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PUMP CLINIC 20

PUMP SELECTION
'HOW TO PICK THE CORRECT SIZE AND TYPE OF PUMP FOR YOUR APPLICATION'

Have you ever wondered why sometimes after giving two or more suppliers the same information they come back with quite different pump selections or, why sometimes pump suppliers ask a lot of questions? Many readers of these articles will know what goes into a good pump selection but here we will look at a few of the basics so anyone who is not as familiar with the pump selection process will understand where all the questions are coming from.

We need to begin by deciding what operating conditions the pump has to meet. Generally when you approach a pump supplier you will be armed with this information. To clearly define the capacity and pressure needs of your system sometimes you may construct a system curve. This system curve will then be given to the pump suppliers and they will try to match it with a pump curve that satisfies these needs as closely as possible.

- Decide the capacity you'll need. This means the flow rate usually in cubic meters per hour or litres per second. You must also consider if this capacity will change with the operation of your process. A boiler feed pump is an example of an application that needs a constant pressure with varying capacities to meet a changing steam demand The demand for boiler water is regulated by opening and closing a control valve on the discharge side of the pump with a discharge re-circulation line returning the unneeded portion back to a convenient storage place, or the suction side of the pump. Remember that with a centrifugal pump if you change its capacity you change the head also. A positive displacement pump is different. It puts out a constant capacity regardless of the pressure.

- For other centrifugal pump applications, you're going to have to calculate how much pressure will be needed to deliver different capacities to the location where you'll need them. You'll need enough pressure to :

    - Reach the maximum static head or height the fluid will have to attain.

    - Overcome any pressure that might be in the vessel where the fluid is discharging, such as the boiler we just discussed. This is called the pressure head.

    - Overcome friction resistance in the lines, fittings and any valves or hardware that might be in the system. As an example: high-pressure nozzles can be tricky, especially if they clog up. This resistance is called the friction head.

These heads need to be calculated for both the suction and discharge side of the pump. To get the total head you'll subtract the suction head from the discharge head. This is the head that the pump must produce to satisfy the application.

The total head of a pump seldom remains static. There are a number of factors that can change the head of a pump while it is operating and this is the point where most people start adding in safety factors to compensate for some of the unknowns such as aging or clogged pipework or fittings with unknown resistance. These safety factors will almost always guarantee the selection of an oversized pump that will run off its best efficiency point (BEP) most of the time.

The pump itself requires a certain amount of net positive suction head (NPSHR) to prevent cavitation. This value is shown on the pump curve. When you look at the curve you'll also note that the net positive suction head required (NPSHR) increases with any increase in the pump's capacity. Remember that the net positive suction head required (NPSHR) number shown on the pump curve is for fresh water at 20°C and not the fluid or combinations of fluids you'll be pumping

Either you or the pump supplier will be calculating the net positive suction head available (NPSHA) to be sure that the pump selected will not cavitate. Cavitation is caused by cavities or bubbles in the fluid collapsing on the impeller, and volute and has been covered in previous Pump Clinic articles so we will not expand on it here other than to say its presence has harmful effects on most pump styles over time and it should be avoided wherever possible.

- You may have to install an inducer on the pump, add a booster pump, or go to a double suction or side channel pump design if you don't have enough net positive suction head available (NPSHA)
- Once the duty information has been established you need to look into materials of construction. Will you need any special materials for the pump components?
  - The pump supplier will try to choose pump metal components that are chemically compatible with what you're pumping, as well as any cleaners or solvents that might be flushed through the lines. If the temperature of the pumpage changes, the corrosion rate can change also. Will the material selection have an impact on your stock levels or values if the materials are exotic. This can sometimes be a bit of a balancing act.
  - If the product you're pumping is explosive, or a fire hazard, you should be looking at non-sparking materials for the pump components. Do not depend totally upon the pump manufacturer to make this decision for you. If you're not sure what materials are compatible with your product, how will the pump supplier know? Also, keep in mind that some of the fluids you'll be pumping could be proprietary products known only by their trade name.
  - Dangerous and radioactive materials will dictate special materials.
  - Food products require high-density seal and pump materials that are easy to clean and sterilize. They also sometimes affect the design of the pump internal and external components
  - If there are abrasive solids in the pumpage, you'll need materials with good wearing capabilities. Hard surfaces and chemically resistant materials are often incompatible. You may have to go to some type of coating on the pump wetted parts or select an expensive duplex metal.
- Occasionally you'll find an application where metal is not practical. There are many monomer and polymer materials available for these applications, but their cost is generally higher than comparable metal parts. Be aware that if you're using a mechanical seal in a non-metallic pump, the seal can't have metal parts in contact with the fluid for the same reasons the pump was manufactured from non-metallic materials. Use a non-metallic seal or perhaps magnetic drive in these applications

