

Maintenance and troubleshooting of Pumps **Some common and uncommon tips**

There are different methods used by maintenance engineer for proper functioning of pumps in process industries. If the maintenance staff at a plant are more busy doing troubleshooting and repairs, it is not very commendable. Trouble-free life of a pumps is influenced through all stages of selection, installation and operation of pumps. This article offers various simple, hands-on tips for proper maintenance of pumps.

Different philosophies have evolved for maintenance of equipment like pumps, starting from routine maintenance, breakdown maintenance, preventive maintenance, periodic overhaul, condition-based or predictive maintenance. Basic purpose of all these philosophies is to have the equipment running trouble-free thereby increasing 'availability' of the equipment.

Even when the equipment is to be shut down for repair or overhaul, the anxiety is to reduce the downtime. Some ease of disassembly and reassembly without disturbing the adjoining pipes or the motor. Inventory of replacement spares is also an associated point of concern.

In the event of trouble or operational failure of the equipment, diagnosis of the cause of trouble, as per 'Root Cause Failure Analysis' (RCFA) also becomes important, so that early prevention of frequent recurrence of the trouble can be assured in the process of repair itself.

Keep it like new:

For trouble-free running of equipment, one appealing phrase is 'Keep it like new'. Major factors that need to be addressed are cleanliness, ventilation and cooling to avoid any abnormal build-up of temperature, lubrication, ear for any abnormal noise and/ or vibration. If the equipment does not look like new, is smudged with blots of dirt or has scratches or peeling off of its paint, it indicates indifference suffered by the equipment during its operation and maintenance.

The paint of the equipment is not just for its aesthetics. It would often be a protective coating, especially in case of corrosive environments. It may have been scrupulously selected and would merit due care and attention.

RYBM:

Plant engineers are quite familiar with RYB, the colours of wires in a three-phase electric supply. However, in the acronym RYBM, there is an additional 'M'. This author was privileged to learn about this acronym in a programme on software of computers. There is always the chance that one may have trouble in properly using different features of software. So, if one gets stuck, the best first-aid should be made available by reading the manual. So, RYBM 'Read Your Bloody Manuals'!

Theory and practical:

There is often an impression that things which sound theoretical don't appeal to plant engineers, especially to maintenance engineers. The notion seems to be that things sounding theoretical may be alright in theory, but may not work in practice. It is illogical to buy this argument. How can the working of any engineering equipment be different from its theory? The only reason for such an argument would be, that maintenance engineers become so much given to the habit of 'putting their hands into' the problem, that they tend to become loathe to sit down in the chair and read even the manuals, leave alone the books of theory.

On common occurrence in case of pumps is leakage at shaft seal. The cause of unstoppable leakage may be due to scouring on the shaft sleeve. This itself may be due to run-out on the shaft. The run-out may be due to misalignment. Misalignment may be due to undue vibrations. And, undue vibrations may be due to some foundation bolt not tightened properly.

Pressure of least downtime and RCRA:

One would tend to sympathise with the maintenance engineers, for the stress they suffer to put the equipment back into operation at the quickest time. This stress alone would include the habit of departing from 'RCFA'. The corollary result would be recurrent failures. One common occurrence in case of pumps is leakage at shaft seal. The cause of unstoppable leakage may be due to scouring on the shaft sleeve. This itself may be due to run-out on the shaft. The run-out may be due to misalignment. Misalignment may be due to undue vibrations. And, undue vibrations may be due to some foundation bolt not tightened properly.

Documentation, log books, equipment history sheets:

The diameter of the impeller may have been trimmed during installation and commissioning itself, to avoid the overloading of the motor. If the appropriate diameter of the impeller is not documented, in the even of a replacement, what will be available as a spare would often be an impeller of full diameter. Obviously, with such inadvertent replacement, the motor would again suffer from overload.

Even if the diameter is not trimmed during installation, diameter of the impeller in process pumps may often not be the 'full' diameter. Manufacturers of process pumps do keep a record of the diameter of every pump. So, mentioning nameplate details when ordering spares would prove a sound practice to be religiously followed.

Genesis of troubles:

There are some pumps, which get branded as troublesome right from the beginning right from the beginning. The reason could often be improper selection.

