, but if you extensively use these systems, these training courses are invaluable. The Fan System Assessment is good for optimizing any large fan system. Motors can help evaluate repair-or-replace decisions for small to large sizes. The compressed air course has been used by many specialists to find 15–25% savings in air systems. The pump system training looks at performance problems and practical issues concerning pumps.

If you become a qualified specialist for any of the tools, you can apply for further training as a Save Energy Now Specialist. These Energy Experts conduct energy assessments at major U.S. industrial plants as a part of Industrial Technologies Program's nationwide Save Energy Now effort. You can even have your plant sign up for Save Energy Now and get trained as a Specialist at the same time.

So what are the costs of these DOE training courses? Most are between \$50 to \$75 for one-day training to \$250 to \$300 for three-day training. When you compare that to courses offered by industry groups or universities, you can't find a better value — unless you're based in California. There,, the California Energy Commission is sponsoring a series of these courses throughout the state and offering them for free.

All you need to do is go to its website, check the schedule, and follow the instructions to sign up. To find out more about these courses, go to www.eere.energy.gov and click on Industrial Technologies, or E-mail me

Do Your Own Steam Survey

Finding energy wasters yourself can save a lot of money.

By Gary Faagau, Energy Columnist

THERE ARE many ways to get a professional steam survey at low cost. Steam equipment suppliers usually offer system survey programs. You get instant data from experts while they get an opportunity to sell you the equipment needed to fix your system. But what happens when you pitch the idea and it's shot down? Maybe your boss thinks that your steam system is OK, so it would just be a waste of money. Or, perhaps, there's no budget to fix problems identified. The Catch-22 of any energy work is that you cannot justify the survey without knowing what it will save. But you don't know how much you'll save unless you do a survey. If you think there's money to be made, it's time to start your own survey. Take a Department of Energy steam assessment course or a vendor operated steam course, but in the meantime, look over the system yourself. A thermal gun and sonic device are field survey essentials. An infrared camera is another time saver. It provides great visual evidence and you can point it at almost anything to find temperature variations. Several parts of the steam system must be checked. I've listed the most common problems, but be thorough. The steam boiler can have several energy problems. The most costly is blowdown. Without automatic blowdown, you can lose by having too much or too little contaminates in your system. Too much causes more leaks and line problems, leading to poor efficiencies. Too little means too much water is being removed, which is a large waste of energy. Install automatic blowdown so only the right amount of water is removed and exchange blowdown with fresh water coming in to capture the heat. Calculate stack loss to ensure the boiler works as designed. Boilers are rarely checked. Proper air controls can provide big savings. Make sure the boiler is correctly maintained. If you have several boilers, calculate individual boiler efficiencies. It may pay to move loads to efficient boilers, but make sure to calculate incremental, not overall efficiency. Under normal circumstances, steam coming off a boiler is saturated, so ensure there's no liquid carryover. Making quick demands on a boiler can easily carry liquid into the steam system. It can absolutely overwhelm main traps and find its way into a lot of equipment. Install a cyclone at the boiler's exit point to catch liquid carryover. Traps are for small amounts of liquids while cyclones catch large amounts. Cyclones aren't replacements for traps. They're an addition to your system. If liquid makes it to steam turbines, it can cause poor efficiency or even equipment damage. Check to see if the inlet design can have liquid. Add a cyclone right before those inlets. If the condensate system backs up a lot, do a pressure survey. Chances are steam is leaking directly into the system. The survey may not tell you where it is, but it tell you where it isn't. Moreover, if you hear hammering, the traps aren't closing or there's a design problem. Check the traps, then look at the design to see if liquid is building in the steam line or high-pressure condensate is entering a low-pressure line. If your plant hasn't made a steam trap map, there's a bit of work to do. When surveying the traps use a GPS device or take a map so you can find the same trap next time. If there are a lot of traps and very little labor, prioritize your system by checking all high-pressure traps, traps in systems with condensate problems, older systems, and traps in poorly insulated systems. Insulation is probably one of the easiest to spot and calculate. Missing insulation isn't only a waste of energy, it also causes liquid in your steam system that can overwhelm traps or ruin equipment. Oil in the condensate system is a major reason some plants have low condensate recovery. If you find oil in your system, isolate the equipment causing the problem and remove it from your normal condensate return. For very large systems, use a thermal conductivity analyzer to divert water when oil is present. It pays to check connections between high-pressure and low-pressure systems. Always try to get work out of that steam. Letdowns or passing valves means you're paying a high price for that low-pressure steam. Steam surveys aren't easy and require a lot of work, but by prioritizing and looking for some common problems, you may be able to capture some easy money.

