Pump Reliability in the Food & Beverage Sectors

In this article **Tony Gales**, a director with AVT Reliability's Pump Division (AVTPump), analyses many years' of pump maintenance records following the integration of AESPUMP Ltd and AV Technology Ltd into AVT Reliability and has made some observations from our food and beverage clients' data which it was thought worth sharing with a wider audience.

A challenge that is often heard when talking to food and beverage companies is 'we have to focus on getting the basics right before we talk to you about advanced maintenance techniques!' And, whilst AVT Reliability are a large provider of condition-based maintenance services to this sector in the UK, we see that many successful programs start with ensuring the foundations are in place before building a best practice maintenance management program.

One of the biggest areas for reducing cost, improving reliability/availability and production is associated with pumps. It is no surprise of course that many food and beverage maintenance managers feel they must 'get the basics right' when it comes to pump specification and maintenance; production demands can lead to coping with day-to-day challenges of keeping things going, there is little time to keep up let alone adopt new maintenance strategies.

A review was carried out of the AVT Reliability database which contained total pump management data on 5,000 new pump sales and 13,000 repairs/overhauls across a client base of 1,400 companies and spanning 15 years. And not just food and beverage, but all industrial sectors, all of whom have similar challenges when it comes to contamination control, effective separation, agitation, mixing, purification, concentration, metering and energy efficiency.

The top 5 reasons for failure were calculated based on the analysis of around 4,200 records where accurate and reliable data was cross-referenced with condition monitoring (CM) data – *see Figure 1*. Similarly, over 3,000,000 CM readings were analysed to produce the top 5 faults – *see Figure 2*.

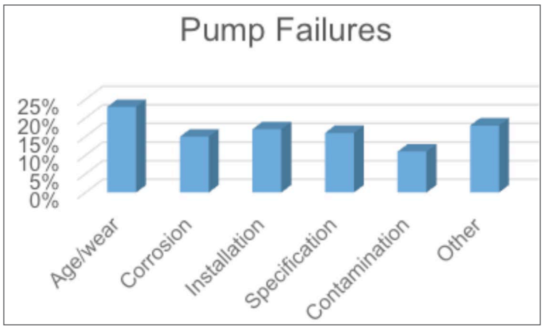

Figure 1 Pump failures

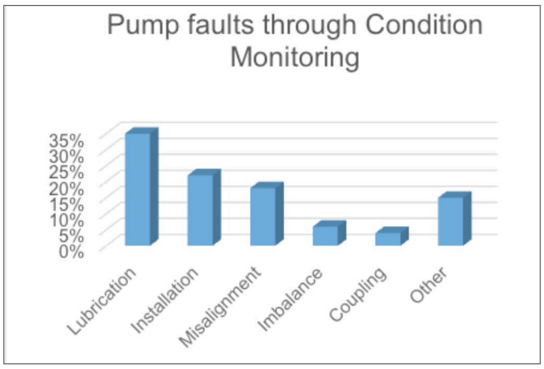

Figure 2 Pump faults

This data supports the need to focus on basics, even when there are effective condition monitoring (CM) programs in place utilizing techniques such as vibration analysis, thermography, oil analysis and ultrasound.

85% of pump faults found through CM and 82% of pump faults found on repair/replacement can be attributed to a small number of basic conditions that can be avoided through an effective pump management and maintenance program.

Adding both findings together highlighted common conditions and helps suggest some focused actions that will greatly improve pump reliability and availability, leading to cost savings and production benefits.

1. Specification

Whilst pump standardisation and rationalisation is very important on a site; unfortunately there is no 'one size fits all' solution for most food and beverage operators. Finding the right pump for the application is critical, as "incorrect specification for the application" was found to be in the top three causes for fault or failure.

There are many ways of specifying a replacement pump, including 'free' online tools, OEM advice, pump suppliers and service companies. The most important thing to make sure is that the advice you are getting is unbiased and that considerations are made to making sure you have considered past failure modes and making sure that the pump will perform within its designed BEP (Best Efficiency Point) – see Figure 3.

In the food and beverage industry it is likely that pumps will not be unique, and accessing free information and assistance to find the right pump for the application is relatively straight-forward.

