Increasing plant uptime by learning from airline best practice

Adopting maintenance practices used in the airline industry could significantly increase the oil industry's operating uptime and profitability. — Tony Geraghty, vice-president, Schlumberger Business Consulting

The oil and gas industry overhauls its gas turbines up to three times more frequently than the aviation sector. I have often wondered what reaction I would get if I pointed that out to an oil industry asset manager at 35,000 feet in a Jumbo Jet.

Given that airline duty is demonstrably harder and the opportunities for damage to the engine are more frequent, conventional wisdom would suggest that airline engines need a higher level of maintenance. Yet, in a piece of groundbreaking research in the 1970s, the airlines disproved conventional wisdom. Their findings enabled them to transform their approach to asset management, achieving remarkable reductions in the requirement for maintenance, while improving safety.

By adopting this approach, the oil industry could achieve valuable increases in operating uptime and profitability.

Many Industrial Gas Turbines are Aero-engine Derivatives

Manufacturer	Industrial version	Aerospace version	
		Unit	Aircraft
General Electric	LM2500	CF6	747, 757, 767, A300 and A310
Rolls-Royce	RB211	RB211	747, 757, 767, A300 and A310
Rolls-Royce	Trent	Trent	777, A380
Rolls-Royce	Avon	Avon	Hunter and Lightening
Rolls-Royce	Olympus	Olympus	Concord Vulcan

Figure 1: Airline and industrial units

A fair comparison?

Is a comparison between the use of gas turbines in the two industries fair? Fortunately, the answer is straightforward *(see figure 1)*: the power plants that keep us in the air are also used extensively in process industries, either to generate electrical power or to provide mechanical drive (for compressors and pumps, for example).

Cycles or hours?

Methods of measuring usage differ, however. In the airline industry, the general unit of usage is the cycle, comprising one take-off and its corresponding landing. In industry, it is normal to refer to numbers of hours of operation.

The notion of a cycle illustrates the arduous nature of airline engine use: the engine is started from cold, used at low power to taxi to the end of the runway, opened to maximum power to haul up to 400 tonnes of air-craft and payload into the sky, reduced to cruising power, before being thrown into reverse thrust on landing, reverting to low power to taxi to the parking stand and being switched off. On modern short-haul aircraft, the process begins again as little as 20 minutes later. A European Jumbo Jet on long-haul duty will accrue around 430 cycles every year.

In contrast, the usage pattern in the process industries tries, so far as possible, to be steady-state running. Ideally, the engine is fired up after commissioning or after a period of planned maintenance and the goal is for that engine to run steadily and continuously until the next planned outage. With maintenance intervals of six

months, an engine would age at a rate of two cycles per year, assuming a trouble-free twelve months.

If it ain't broke, don't fix it

Since aircraft engines operate in more arduous conditions *(see figure 2)*, are vulnerable to airborne damage and are relatively easy to access for maintenance, one might intuitively conclude that airline maintenance programmes would be more intense.

However, this is not the case. Airline maintenance is predominantly condition-based: if all is well, the engine is left alone. Industrial users subject their units to a much higher level of invasive, fixed-interval maintenance, often at the cost of shutting down profitable processes. Condition-based in-formation is collected between shut-downs, but is not used to determine whether a shut-down is required.

In addition, it has always been assumed by process industries that gas turbines derived from the airline industry – of particular value to the offshore industry, where the weight of equipment can have a significant bearing on project economics – are more fragile because of the use of lighter construction materials. This, in turn, has led to the perception that such engines require more maintenance than those designed purely for industrial use. This is also a misconception: the invasive action involved in inspecting a healthy unit increases, not reduces, the chances of damage.