The steam boiler can have several energy problems.

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Direct Steam Injection Hot Water Systems for Jacketed Heating

By Philip Sutter, Pick Heaters, Inc.

MANY PROCESS plants currently use steam or hot water to heat jacketed devices such as tanks, kettles, dryers, reactors, glass lined vessels, or similar adaptations such as coiled tubing placed inside or outside tanks or vessels.

In this article, we will take an in-depth look at the advantages and disadvantages of steam and hot water for jacketed heating, and compare indirect and direct steam injection systems for making hot water.

In heating applications where processes require operating temperature up to 350°F (177°C) steam is often the first heating medium considered because it is readily available. However, hot water should be given equal consideration.

ADVANTAGES AND DISADVANTAGES OF STEAM

Figure 1 illustrates a typical jacketed heating system using steam. Because it is readily available and easy to apply, steam is often used for jacketed vessel heating. Steam provides quick heat-up and it is predictable e.g. 100 PSIG (7 BARG) saturated steam is always 338°F (170°C) with 1,189 BTU/lb total heat content.

Despite its advantages, steam has several shortcomings. It does not offer precise temperature control, and energy transfer is not uniform. Due to uneven distribution, higher temperature steam typically collects in the upper portion of the jacket, with cooler condensate collecting near the bottom.

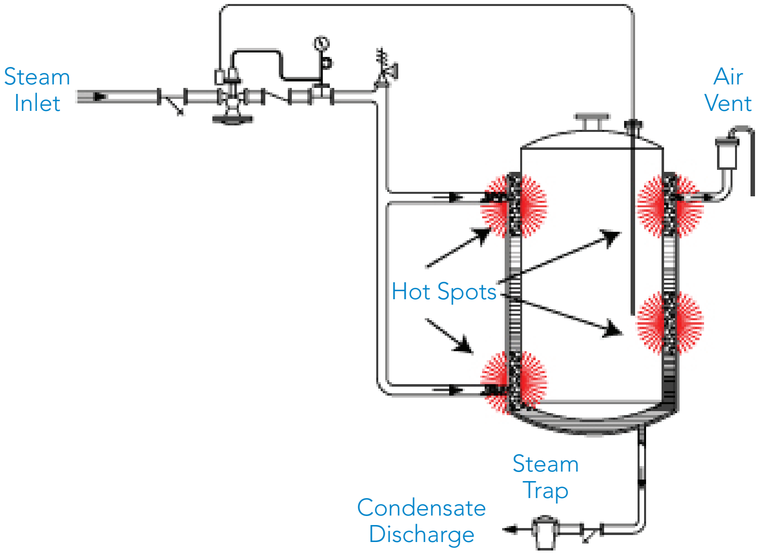


Figure 1. Typical steam heated jacketed vessel

Internal hot spots also develop around hot steam inlet nozzles, adding to the problem of uneven product heating. This increases the likelihood for product burn-on and local overheating.

Furthermore, a steam trap is a necessary component of a steam-heated jacketed vessel. It allows condensed steam to exit the jacket, making room for more steam. If improperly sized or poorly maintained, energy will be wasted and temperature control will be compromised, which frequently results in damaged product or lower product yields.

Reactions requiring both heating and cooling are cumbersome for the steam-heated system because of the dramatic temperature difference between the steam and the cooling water. At the conclusion of the heating cycle all steam and condensate must first be driven out of the jacket prior to introducing cooling water. This is a time-consuming process that is often not done completely. The problem is most severe with glass-lined reactors, which may be damaged by thermal shock and steam hammer if cooling water contacts residual steam in the jacket.

Currently, an increasing number of process engineers are switching from steam to hot water for jacketed heating. There are several basic reasons for this trend:

- The temperature in the jacket can be controlled much more accurately with hot water than with steam. This higher degree of control protects against damage to or loss of product through overheating.
- Hot water distributes heat more evenly than steam. This eliminates hot spots which often cause product to bake onto the walls of the vessel, and at worst, ruin the entire batch.
- Hot water ensures a better quality end product. This is particularly important in processes requiring very precise product temperature control.
- In critical processes utilizing glass-lined reactors, steam can shock and damage the lining. Hot water allows smooth transitions from heating to cooling with no thermal shock.