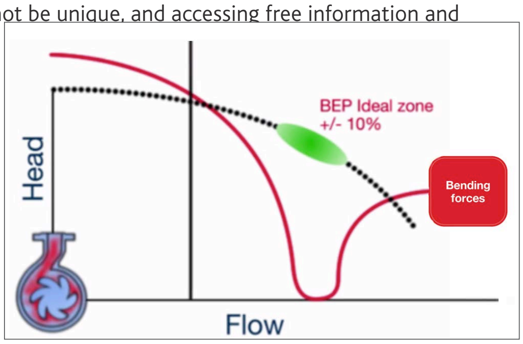

Figure 3 Best efficiency point

The challenge is more likely to be which pump to go for; in which case price, maintainability, reliability and technical support will be important aspects to consider. But as can be seen, choosing simply like for like or the cheapest similar pump is a risky thing to do. Stick to quality brands and do not be tempted by cheap imports. Consider a wide range of OEMs and pump types before selecting the right equipment for the application.

When working out options for a replacement pump, focus on the operational requirements and not like for like: what the system was designed to do may not be what it is doing now! it could be a good opportunity to test your assumptions about pump types and makes, especially when processes may have changed and could be adversely affecting the maintenance and energy bills as well as production. Pump technology may also have moved on, so be prepared before looking for a suitable replacement. Table 1 shows is a simple log of data you need to provide a pump supplier to get the right advice: suppliers will, of course, help but it is best to steer the options from the outset.

Consider a pump specified and operating efficiently for constant running; this could last longer than one that is working intermittently, simply because of the significant impact that 'stop-starts' can have. When the pump stops the product may change; viscosity increases as temperature drops, product can crystallise, solids settle, etc, all of which

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No of pumps required	*1*
Preferred pump manufacturer	
Pump orientation -vertical/end suction	*End suction*
Flow (m³/hr, l/s, gpm)	*51m³/hr*
Head (m, ft)	*40m abs*
Liquid	*Brine (24% w/w CaCl□)*
Solids	*Nil*
Liquid Temp (°C)	*Min -15°C Max 70°C (Design 130°C static design temp 200°C)*
SG (dynamic)	*1250 Kg/m³*
Viscosity (cp, cts)	*2cP*
Vapour pressure	*0.05bar abs*
NPSH available (m, ft)	*21.7m abs*
Motor zone (T1,T2,T3,T4)	*T3*
Voltage and phase	*415V 3-phase 2900rpm*
Historical equipment can help in bottoming out recent failures to prevent repeating the errors	
Make of pump (if repeat)	
Model of pump (if repeat)	
Serial No (if known)	

Table 1 Log of data

can damage both seal and pump. There are, of course, solutions including jacketing a pump or trace heating to replicate the conditions of a 24hr running hot system. This is just one example where replacing like for like may not be the best approach.

2. Installation

Over the years the focus has been to reduce the purchase price of pumps and replacement pump support/repairs by operators. But the data tells us that poor installation causes 15-20% of premature failures or faults and that this area must receive the same level of attention, if not more.

Further analysis shows that pipe-strain, pipework design, soft-foot, misalignment, imbalance, incorrect gauging and a lack of bearing protection are very common factors in the area of installation related reliability issues. For example, pipework is often not reviewed as to efficiency or impact on the pump; a 90° bend fitted immediately on the pump suction can induce an impeller imbalance and shaft deflection which will lead to a significant reduction in Mean Time Before Failure (MTBF). When reducing pipework remember to use eccentric reducers installed as a flat top, something often overlooked.

When installing a pump it is important not to forget suction and discharge gauges; for minimal initial cost the saving when monitoring or problem solving can be substantial.

A well-known confectionery manufacturer with good maintenance management and competent personnel improved the MTBF of equipment by over 15% as a result of implementing a precision engineering installation approach; also reducing pressures on production and maintenance teams.