When the pump supplier has all of this information in his possession he can then hopefully select the correct size pump and driver for the job. Since we all want to quote a competitive price we are now going to make some critical decisions:

First we need to look at the style of pump we would recommend:

- If the capacity were going to be very low we would recommend a positive displacement (PD) pump. This could be a gear or diaphragm type pump for small capacities.
- Between about 5 m^3/hr and 120 m^3/hr, depending on the differential head we would probably select a single stage end suction centrifugal pump. At higher capacities we may go to a split case or double suction design with a wide impeller or even use two pumps in parallel.
- You might need a high head, low capacity pump in which case we may look at a positive displacement pump again or a multi stage centrifugal pump
- Does the pump need to be self-priming? A self priming pump removes air from the impeller eye and suction side of the pump. Some operating conditions dictate the need for a self-priming design. If you

do not have a self-priming pump and you're on intermittent service, will priming become a problem the next time you start the pump?

- How will the pump be operated?
    - If the pump is going to run twenty-four hours a day, seven days a week and you're not going to open and close valves; you will not need a heavy-duty pump. It's easy to select a pump that'll run at its best efficiency point and at the best efficiency point (BEP) there's very little shaft displacement or vibration.
    - Intermittent service is sometimes the more difficult application because of changing temperatures, vibration levels, thrust direction, etc.
- How important is efficiency in your application? High efficiency is desirable, but you pay a price for efficiency in higher maintenance costs and a limited operating window. You should be looking for performance, reliability, and efficiency in that order. Too often the engineer specifies efficiency and loses the other two. The following designs solve some operation and maintenance problems, but their efficiency is lower than conventional centrifugal pumps.
    - A magnetic drive or canned pump may be your best option if you can live with the limitations they impose. The main ones being their intolerance of dry running and solids
    - A vortex or slurry pump design may be needed if there is a concentration of solids or "stringy" material in the pumpage.
    - A double volute centrifugal pump can eliminate many of the seal problems experienced when we operate off the pump's best efficiency point. The problem is trying to find a supplier that will supply one for your application. Although readily available for impellers larger than 14 inches (355 mm) in diameter they have become very scarce in the smaller diameters.
- The supplier should recommend a centerline design to avoid the problems caused by thermal expansion of the wet end if you're operating at temperatures over 200°F (100°C)?
- Will you need a volute or circular casing? Volute casings build a higher head; circular casing are used for low head and high capacity.
- Do you need a pump that meets a standard? ANSI, API, DIN or ISO are some of the current standards.
- The decision to use either a single or multistage pump will be determined by the head the pump must produce to meet the capacities you need. Some suppliers like to recommend a high speed small pump to be competitive, other suppliers might recommend a more expensive low speed large pump to lessen NPSH and wear problems.

There are additional decisions that have to be made about the type of pump the supplier will recommend:

- Will the pump be supplied with a mechanical seal or packing? If the stuffing box is at negative pressure (vacuum) a seal will be necessary to prevent air ingestion.
- If fitted with a mechanical seal will it also have an oversized stuffing box and any environmental controls that might be needed?
- Will the pump have a jacketed stuffing box so that the temperature of the seal fluid can be regulated? How do you intend to control the stuffing box temperature? Will you be using water, steam or maybe a combination of both? Electric heating is sometimes an option.
- How will the open or semi-open impeller be adjusted to the volute casing or back plate? Can the mechanical seal face loading be adjusted at the same time? If not, the seal face load will change and the seal life will be shortened.

- If the pump is going to be supplied with a closed impeller you should have some means of knowing when the wear rings have to be replaced. If the wear ring clearance becomes too large the pumps efficiency will be lowered causing heat and vibration problems. Most manufacturers require that you disassemble the pump to check the wear ring clearance and replace the rings when this clearance doubles.

- Is the pump fitted with a metric motor frame adapter, or will the pump to motor alignment have to be done manually using dual indicators or a laser aligner to get the readings? A close-coupled design can eliminate the need for an alignment between the pump and driver.

