PLANNING AND DESIGNING A BREWERY PLUMBING LAYOUT

Three-dimensional (3D) non-verbal thinking: Precondition for proper planning?

Even though humans always think three-dimensionally, many people have trouble thinking in terms of spacial concepts. Technical solutions, however, more often than not, tend to require 3D solutions. This is especially true for the construction of production equipment and installations. For an effective implementation of installations, the deployment of valves is a necessity. For the selection of optimal practical solutions from a technical and economic perspective, an understanding of the function and construction of individual components is essential. This article provides an overview of several conventional valving solutions and operations.

On January 30, 1975, the Rubik's Cube was patented. Since then, however, only a few people have succeeded in sorting the 3D mechanical puzzle's components correctly in 18 moves; or can do so in less than one minute. In 1990, Lotus introduced its product 1-2-3 as a 3D development of its two-dimensional (2D) spreadsheet. Fewer than two per cent of Lotus users, however, made the switch. Instead, they preferred to stay with their 2D Lotus spreadsheets or decided to create complex links among several 2D spreadsheets.

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3D theory and practice

Pipe and instrumentation diagrams (p+i d) are usually drawn up in 2D. Construction drawing, too, used to be in 2D, until the introduction of CAD-Systems. Much of the blame for most people's difficulties with 3D goes back to their school days. Non-verbal thinking is generally discouraged in schools because 3D thinking is so difficult to document using pen and paper. The effect is often an intuitive self-restriction to just 2D thinking. By this mechanism, 3D thinking shrivels up and remains under-developed, is rarely used in society, and is also rarely understood.

People who build mills often take gravity into account. Planning any tubing for a flour mill, for instance, requires consideration of where the material exits a machine on one floor and where it enters another machine on a floor below. This requires 3D planning.

Installing a hose of a given length between two connections usually does not constitute a problem, even in 3D. However, if the course of the hose needs to be placed in a drawing in advance, even engineers have sometimes difficulties with this task – and not just because a hose has a fixed length and no right angles.

But does it make sense to make the specifications of a project dependent on the drawing capabilities of a planner? Does it make sense to leave it up to the installer to convert 2D R+I schematics into a 3D installation? Can someone who has been blind from birth understand colours? Those who cannot think in 3D and in non-verbal dimensions are not capable of finding optimal solutions.
This appears not to be a problem, however, because in practice, even sub-optimal solutions often perfectly satisfy the expectations of the user.

Various possibilities of designing a transfer path

A brewery is usually able to carry out any type of liquid transfer, provided there are enough hoses, pipes, T- and U-junctions, connecting pieces, as well as inline valves and mobile pumps. The effort involved in planning the transfer is minimal and usually takes place in parallel with the search for the proper piece in the iodophor sanitiser tub. Unfortunately, hoses are not cheap. Their deterioration from constant use and the resulting need for replacements amounts to a significant cost factor. Automation of hose transfer is also possible only to a limited extent.

The function of pipe fences is relatively easy to understand. However, it is not always easy to figure out how many positions of all the possible permutations and how many valves are required. Especially in the case of recirculating liquids, dead spaces are often unavoidable. Also, if unused U-connection pieces are not removed from the fence, there is always the unintended risk of mixing “incompatible” liquids. Finally, operators often forget to include the U-connection pieces in the CIP cycle.

Distribution panels generally have a much smaller risk of operator error than do pipe fences. Also, the problems of angular dead spaces or U-connection pipes not being included in the CIP cycle are usually much smaller. The anticipated function of the panel, however, must be planned carefully in advance. In this context, moving mentally from hose connections to panel connections tends to be difficult for most people.

Installing pipe fences and panels

In many jurisdictions, the installation of pipe fences and panels is subject to norm DIN 11853, or 11864, respectively. This norm requires that fittings be mounted as fixed points with only little tolerance. Normal tolerances as are common in welding operations, therefore, are not acceptable, and to achieve the required low tolerances is usually not possible during on-site welding. In the case of pipe fences, it is virtually impossible. With panels, tolerances can be met if the planning and execution is carried out with the utmost care. Sometimes it is useful to fix the position of the pipe supports with junction plates.

Pipe fences and panels are fitted almost exclusively with butterfly valves with ethylene propylene diene monomer (EPDM) seals. These valves are rarely automated, because they would not meet the safety requirements for mixing liquids. Valve automation with the proper safety margins are possible, but tend to be cost-prohibitive.

Whenever several tanks are connected to several filling, emptying, and cleaning lines, it is usually necessary to install a complex valve matrix.