This is an area where the chosen OEM or service provider/systems integrator can assist. OEMs will often provide free training but this important area needs a lot more though than that. Review your installation team (in-house or outsourced) standards, competence assessment/ development program, installation standards and quality checking processes, ensuring that:

- Equipment installed is always laser-aligned
- Personnel are competent (training, qualifications and experience)
- Standard procedures are written down and adhered to, which include a quality check
- Gauges, bearing protectors and other supporting equipment is considered, linked to requirements driven by an FMECA-based (Failure Mode, Effects and Criticality Analysis) selection approach

3. Effective sealing and contamination control

As part of the AES Engineering Group (with AESSEAL as sister company) AVT has access to food and beverage technical support for mechanical seals and seal support systems including bearing protectors. In addition, as a provider of lubrication management services to the food and beverage sector. AVT is interested in how to protect bearings, maintain lubricant and avoid food contamination. Thus, knowing where to look to improve reliability and avoid contamination may have skewed the figures slightly. Nonetheless, this study has highlighted the importance of sealing and contamination control as it is also based on some significant improvements as well as over 40 year's empirical evidence.

Case study

Dairy Crest Severnside had recurring water ingress issues with water cooling towers that were resulting in a low MTBF on the pump motors (<1 year). Analysis indicated that the motors were prematurely failing due to water ingress into the bearing housing. This ingress compromised lubrication and caused the bearings and, ultimately, the motor to fail – see Figure 4.

Figure 4 A failed electric motor

Further investigation found that the standard oil seals could not handle the harsh environmental conditions within the cooling towers, which was not helped by the fact that they were vertically mounted. As a result, once the drive end seal failed, water and chemical ingress into the motor bearings and subsequent pump failure became inevitable.

A labyrinth design bearing protector seal was recommended to protect the bearings from further contamination failures – see Figure 5. As a consequence there have been no subsequent failures due to contamination and the MTBF is now expected to be around 5 years. (More details at avtreliability.com/case-studies)

Figure 5 A labyrinth design bearing protector

OEM's and systems integrators will not necessarily focus on contamination control, so make sure consideration is a part of the specification for new pumps and pump repairs where there is a known challenge. The upfront cost will be negligible, but the benefit in terms of

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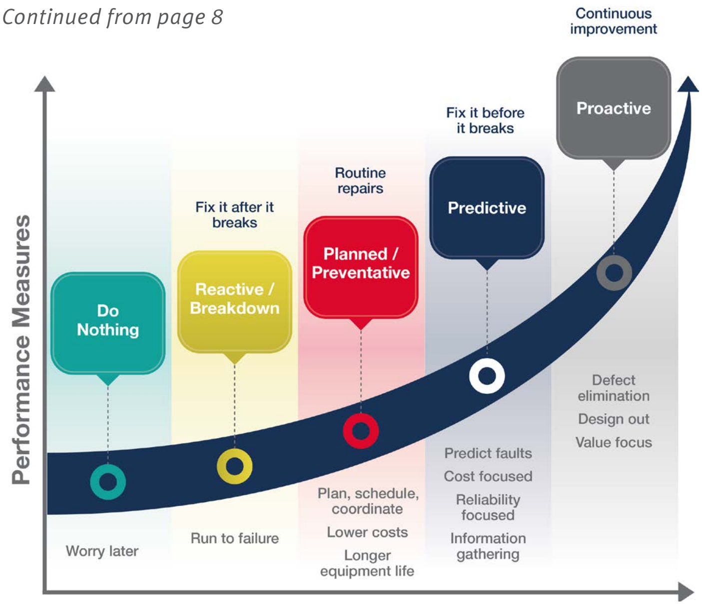

Figure 6 Maintenance strategy

availability, reliability and cost reduction will be significant, so it is worth investing a little time.

4. Maintenance

Misalignment, soft foot, pipe strain, etc, could all fall into this, as well as in the installation category.

Maintenance strategies can be considered to incorporate reactive, planned, predictive and proactive methodologies – *see Figure 6*. You may be well on the way to a proactive approach to maintenance but, nonetheless, the evidence shows that it is the basics that can catch us out. For example, all of AVT's CM customers are operating predictive maintenance strategies but their data shows that lubrication, installation and misalignment are still causes for concern.