In addition, many are switching to direct steam injection (DSI) systems to create the hot water for several basic reasons:

- With an advanced-design steam injection heating system, the temperature of the process can be adjusted at any predetermined rate on any desired time cycle.
- A steam injection hot water system can be programmed to heat then cool a process by stopping the heating cycle and introducing cooling or tempered water into the jacket at any desired rate and temperature.
- In this system the condensate (from the steam that was injected) leaves the circulating loop through a back pressure relief valve at the lowest temperature after all the possible heat has been extracted. In a steam system, on the other hand, condensate at a much higher temperature must be returned to the boiler in a condensate return line with its inherent heat losses.

ADVANTAGES AND DISADVANTAGES OF HOT WATER

The use of hot water to heat reactor vessels solves many of the problems associated with steam. The jacket temperature can be controlled more accurately with hot water because hot water distributes heat more evenly over the wetted surface of the vessel. This eliminates hot spots, which can cause the product to burn onto the walls of the vessel and potentially ruin the entire batch. By eliminating burn-on, product quality is protected and product filtering and costly clean up time are minimized.

Hot water offers a wide range of operating temperatures because when pressurized, water will remain in the liquid state and not flash into steam. For example 72 PSIG (5 BARG) water can be heated in a pressurized circulating loop to 310°F (154°C) without boiling. The process can be gradually ramped up or down to desired temperatures, eliminating the potential of thermal shock.

For processes requiring both heating and cooling, hot water can be adjusted at a predetermined rate on a desired time cycle through the use of cascade or heat/cool temperature control loops, or an in-plant PLC or DCS. A hot water system can be programmed to heat, hold, then cool a process by introducing cooling or tempered water into the jacket at a controlled rate and temperature without having to stop the process as when using steam.

In addition to offering precise temperature control, water is readily available, easy to handle, nonflammable, safe to the environment, and inexpensive as compared to heat transfer fluids.

What is the downside of using hot water in jacketed vessels? The product heat-up time using hot water will not be as rapid as it is with steam. However, once up to temperature the steam heated system may be difficult to keep from overheating.

Another limitation is that the jacket water temperature cannot equal or exceed the saturated temperature of the steam supplied to the system. For example, when operating the system with 150 PSIG (10.3 BARG) steam, the jacket water temperature cannot exceed 352°F (177°C) at 130 PSIG (9 BARG), because of the 20 PSIG (1.4 BARG) pressure differential requirement for DSI, and above that temperature the water will flash back into steam.

MAKING HOT WATER WITH INDIRECT HEAT EXCHANGERS

Where steam is available, indirect heat exchangers are commonly used to heat water for jacketed vessels (see Figure 2). In these systems, steam does not come in direct contact with the water which is being heated. Heat energy is transferred across a membrane such as a tube bundle or series of plates. As energy is transferred, steam condenses and is discharged through a steam trap and routed back to the boiler.

Indirect heat exchangers are designed to use only the latent heat from the steam or approximately 83% of the total heat energy, while the sensible heat (or approximately 17% of the total BTU's) is discharged from the exchanger in the form of condensate.

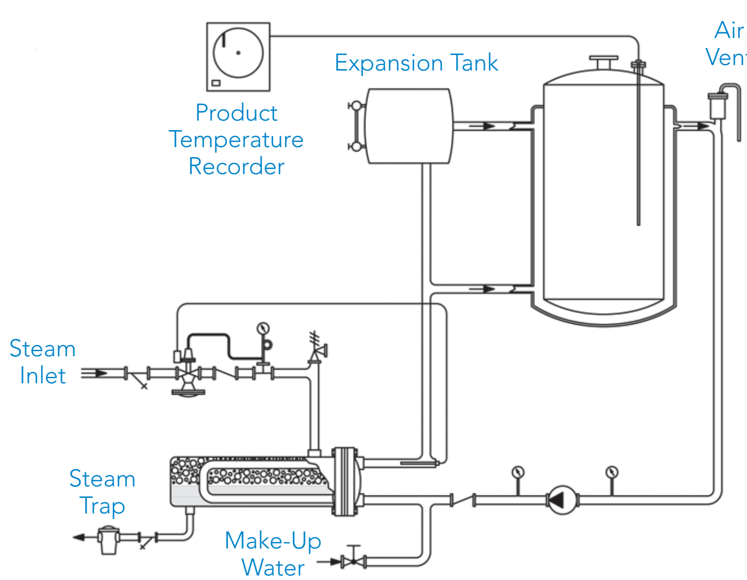


Figure 2. Typical hot water jacketed heating system with indirect heat exchanger

Much of the remaining BTU's are lost en route back to the boiler making the indirect heat exchanger an inefficient method of heating a reactor vessel.

