Plant performance: should maintenance deliver much more?

Maintenance is failing to deliver consistently high plant performance and reliability for many companies in the manufacturing and process industries. Michael Dixey identifies six factors affecting performance, which are not recognised by traditional maintenance wisdom

IN MOST industries, maintenance routines are established by either the equipment manufacturer or the company's own plant engineers. These routines focus on maintaining the equipment to prevent it failing – so-called 'preventive maintenance'. In so doing, they miss many important factors which can adversely affect plant reliability and performance. These are the need to take into account the equipment's operating context, differing equipment applications, the importance of process integrity, the significance of random failure, modern plants' reliance on protective systems, and the role of the operator.

importance of the equipment's operating context

The maintenance engineer's objective is, so often, to prevent failure. Yet it is not the failure that is important – it is the consequences of failure.

Take the centrifuge as an example. A food company uses a standard model at a number of its plants. At Plant A, it has three centrifuges, two normally operating and the third on stand-by. At Plant B, it has only one unit through which all production is passed.

The operating contexts of these centrifuges are very different – even though they are the same model and handling similar products. The consequences of a centrifuge failure in Plant B, where there is no stand-by, are potentially far more serious than a failure in Plant A. Clearly Plant B's centrifuge therefore warrants a more rigorous maintenance regime than those in Plant A.

Yet the manufacturer of the centrifuge and the company's plant engineers will almost certainly recommend the same preventive maintenance routines for the centrifuges in Plant A as for the one in Plant B – despite their different operating contexts.

differing equipment applications

The majority of plant in most manufacturing and process companies comprises relatively standard equipment (pumps, motors, valves, heat exchangers, conveyors, palletisers, and so on) configured in unique ways. But the application of these individual items of equipment will vary enormously and may also be very different from those for which they were originally designed.

Take the example of the centrifuge again – where relatively standard models are used across a wide range of industries from food and drink to petrochemicals. The nature of the solids within the liquid being centrifuged may range from spent grain (brewing) to fine sand (oil refining). Even within the same plant, identical centrifuges may have widely different applications.

The causes of poor performance will differ markedly between these applications – yet seldom will the maintenance procedures reflect this. The 'one cap fits all' approach is clearly not appropriate – but again this is the line which most companies take.

The different causes of failure, as well as the different operating contexts, need to be taken into account when preparing preventive maintenance routines.

the importance of process integrity

In the process industries, the most important issue is not usually equipment reliability (whether it keeps running), but process integrity (whether it produces to specification). For example, the accuracy of key process control instrumentation can be far more critical than equipment breakdown.

Inaccurate instrumentation can lead to major product quality and integrity – and will often not be apparent to those operating and maintaining the plant. This may result in significant quality problems or reductions in yield over a considerable period of time. Anyone who has been involved in a major product recall will not wish to repeat the experience.

Breakdowns, on the other hand, may stop production in a section of plant but will only be apparent to those operating the plant – and can usually be rectified relatively quickly. The consequences are therefore likely to be less serious.

This has long been recognised in the food industry, which has developed a methodology called Hazard Analysis and Critical Control Points or HACCP (see box). However, most companies undertaking a HACCP exercise see it as a quality assurance methodology, and do not involve the plant engineers in the process.

the significance of random failure

Traditional maintenance wisdom tells us that equipment, over a period of time, wears out. This wear-out time or life is established from historical data or from the manufacturers' recommendations. The equipment is then overhauled or replaced at intervals less than the life of the equipment.

Research work into failure patterns has shown that in practice most failures are either 'burn-in' (when

HACCP

HACCP was developed by the food industry. It is used to identify critical control points in the process of food preparation and production, and to ensure that the systems are in place to prevent failures.

It was derived from HAZOP (hazard and operability studies) – a methodology developed initially by ICI as a means of examining the design of complex plants, and identifying and removing hazards and operating problems.

equipment is new, has just been maintained or has been changed over) or are random. Pioneering work on failure patterns was carried out by the airlines in the 1960s and has since been validated across a wide range of industries. The findings for the airlines are shown in Figure 1. Six failure patterns were found to exist and the graphs show the conditional probability of failure against age.

