Simplify Your Pilot Plant

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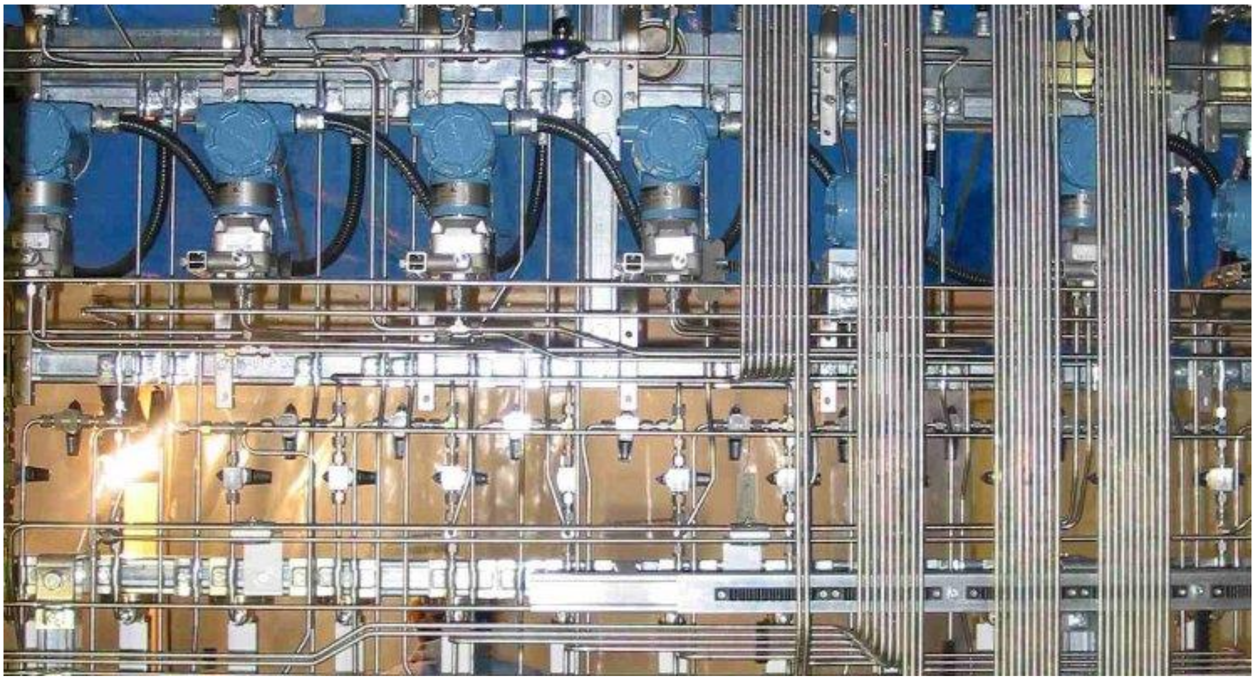

Sometimes, complexity is necessary to function- like this DP monitoring system for a fluid bed reactor.

Unnecessary complexity leads to unnecessary delay and increased costs, money that is better spent on additional training for operators or more campaigns. Indeed, the labour costs of installation and testing, procurement, and engineering specification and selection rise in nearly direct proportion to the number of tagged items on a plant's P&ID drawings, and these labour costs often dwarf the cost of the item itself. Elimination of unnecessary components can result in significant reductions in the cost and delivery lead time for a plant.

The first step toward simplicity is to consider carefully the life cycle and operating mode of your pilot plant. Will it be essential or even permissible to continue operating while you repair or replace key pieces of instrumentation or equipment, or will a shutdown be inevitable? If the latter is true, block and bleed valves on instruments, double-block valves, and bypasses around control valves and the like may merely add unnecessary cost and complexity to the system without adding significant safety or other value.

I know that several readers are already shaking their heads after reading the previous paragraph. “Just try operating a plant without adequate block and bleed valves, and you’ll install them on everything!” But you need to HAZOP that assumption for a minute before making up your mind. Take, as an example, the common configuration for a control valve that many customers seem to want as a matter of course: a block valve immediately upstream and downstream of the control valve itself, plus a needle valve (and possibly another block valve too) in parallel to bypass the control valve.

Let’s first look at the needle valve bypass. It can, sometimes, serve a very useful purpose while you’re shutting down or doing clean-out operations, by giving you a valve with a much larger Cv than that of the control valve which you can use to do the last bit of depressurization or to flush waste out of a line. But let’s think about the situation when the control valve’s trim has become clogged with debris or the valve is otherwise non-functional. Are you really going to continue to operate with an operator manually adjusting that needle valve? One hand on the valve handle, the other on the radio to the control room? Would that be safe? The answer is almost always no, except in cases where you probably should have replaced the control valve itself with a manual globe or needle valve. Does the needle valve improve operability enough to warrant the safety risk of using or misusing it? That depends on how robust your procedures are, and how well trained your operators are, but the decision also has implications for the pilot plant designer’s relief calculations. That needle valve is almost certainly going to cost you a lot more than you expect, on many levels.