Another problem inherent in indirect exchangers is poor temperature control due to the lag time between the adjustment of control equipment and the time it takes to transfer heat energy from the steam through the tube bundle or plate surface. System start up times will be longer as all the metal mass in the heat exchanger must be heated up, and additional components such as an expansion tank is required to balance the system pressure.

Finally, a steam trap is still required in an indirect system with all of its inherent costs, maintenance, energy loss, and reduced productivity problems.

ENERGY COMPARISON - DIRECT VS. INDIRECT HEATING OF WATER

Direct steam injection (DSI) heaters inject steam directly into the circulating water loop.

For processes which return the jacket water below 212°F (100°C), they achieve 100% heat transfer by using both the sensible and the latent heat of the steam. Above this temperature there is a minimal drop in efficiency.

Let us compare the efficiency of an indirect (shell and tube type) heat exchanger to a DSI heater. The application chosen demonstrates the annual energy consumption for heating a jacketed blender which mixes powders with liquids and then dries the mixture. Assume the process operating conditions are as follows:

Product volume:	**10,000 lb of a water-like product**
Blender operating heat load:	**4,816,340 BTU/hr**
Jacket water temperature:	**250°F**
ΔT across jacket:	***55°F (250° - 195°F)**
* This is the required ΔT to be made up by the heater.	
Water circulating flow rate:	**175 GPM**
Water loop pressure:	**50 PSIG**
Steam pressure:	**150 PSIG Saturated**
Hours of operation:	**16 hr/day; 4000 hr/year**
Boiler fuel type and cost:	**Nat. Gas at 0.85 /Therm**
Boiler efficiency:	**82%**

Based on these conditions, the steam requirement for heating with an indirect heat exchanger would be 5,620 lb/hr, while the steam requirement using a DSI heater would be 4,662 lb/hr. Factoring in the energy required by the boiler to preheat the feed water and to generate steam at 82% boiler efficiency, the indirect heat exchanger will require 7,182,634 BTU/hr while the DSI heater will require only 6,612,080 BTU/hr or 7.9% less energy than the heat exchanger! This energy savings of 570,554 BTU/hr will result in an hourly fuel savings of 5.71 therms of natural gas (a fuel heating value of 100,000 BTU/therm). At 85¢/therm this translates into a fuel cost savings of $4.85/hr, or an annual fuel savings of over $19,000. Results may vary depending upon fuel costs and operating conditions. This example demonstrates the dramatic energy savings to be realized by the DSI heater and is based upon the very conservative assumptions that:

1. The heat exchanger steam trap does not leak steam.
2. There is no volumetric loss due to condensate flashing at the receiver tank.
3. 195°F water discharged from the system using the DSI heater is not returned to the boiler. Instead, 65°F boiler make-up water is used.