These findings show that only 6% of items have a clearly defined age-related failure pattern – increasing to 11% if Pattern C is included. Only a small percentage of failures are therefore caused by items wearing out. Overhaul or replacement at some fixed time interval is then at best a waste of time and resource, and at worst may be counter-productive if there is a possibility of post-maintenance burn-in failure.

modern plant's reliance on protective systems

Highly automated modern plant is very reliant on protective systems, for example high temperature alarms, overspeed protection, back-up systems, interlocks, etc. Traditional maintenance tends to overlook these systems. They are considered to be maintenance free – as they are often electrical or electronic, and are considered to be very reliable. They are also often small and 'out-of-sight and out-of-mind'.

Yet these protective systems can and do fail and, when they do so, it may not be apparent that protection has been lost. Hence they are called 'hidden failures'

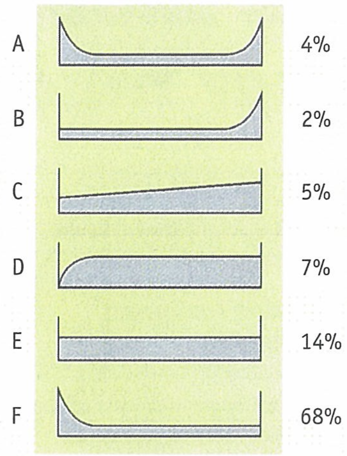
Hidden failures, where protective systems do not work correctly, have been a major factor in most of the really big plant disasters (including Bhopal, Piper Alpha and Chernobyl) and in many less serious accidents over the past 50 years.

We have seen cases where decentralised maintenance, with engineers reporting in to operations management, has reduced the attention given to protective systems with the result that hidden failures stay hidden until disaster occurs.

the role of the operator

Plant operators should be the eyes and ears of the maintenance engineers in most plants. They are far better placed to detect early signs of failure or equipment malfunction than the engineers. Yet few maintenance regimes recognise this. The maintenance schedules are still constructed around the belief that the engineers should do all the inspections, checks and monitoring.

This is not so much a failure to do the right things in maintenance – more a lost opportunity to get real benefits for little or no additional cost.



Failure pattern A is known as the bathtub curve. It shows a high initial failure rate (burn-in) then a constant or slowly increasing failure probability and finally a wear-out zone. Pattern B shows constant or gradually increasing failure probability, followed by a wear-out zone. Pattern C shows a gradually increasing probability of failure but no identifiable wear-out zone. Pattern D shows a low failure probability when the item is new then a quick increase to a constant level. Pattern E shows a constant probability of failure at all ages, that is, a totally random failure pattern. Finally, Pattern F shows a burn-in period followed by a constant or very slowly increasing probability of failure.

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Figure 1: Six failure patterns were found to exist in a study undertaken by the airlines. The graphs show the conditional probability of failure against age

conclusions and recommendations

Traditional preventive maintenance practices are failing to deliver consistently high plant performance and give value for money for most companies in the manufacturing and process industries, for the reasons just described.

Companies that have changed their organisation structure in an attempt to improve performance – with the engineers reporting into operations management – may actually make matters worse. The changes may result in a loss of focus on critical areas such as protective systems and hidden failures.

An approach that has been found to be highly successful is to use derivatives of reliability centred maintenance (RCM). RCM was developed in the airline industry for establishing preventive maintenance routines for civil aircraft. It has been outstandingly successful in improving aircraft reliability. However, this is a very specialised application and attempts to apply 'classical' RCM to manufacturing plant and equipment have had only limited success. Reasons include the excessive time taken to complete analyses, the jargon used, and the failure to tackle some of the issues discussed here.

The derivatives of RCM that have been developed are a great deal quicker to use, and focus on the needs of the manufacturing and process industries. They combine the best features of a number of other approaches including failure mode, effect and criticality analysis (FMECA), total productive maintenance (TPM) and quick changeovers (SMED). These derivatives include fast-track RCM and review RCM.

The RCM element of these derivatives provides the structure and logic for deciding what to do to achieve best plant performance. In particular it gives full recognition to operating context, random failure and the importance of protective systems. FMECA addresses both the equipment design and the process integrity issues. SMED focuses on the problems of burn-in following changeovers, while TPM ensures involvement and effective use of operators in obtaining best performance from plant.

The key recommendation then is that managers should ask a few searching questions:

- are we getting the performance we should from the plant?
- do our maintenance and plant care activities take account of all the factors discussed in this article? and
- are we getting value for money from these activities?

If any answer is 'no', managers should be looking at their maintenance approach and the methodology they are using for deciding what to do to get the best performance from plant. ■

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