Now let’s look at the upstream and downstream block valves. There’s almost always another block valve upstream and downstream, and on a pilot plant that valve is probably only a few feet away, even though it might be on the previous P&ID drawing and hence may be easily overlooked. And since we’ve likely already concluded that you’re not going to continue operating with a defective control valve, do you really need valves to isolate both sides of the control valve as if you were going to pull that valve for maintenance during operation? And if the answer to that question is yes, is the isolation provided by a single valve safe enough?

In our opinion, setting arbitrary rules such as “we want blocks, bleeds and bypasses around every control valve” etc. is a sure way to make your pilot plant more complex and expensive than it needs to be, without adding proportionate value. We will be *delighted* to do it if you insist, and are willing to pay for it! But in our view, it is far better to give some thought to operational, maintenance and isolation strategies or philosophies for the pilot plant, and then let the designer assess the valve needs for each line based on the service. Those decisions should then be checked carefully during the HAZOP review.

Focus on what you need to pilot and do not pilot the rest!

If it adds complexity without improving the plant’s ability to give you the data or product you need, eliminate it!

There have been many occasions when an evaluation of a client’s flowsheet has led me to suggest the complete elimination of whole steps or trains from a proposed pilot flowsheet, to be replaced with either a simpler but commercially uneconomic alternative with lower capital costs, or in some cases even with the very cheapest option: analysis and simulation. Where this can be done without significant impairment of the process development goals of the pilot project, it is a very attractive option.

Many customers have a strong desire for similarity between the pilot plant and their ultimate commercial plant, and sometimes this extends to similarity that is actually detrimental or impractical. And often, the similarity desired is an aesthetic one rather than one which has true technical significance.

Remember that you're piloting the process- not the equipment! Sometimes, testing the function or efficiency of a particular type of equipment is itself a key goal of the pilot program, but these are the exception rather than the rule. A clever and experienced pilot plant designer can often find a cheaper and more reliable means to accomplish each unit operation in your flowsheet, with the turn-down required for successful piloting, instead of merely trying to reproduce a miniature version of your commercial plant.

A primary example is heat integration. Heat integration, i.e. the use of hot process streams to transfer heat to cold process streams via cross exchangers, is something commonly practiced in commercial designs where it offers significant energy savings. However, energy consumption in a pilot plant is typically a third-order priority at best, well behind the cost of labour to operate the unit, the opportunity cost of pilot program schedule delay, and the venture capital cost of the pilot plant itself. Typically, a cross exchanger also requires a "trim" utility exchanger on at least one and sometimes BOTH streams, to make up the difference between the performance of the cross exchanger, particularly once it becomes fouled, and the needs of process control. Then there's the problem of start-up, and particularly the time to steady state: on start-up, process effluent will not be hot enough to transfer meaningful heat to the feed, necessitating either that the start-up heater be designed for the full duty (cross exchange plus trim duty), or that the start-up be done at a greatly reduced flow etc. You therefore end up with at least two and sometimes three exchangers rather than one. Though there are always exceptions, the correct approach for a pilot plant is usually to simplify by specifying separate heaters and coolers for the feed and products, with utilities supplying and absorbing the required heat.

Rotating equipment also offers an opportunity for simplification. A centrifugal pump used as a pressure source can also be used to effect mixing and even gas/liquid contact by combining it with a venturi eductor. The result is to use some of the energy typically wasted in a pilot plant by operating a centrifugal pump well to the left of its best efficiency point (BEP) for a truly useful purpose, while also saving the capital and installation cost of a mixer or compressor and its motors, seals and controls.

The nature and scale of pilot plant work also frequently pushes the designer away from not only cross exchange, but also flue gas and steam as sources of heat, toward the use of electric heaters. Electric heaters, when properly designed and specified, are an ideal match with many process heating services on pilot plants. This will hopefully be the topic of a longer future article in this series.

Here is an example of what you can do on a hydrometallurgical pilot plant, downstream of the pressure leaching equipment where there are large numbers of repeated equipment items such as multiple CSTRs in series:

- Where height permits, use gravity overflow instead of pumps.
- Standardize on a few tank sizes with variable overflow level.
- Eliminate level controls in favour of air-tolerant pumps.
- Use a single variable speed motor to drive multiple agitator shafts, a single peristaltic pump driver to drive multiple pump heads, or a single VFD to drive multiple motors.

These suggestions are so simple as to seem a little inane, but they have been used to drive literally millions of dollars of otherwise unnecessary cost out of pilot units for such systems. This can sometimes mean the difference between proceeding with a project and abandoning all the lab work to date due to insufficient budget to carry it forward at the pilot scale.