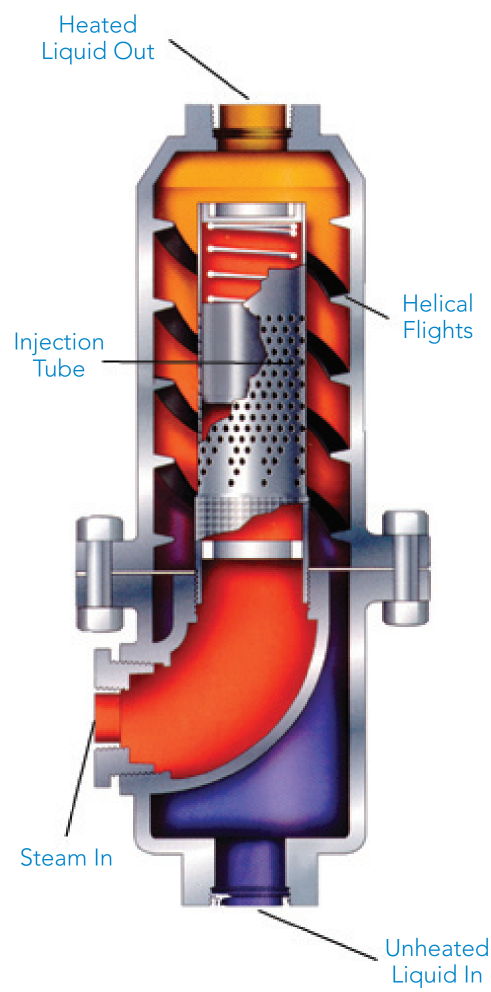


Figure 3. Multiple Orifice DSI Heater

PLEASE NOTE:
The 195°F water discharged from the closed loop as a result of DSI may be returned as boiler make-up water which would increase the fuel savings even further, up to 17% more efficient than the heat exchanger.

There are several objections to the use of DSI which need to be addressed when considering this approach. Most of these relate to the fact that the steam must be thoroughly absorbed into the water at the point of contact or it may result in "steam hammer". If the steam is not thoroughly absorbed, it will expand and then collapse downstream in the piping or the jacket. This creates an implosion due to the dramatic change in volume between steam and water which results in noise and vibration known as steam hammer. This is especially a problem with simple steam-to-water static mixers, spargers, and venturi/eductor type heaters. In order to assure thorough absorption of steam into water, the steam pressure should be at least 10-20 PSI greater than the water pressure at the point of injection.

Furthermore, cold make-up water must be heated at the boiler, because condensate might not be returned to the boiler. This could result in additional costs for chemical treatment. However, the energy savings from DSI will more than offset these costs.

MAKING HOT WATER WITH A DIRECT STEAM INJECTION (DSI) SYSTEM

When using an advanced design Pick™ DSI System, steam flow is modulated at two points: the steam control valve, and also at the point of injection within the heater. This dual modulation results in superior temperature control over a wide range of hot water demands or when a sequence of varying temperatures or pressures are needed to meet process requirements.

In a Pick™ DSI Heater, steam enters the cold water at low to moderate velocities through hundreds of small orifices in an injection tube (see Figure 3). By breaking up the steam into multiple small streams and also maintaining a positive pressure differential, all the steam is quietly injected and instantly mixed into the flow of water within the heater body.

During operation, steam pressure works against a spring-loaded piston inside the injection tube assembly. As the steam flow varies, it forces the piston to rise or fall exposing more or fewer orifices (see Figure 4).

By applying water pressure and spring force against the incoming steam, the spring-loaded piston constantly maintains steam pressure in excess of incoming water pressure. This prevents steam hammer which occurs when steam and water pressures are at or near equilibrium.

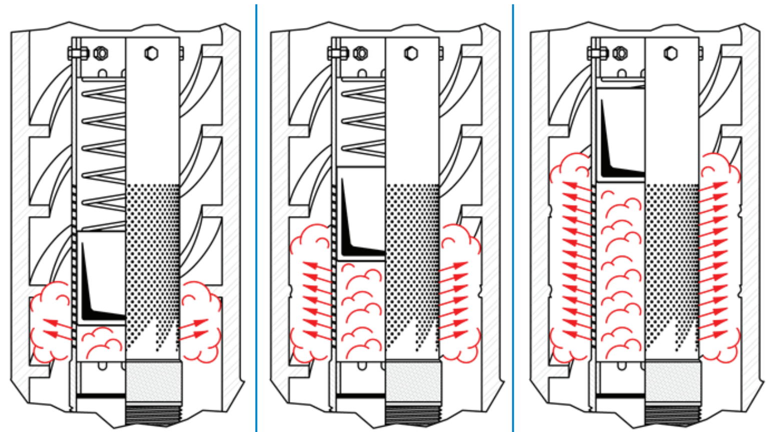


Figure 4. Variable Orifice Steam Ine

Another important design feature of the Pick™ DSI Heater is the helical flights within the mixing chamber. These create controlled turbulence to assure thorough and immediate mixing of the steam and liquid within the heater rather than in downstream piping. As a result, these heaters are much quieter to operate than (high velocity) venturi or static mixer type heaters.

The heater creates very little internal restriction to liquid flow. Velocities are not excessive and very little pressure drop (less than 2 PSI) is generated across the heater, minimizing friction losses and pump horsepower requirements. The hot water discharge temperature can be sensed immediately downstream of the mixing chamber and requires very minimal piping (less than 5 pipe diameters) before entering the jacket.