Another reason can be an improper installation. There have been instances of flange of the casting getting sheared off when unfastening the pipe flange. It simply means that during installation, the flanges were matched forcibly with excessively undue nozzle loads and moments and stresses. May be there are such instances, which prompted American Petroleum Institute (API) to specify the nozzle loads and moments criteria in the standard API-610.

The third reason is improper operation. For example, in case of a pump handling liquids that have a tendency to solidify at ambient temperature, if effort is made to start the pump without starting the heating circuit and without waiting for the matter to liquefy, it may lead to either shearing, bending or run-out on the shaft. As another example, if the safe flow bypass valve does not operate properly, the pump may work with less than 'safe minimum flow' and the pump would suffer.

Change overs in parallel operation systems and any other system transients have to be operated with due care and caution.

Cavitation:

Although discussing this phenomenon is important, here, it should suffice to say that often cavitation gets 'installed'. The simple rule is that cavitation will occur, if $NPSHa < NPSHr$. Since $NPSHa$ is what is needed to be available in the system, it being less than $NPSHr$ is eminently a system problem, so a problem as installed or as operated. If the pump is operated beyond the recommended range, then also it can suffer cavitation. This again underscores the importance of 'RYBM'!

Cavitation damage can become very severe to the extent of washing off the vanes of the impeller! Often a simple habit or 'ear for any abnormal noise' can help detect cavitation in right time. Cavitation damage is cancerous. It does not cause the pump to stop functioning. It does not cause the pump to stop functioning. But the pump performance depletes and the damage progresses non-stop.

The logical solution to resolving the problem of cavitation is to ensure that $NPSHa > NPSHr$. Again the equation for $NPSHa$ is:

$$NPSHa = P_s \pm z - V^2 / 2g - H_f - V_p$$

The simple fact that there are as many parameters in the equation means that there are as many options for solution! It would not help plant engineers to be averse to sitting at the table and doing the calculations to apply the equation.

Symptoms, causes and remedies:

With the engineering equipment remedial measures are quite straight forwarded. If there is sparking in electric circuit and if the sparking is due to loose connection, the remedy is to tighten the connection. In medical practice, with human machine it is not as straight forwarded. One gulps a pill into one's stomach even for a headache. Fortunately, man has yet not been able to construct a human being !

But the symptoms have to be diagnosed with RCFA approach. In handbooks and standards, and also in manuals of manufacturers ready checklists are provided for troubleshooting. Some common symptoms indicating trouble with the pump are:

- Pump does not start pumping
- Pump loses prime
- Pump discharge is less
- Pressure or head is less
- There is profuse leakage at shaft
- Pump gets heated up
- Pump makes too much noise
- Pump vibrates
- Motor gets overloaded.

There are as many as 47 different causes for the above symptoms listed in checklists. And against some symptoms there would be some 15-20 causes to diagnose a symptom. That itself can be an onerous task and may not always lead to RCFA. According to the author, the logical approach should be to first check that everything is as it should be. For example, the discharge may be less because the direction of rotation is not proper ! Some electrician may have an atrocious habit of taking out all the wires at one go and not tagging them due to overconfidence of his own memory. And he may end up changing the phase sequence when reconnecting. There is more problem, if the reconnection has to be done by another electrician.

Another common cause is misalignment. The author often feels amused seeing auto garages proclaiming 'computerised wheel alignment' (for Indian road conditions). Well, why not? A vehicle attended with 'computerised wheel alignment' should be able to withstand the inflictions of Indian road conditions better than one without such alignment. Do it right the first time ! If computerized wheel alignment is in practice for autos, who good is the alignment practice for industrial equipment? This reminds one about shearing off of causing flange, basically a problem of indifference to proper alignment.

Wrenching is another weakness of a maintenance technician. One would like to dream that breed of technicians who can make a good leak-tight high-pressure joint with just adequate wrenching would grow. It seems logical to hypothecate that excessively wrenched fasteners would suffer more corrosion due to seizure and galling.

Human errors and instrumentation:

Pressure-booster type hydro-pneumatic systems for constant water supply, especially in multi-storey buildings are good examples of small scale automation of a pumping system. One may argue whether such systems are energy-efficient. But given such a system, the automation, as is often built in, merits appreciation. Industrial systems would be more demanding and it is more essential that the chance for human error is minimal.

MTBF and 'fail'safe' designs:

The basic purpose of maintenance activity is to have long Mean Time Between Failures (MTBF). Failure is not necessarily only breakdown. Depletion in performance is also a failure, because the pump is not pumping as much as it should. That is why, discharge and less pressure are listed as trouble-symptoms. But it could be open to argument whether depletion in performance should be taken into account when calculating MTBF.