- What type of coupling will you use to connect the pump to its driver? Couplings can compensate for axial growth of the shaft and transmit torque to the impeller. They cannot compensate for pump to driver misalignment as much as we would like them to although this is much better than it was a few years ago. Universal joints and 'Hardi Spicer' shafts are a potential problem for those not experienced with their use because they have to be misaligned to be lubricated properly

- Belt drives are an option that allows a reasonable amount of fine tuning of pump speed to be achieved as well as changes of speed later in the pumps life. They are often used on slurry applications.

- The supplier may decide to run two pumps in parallel operation if you need a high capacity, or two pumps in series operation if you need a high head. Pumps that run in parallel or series require that they are running at the same speed. This can be a problem for some induction motors or installations where identical location of the pumps is not possible.

- An inline pump design can solve many pipe strain and thermal growth problems.

- The pump supplier must ensure that the pump will not be operating at a critical speed or passing through a critical speed at start up. If he has decided to use a variable speed drive or motor this becomes a possibility.

- We all want pumps with a low net positive suction head required to prevent cavitation problems but sometimes it's not practical. The manufacturer sometimes has the option of installing an inducer or altering the pump design/application to lower the net positive suction head required, but if he goes too far all of the internal clearances will have to be perfect to prevent cavitation problems.

- Shaft speed is an important decision. Speed affects pump component wear and NPSH requirements, along with the head, capacity, and the pump size. High speed pumps cost less initially, but the maintenance costs can be much higher depending on the pump duty. Speed is especially critical if you're going to be specifying a slurry pump.

There are multiple decisions to be made about the impeller selection and not all pump suppliers are qualified to make them:

- The impeller material must be chosen for both chemical compatibility and wear resistance. You should consider one of the duplex metals because most corrosion resistant materials are too soft for the demands of a pump impeller.

- The decision to use a closed impeller, open impeller, semi-open, or vortex design is another decision to be made.

- Closed impellers require wear rings and these wear rings present another maintenance problem.

- Open and semi-open impellers are less likely to clog, but need manual adjustment to the volute or back-plate to get the proper impeller setting and prevent internal recirculation.

- Vortex pump impellers are great for solids and "stringy" materials but they are up to 50% less efficient than conventional designs.

- Investment cast impellers are usually superior to sand cast versions because you can cast compound curves with the investment casting process. The compound curve allows the impeller to pump abrasive fluids with less vane wear.

- If you're going to pump low specific gravity fluids with an open impeller, a non-sparking type metal may be needed to prevent a fire or explosion. You'll be better off choosing a closed impeller design with soft wear rings in these applications.

- The affinity laws will predict the affect of changing the impeller speed or diameter.

- Either you or the supplier must select the correct size electric motor, or some other type of driver for the pump. The decision will be dictated by the specific gravity of the liquid you'll be pumping, along with the specific gravity of any cleaners or solvents that might be flushed through the lines. The selection will also be influenced by how far you'll venture off the best efficiency point (BEP) on the capacity side of the pump curve. If this number is under-estimated there is a danger of burning out some electric motors.

- How are you going to vary the pump's capacity? Are you going to open and close a valve or maybe you'll be using a variable speed drive, or maybe a petrol or diesel engine. Will the regulating valve open and close automatically like a boiler feed valve, or will it be operated manually? A variable speed motor or a frequency inverter might be an alternative if the major part of the system head is friction head rather than static or pressure head.

- The viscosity of the fluid is another consideration because it'll affect the head, capacity, efficiency and power requirement of the pump. You should know about viscosity and how the viscosity of the pumpage will affect the performance of the pump. There are some viscosity corrections you can make to the pump curve when you pump viscous fluids.

- After carefully considering all of the above, the pump supplier will select a pump type and size, present the quote and give you a copy of the pump curve. Hopefully you'll be getting the supplier’s best pump technology.

If all of the above decisions were made correctly, the pump supplier will place his pump curve on top of your system curve and the required operating window will fall within the pump's operating window on either side of the best efficiency point (BEP). Additionally, the motor will not overheat and the pump should not cavitate.

If the decisions were made incorrectly, the pump will operate where the pump and system curves intersect and that will not be close to, or at the best efficiency point, producing radial impeller loading problems that will cause shaft deflection, resulting in premature seal and bearing failures. Needless to say the motor or driver will be adversely affected also.