Avoid T-fittings

Cleaning of T-pieces is possible through cycling the CIP phase. However, this adds significant cleaning and rinsing times, and increases the amounts of cleaning solutions, mix water, and rinse water. Given the current state of technology, T-pieces are no longer needed in a brewery’s piping system. Then what are the alternatives to T-pieces? There are block-

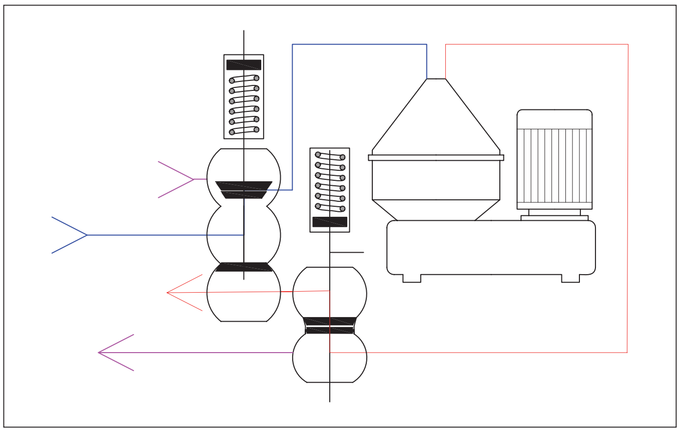

Figure 1: Bypassing a unit (here a separator) by way of a double-seat shuttle valve and CIP connection.

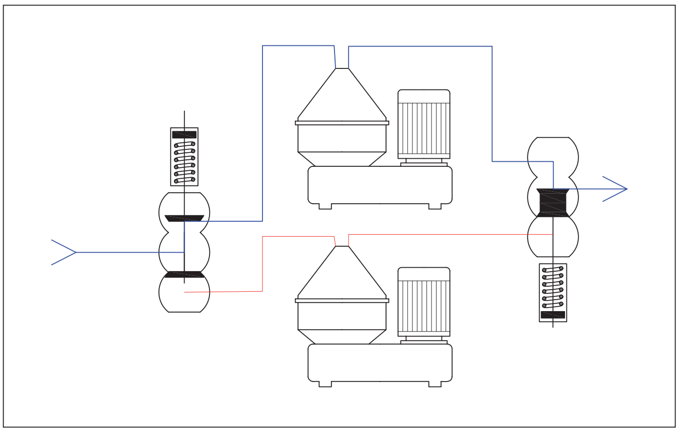

Figure 2: An often used but impractical arrangement of shuttle valves, because CIP connections are missing.

and-bleed arrangements and leakage-free butterfly valves that can serve as replacements of double-seal or double-seat valves provided they are used as shut-off valves. Double-seal or double-seat valves, when installed cleverly, usually afford more than one connection.

Then when do you use double-seal and when double-seat valves? If you use leakage-free double-seat valves, what are the advantages and disadvantages? Do you need balancers in both the upper and the lower chamber? Do you need valve seat cleaning of the upper and/or lower chamber? Is rod flushing a good idea? When do you use a shuttle valve, when do you use a double-seat shuttle valve?

Double-seal and double-seat valves

Early double-seat valves opened to the bottom. This is because they close – or should close – against the direction of the flow, which is from top to bottom. This is especially useful for highly viscous products such as tomato ketchup, which allows for blowing air though the pipes to reclaim a substantial amount of product. Thin liquids, on the other hand, are usually pushed with water near the end, which is why valves that open to the bottom do not constitute an advantage.

Because these valves have an axial sealing system, the valve plates need to be disassembled from the bottom. With few exceptions, therefore, these valves were discontinued around the end of the 1960s and the early 1970s. They have been replaced by double-seat valves that open to the top.

This new construction was much easier to clean and to maintain. They were also more reliable. Successful products had the following characteristics: The spherical chamber can sustain high pulsating pressures; there are no dead spaces in the dome or the product chamber; there is a metal stop according to defined specifications; and it is possible to effectively rinse the leakage chamber.