Lubrication is clearly important in terms of failure modes that should be addressed as part of a pump reliability improvement program according to our statistics. Sub-optimal lubrication is not unique to the food and beverage industry, however HACCP requirements and food safety are. So for many companies this could possibly be the most important area to focus on in terms of improving reliability and safety, especially when looking at the evidence.

Lubrication management processes, competences and controls should be reviewed to highlight opportunities in storage and handling, contamination control, schedules, spill management, competences and training, waste management and goals/metrics to manage performance. External experts (eg AVT and most oil OEMs) can assist with an external review of lubrication standards and there is a lot of information available on the internet as to best practice standards.

For example, a lubrication assessment carried out by AVT in 2010 on a drinks plant operating over 3000 pumps at very close to best practice lubrication, showed their score against ICML Standards (International Council of Machinery Lubrication) was <60%. Over the last 5 years the reliability has increased significantly; bearing failures used to be common and are now very rare; and OEE has increased by 6.5% as a direct result of maintenance improvements, of which lubrication was improved the most

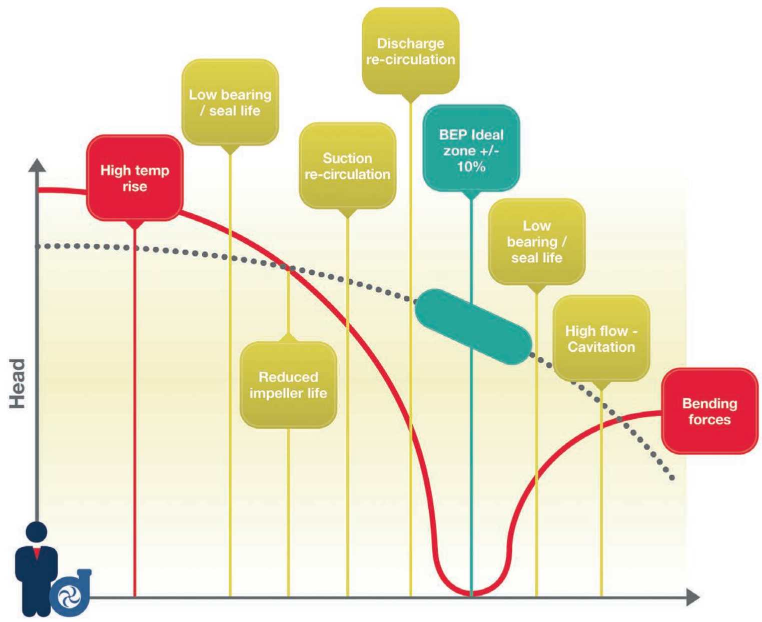

Figure 7 Operating outside the best efficiency point (BEP)

5. Monitoring

Considering the evidence that pump failures occur largely as a result of age, corrosion and poor lubrication and that production demands change, then condition and performance monitoring is an important tool to avoid unplanned downtime and costly repairs.

Assuming the points under heading 1 to 4 above have been suitably addressed and management attention is able to shift towards predictive maintenance, then techniques such as pump performance monitoring, vibration analysis, oil analysis, thermography and ultrasound should be considered. But before investing in vibration analysers, thermal imaging cameras and such like, it is very important to understand likely failure modes; carrying out a FMECA will help you match a maintenance and monitoring strategy to the most likely failures modes and their frequency. This can then be used as a basis to introduce a managed monitoring program internally or as a guideline to outsourcing the service.

Conclusion

Challenged by operators who think they just need to speed up the pump to get more out of it we are able to prove that moving from the best efficiency point – running the pump faster to increase the head – can severely strain the shaft, the deflection of which can cause premature bearing failure and, in extreme circumstances, contact leading to catastrophic pump failure – *see Figure 7.*

Although this article has centred on the food and beverage processors the lessons learnt can be applied to all industrial sectors. AVT has found that an approach that combines different manufacturers has the best effect on machinery availability and reliability when delivered through a reliability-centred pump management program, but that is the key: – effective pump management, selection and installation!

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NB. AVT Reliability would be very interested to learn about readers opinions based on their own experiences on how to increase pump reliability and performance. Email your comments to info@avtreliability.com