The external steam control valve is actuated by a temperature controller, which is responding to water discharge temperature. This may be manually set to any desired outlet water temperature as Figure 5 illustrates. Water temperature setting may also be regulated remotely by a pneumatic or electronic temperature controller (PLC, DCS), and by sensing the product temperature (commonly referred to as cascade temperature control). With this arrangement, system operation is fully automatic. The operator simply inputs the desired product set point temperature. At the beginning of the cycle water temperature is driven to a predetermined maximum level. Then, as the product approaches set point, water temperature is gradually decreased to prevent overshoot.

Control is automatic – regardless of outflow demand. System loop pressure is maintained by an adjustable back pressure relief valve (BPRV) which eliminates

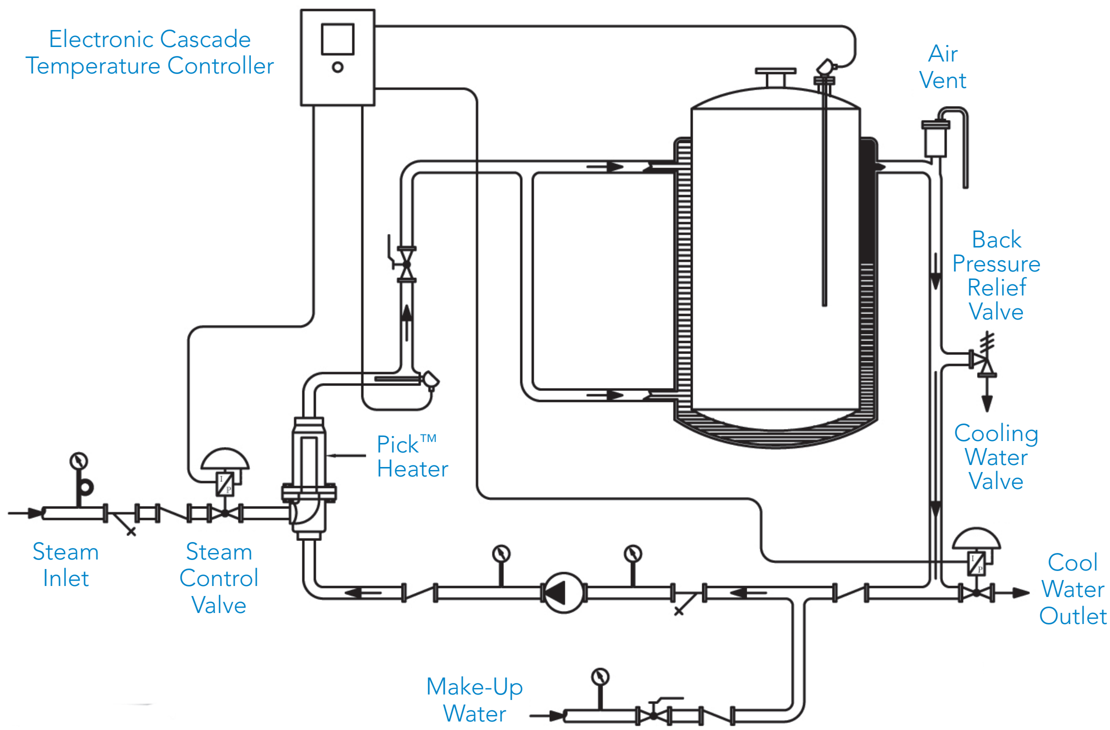


Figure 5. Typical jacketed heating system with Pick™ DSI heater

the need for an expansion tank. As steam enters the system, an equal volume of condensate is pushed out of the BPRV. System pressurization at this valve permits water loop temperatures above 212°F (100°C).

A single steam control valve provides better than a 10:1 turndown capability. Turndown capabilities up to 100:1 can be obtained with the use of dual steam control valves. This capability is particularly important in heating jacketed vessels because the hot water demand at reactor start-up is significantly greater than it is as the product approaches set point.

IN CONCLUSION:

Water is superior to steam for heating jacketed reactors because it:

- eliminates hot spots and uneven heating – unlike steam, where temperature control is difficult to maintain and easily overheats.
- allows smooth transitions from heating to cooling with no thermal shock – unlike steam which requires complete purging of steam prior to the addition of cooling water.
- is environmentally safe and non-flammable – unlike heat transfer fluids which require special handling and constant monitoring.