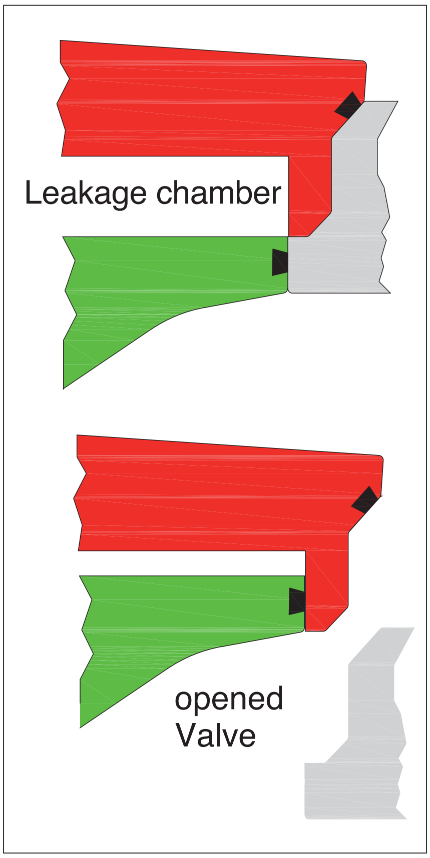

Figure 3: Example of a schematic of a leakage-free double-seat valve. The bottom plate (green) seals radially. Upon opening, it moves to the top against the top, axially-sealing plate (red) with a metal stop and seals the leakage chamber. Then both plates open the valve (bottom schematic).

Lesser products generally did not have a metal stop in the direction of the product flow. Because of production tolerances and the heat expansion of the valve rod, therefore, the product flow could not perform its function. Without a functioning metal stop, the seals were highly stressed and product deposits were virtually compressed onto the seals. Valve seat aeration was often required to keep the seals clean. Poorly constructed rod seals required cleaning connections to minimise the effects of construction faults. Cylindrical housings often were insufficient to the pressure and cracked under stress.

If classic double-seat valves (those that open to the top) experience too much pressure in the upper chamber, the upper plate is pressed into the seat. This means that the product flow pressure is insufficient to open the valve. If there is too much pressure in the bottom chamber, on the other hand, the bottom plate is lifted and the product in the lower chamber can escape through the leakage opening.

The desire to reduce the costs of double-seat valves led to the development of so-called combination gas and CIP valves, which allow for the evacuation of leakage through a pipe in the product flow side of the valve. As the name implies, these valves are used not just for product. They have only one valve housing.

A second development to reduce costs is the double-seal valve. This valve has only one valve plate but – similar to a double-seat valve – seals at two locations. Between these two seals, there is a solid leakage space, which can be connected to separate leakage valves and rinse valves. This is similar to a block-and-bleed arrangement.

The product flow must move only one plate, which means its construction is fairly simple. Generally, the double-seal valve opens in the direction of the product flow; it has axial seals and a stop in the closed position. If the double-seal valve is pushed open by an out-of-spec over-pressure, incompatible media can mix. Installation is flexible, as long as any leakage can be evacuated via a leakage valve. The installation flexibility is the main technical advantage of such valves. They can even be installed along the side of a tank wall. Except for such applications, the double-seal valve was not able to gain much acceptance in Europe.

Function and the need for balancers

Unacceptable pressures cannot occur, for instance, when a valve housing is connected directly to a tank, without any additional shut-off device. Pipes can experience enormously high pressures when a valve shuts very fast or when liquid trapped in a piece of pipe warms up and expands. Balancers are used to prevent the valves from being opened under such conditions. A balancer is simply an enlargement of the valve rod to exactly the same projection area of the valve plate so that the force exerted on the valve plate is the same as that exerted in the opposite direction so that the two forces “balance” out.

In the case of double-seat valves with axial seals and a stop, balancers are rarely used; and if they are used, then only in the bottom housing, because, if the installation is properly planned, unacceptable pressures practically never occur. Because these valves allow for leakage in case of a fault situation, there is no uncontrolled mixing of products, and the use of a balancer cannot be justified on technical or economic grounds.

As soon as a double-seat valve with axial seals opens, the bottom plate is raised from its seat and comes to rest against the upper plate. This seals the leakage space, and both plates now jointly open the valve. During the time it takes for the bottom plate to move against the top plate, there is a connection between the leakage space and the bottom valve housing, which causes a switching leakage. In terms of amounts, however, this leakage can be ignored. However, there is a need for rinse water to rinse the leakage away.

To avoid a switching leakage, the bottom plate must continue to seal the leakage chamber, while it is on its way to the top plate. For this, there must be a radial seal that slides over the wall during opening and closing. First experiments with such seals in the 1980s, however, were not satisfactory, because the radial seals wore out faster than did axial seals.

A manufacturer fits both valve plates with radial seals, if the valve is supposed to open to the bottom. In this case, a stop in the direction of the flow prevents an opening to the top. Therefore, the balancer must be fitted in the top housing in order to achieve the same safety functions as in a top-opening valve.

Shuttle valves are generally single-seat valves. They are double-seat valves that function as distribution valves, in which case one housing is sealed with a double seat and the other with a single seat. However, before such valves are installed, it is prudent to consider the amount of required maintenance, because even experts often have a difficult time to take these valves apart and to put them back together.

Conclusion

Even if only few people are capable of planning an optimal installation, many technical and economic solutions are possible. □