For pumps in critical applications, e.g., a boiler feed pump at a power generating station, it becomes logical to have condition-monitoring systems 'installed'.

I know of submersible dry motor sewage pumps provided with resistivity sensor embedded to stop the pump, if the inboard seal has failed. The leakage would make the barrier oil more conductive.

Equipment life:

Thinking of primary coolant pumps in nuclear power stations, one can agree that pumps can be built for really long MTBF. Conversely, agricultural pump of a farmer needs to run only for some 1,500 hours out of 8,760 hours in one year, that too, very intermittently, may be for maximum eight hours a day. So, equipment life is an application specific consideration. Primarily, coolant pumps serve evidence that designers can cater to the demands of the application.

For rotating equipment, the equipment life is mostly the bearing life. As long as the bearings are good, the rotation of the equipment will be good. If the rotation is good, it will keep operating good. Equipment life is thus in-built in the design by selection of bearings of appropriate life. Manufacturers of anti-friction bearings give guidelines for selection of bearings for desired bearing life.

Popularity of anti-friction bearings has ingrained the concept of bearing life so much that one thinks of bearing life for all types of bearings. However, the concept is not all that relevant for journal bearings. It is more appropriate and consonant with the theory of tribology, that journal bearings would have really infinite life. The essence of a journal bearing is the film of lubricant which separates the 'bearing' surface. It is actually the film which 'bears' the load. As long as the film is retained, the so-called bearing surfaces do not have to suffer any wear. If they won't wear, the life will be infinite. Substantially, the rotation itself helps to sustain the film. If the rotating axis is horizontal, the dead weight of the rotating unit will settle down when rotation is stopped. Pressurised lubrication can help to provide that the film does not suffer rupture even with the dead weight settling down. Systems with transients are of course more hazardous. This underscores why lubrication is an essential item of attention during maintenance.

Reliability:

Reliability is different from equipment life. Even if a farmer uses his pump intermittently, he needs reliability that the pump would do pumping as and when he wants. It is sound logic that in systems having standbys no particular pump is designated as standby pump. Sequence is set up that all pumps would get their turn to be the 'running' pump.

So, whereas preventive and condition-based maintenance would help long MTBF, routine maintenance would provide reliability. Equipment needs attention and care even during storage and in idling.

Least downtime:

Barrel casing type multistage boiler feed pumps can be considered as good examples of pumps with 'least downtime' as an in-built feature. All the hydraulic and mechanical components are made as capsules. In the event of repair or overhaul, what is needed is to take out one capsule and replace with another. The capsule to be repaired can be given all the needed attention subsequently. Pump can be put into operation readily with the replacement capsule.

For axially split casing pumps also, one can have in the inventory a ready, assembled rotating unit, instead of having shaft, impeller, etc. as independent items.

Wear, MOC, energy efficiency and periodicity of overhaul:

However good one may wish, there is bound to be wear. In case of pumps, one significant effect of wear is roughening of surfaces and increase in running clearances. If the pumpage is abrasive and/ or corrosive, the wear can be alarmingly fast. Selection of materials of construction (MOC) of pumps is thus a very important consideration. System transients would also accelerate the wear. Many coatings are also being practiced to combat abrasive, corrosive and frictional wear.

Both roughening of surfaces and increase in running clearances would also reduce the energy efficiency of pumps. Tolerance on depletion of energy efficiency can be fairly subjective or application specific. So, periodically or overhaul ought to be application based.

In conclusion:

Trouble-free life of a pumps is influenced through all stages of selection installation and operation of pumps. The whole gamut of technologies of pump construction and design, material technologies, protection devices, instrumentations, alignment tools, automations can be explored to get the best of the pump in process plants.

Some electrician may have an atrocious habit of taking out all the wires at one go and not tagging them due to over-confidence of his own memory. And he may end up changing the phase sequence when reconnecting. There is more problem if the reconnection has to be done by another electrician.

If the maintenance staff at a plant are more busy doing troubleshooting and repairs, it is not very commendable. If the equipment is 'maintained' 'like new' the maintenance staff can be considered better eligible to be called as 'maintenance staff' and for themselves also, they can have a far more relaxed life.

Reference book:

Indian Pumps
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