Direct steam injection (DSI) is superior to indirect exchangers for heating water because of:

- rapid response to changing process conditions – ensures precise temperature control within a fraction of a degree.
- demonstrated costs savings – 100% energy efficiency saves as much as 17% in fuel costs.
- compact design and ease of maintenance – saves space and system down time.

In particular, Pick™ DSI heaters with dual modulating steam injection control provide:

- thorough mixing of steam and water within the heater body – eliminates the need for excessive downstream piping.
- the ability to handle the widest range of steam flow turndown of any DSI heater.
- lowest water pressure drop and lowest noise level of any DSI heater.

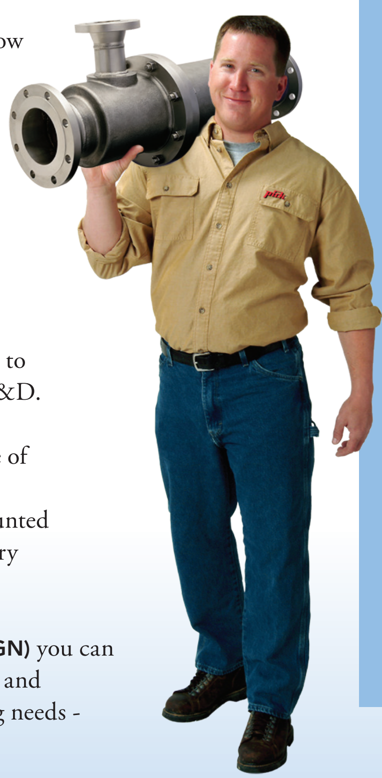
Philip Sutter is a Vice President with Pick Heaters, Inc., West Bend, WI (262-338-1191; Fax 262-338-8489). He has over 30 years of experience designing, engineering, and selling liquid process heating systems for the food, chemical and pharmaceutical industries.

Innovation in Direct Steam Injection Heaters Since 1945

In 1945, Pick Heaters developed and patented a unique concept of Direct Steam Injection Heating. The original approach has remained unaltered...keep it simple and self-stabilizing, minimize moving parts and make it completely reliable regardless of operating environment. It is this design philosophy that has Pick at the heart of heating for over 60 years in industries ranging from food to chemical and pharmaceutical processing, pulp and paper to power plants.

Out of this philosophy has come a continuous flow of refinements and innovations.

- Pick is the only DSI company to offer a true **VARIABLE FLOW** design for multiple use points and on/off applications.
- Pick's **BX** heater is truly innovative. It's open design allows slurry flow without obstruction, at negligible pressure drop. For industrial starch cooking and slurry heating.
- Pick's **FABRICATED HEATERS** allow for flow rates and pressures far above the norm - up to 25,000 gpm or 1,400 PSIG. They also conform to existing piping from 1/2 to 32 inches and beyond, and in various materials of construction.
- Pick was the first direct steam injection (DSI) company to introduce a **3A CERTIFIED SANITARY HEATER** in 1984 and was also the first DSI company to offer a pilot scale version especially for R&D.
- Over 20 years ago Pick expanded its scope of supply to include **CUSTOM DESIGNED, PACKAGED SYSTEMS** including skid mounted pumps, instrumentation and other ancillary equipment to meet customers needs.
- Now, through **PCD (PICK CUSTOM DESIGN)** you can combine Pick's experience in heat transfer and packaging to meet all your process heating needs - direct or indirect heat transfer systems.



WHY CHOOSE PICK FOR DIRECT STEAM INJECTION?

Energy Efficient
100% heat transfer cuts fuel costs up to 28%

Precise Temperature Control
to within 1°C or less for many systems

Wide Operating Range
variable orifice injector provides unlimited turndown

Low Noise Level
normally below 85 dba

Low Liquid Pressure Drop
does not exceed 2PSI within normal flows

Complete Mixing in Heater Body
no need for pipe lengths after heater

Pick Heaters has a worldwide network of qualified engineers along with its highly qualified factory staff to work with you to design a process heating system to meet your specific requirements. Pick's international certifications include: CRN/Canada, CE/Europe, SA/Sweden, and TÜV/Germany.

PICK COMBINES THE RIGHT PRODUCTS WITH THE RIGHT PEOPLE - PICK THE BEST.