The airlines' condition-based approach stemmed from the Joint Industry Reliability Program (JIRP), a study carried out by the airline industry in the 1970s in response to evidence that the reliability of many aircraft items remained unaffected or deteriorated

The operating contexts of the assets are markedly different

Aerospace	Industrial
▪ Massive load cycles	▪ Usually runs on continuous load
▪ Massive thermal cycles	▪ Normal temperature variations
▪ Kerosene fuel of variable quality	▪ Gas/Diesal fuel often poor quality
▪ Inlet air not filtered resulting in dirt ingress and foreign object damage	▪ Inlet air filtered so foreign object damage is unlikely
▪ Continuous monitoring of parameters	▪ Health monitoring not widely used
▪ Spare unit installed	▪ Sometimes spare capacity
▪ Available for maintenance at night	▪ Shut downs required for maintennce

The operating conditions for aircraft gas turbines has been described in the GE LM2500 manual as 80 x more arduous than those of industrial units

Figure 2: Comparison of operating duty

The first insight: patterns of failure

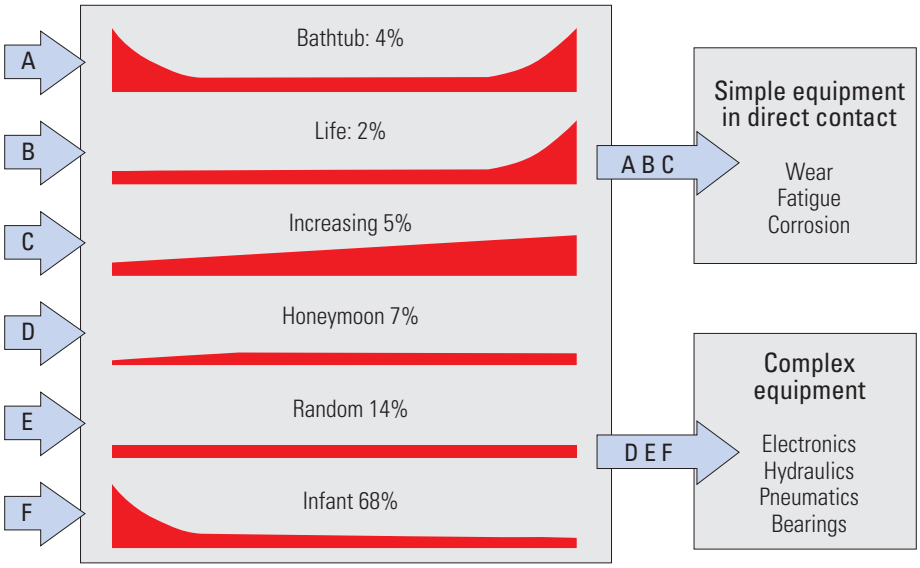

Figure 3: The JIRP research

no matter how often or how intensively planned maintenance was performed.

Published in 1978, the research – which became known as "The six patterns of failure" *(see figure 3)* — demonstrated the limitations of fixed-interval maintenance. It found that 89% of the failure modes suffered by an airliner are not treatable by the application of planned maintenance, which presupposes a positive relationship be-

tween age and likelihood of failure. Here was scientific proof of the adage, "If it ain't broke, don't fix it!" – known in the airline world as Pattern F.

Managing gas turbines: key to a healthy airline

It could be argued that mastering the management of gas turbines is at the heart of the success of an airline business. This is due to two seemingly opposing facts:

1. Modern airliners do not glide well – propulsion is essential to safety; and
2. Gas turbines account for 50% of airline maintenance costs.

On the one hand, there is a business driver to minimise the possibility of in-service failure and, on the other hand, a business driver to minimise maintenance costs.

With flights to around 300 destinations a day, British Airways alone has close to 1,000 gas turbines in the sky over the course of a day. The rate at which the airline industry as a whole accrues operating experience is, therefore, far in excess of that of the oil industry and airline companies' maintenance programmes are field-tested to a degree that is almost unimaginable to the oil industry asset manager.

On a Jumbo Jet, it is likely that the overhaul frequency of the engines is set at 3,000 cycles – a limit that takes seven years in operation to reach. Considering that it is the cyclical duty that imposes metallurgical stress and is the most significant factor in increasing the likelihood of failure, it is astonishing that a typical oil-industry turbine will be overhauled after just three years in service, over which time it might have accrued, taking into account unforeseen incidents and planned interven-tion, something like 30 cycles, compared with almost 1,300 cycles safely achieved on an airliner.

Conclusion

Moving to a maintenance approach that is more aligned with airline practice could significantly increase plant uptime and improve profitability in the oil industry. In addition, the maintenance schedule for gas turbines often determines the maintenance programme for other items of equipment, because, with operations already shut down, inspections can be made at little additional cost. Changing the accepted practice could lead to efficiency improvements elsewhere.

Better performance can be achieved without any compromise in safety. On the con-trary, airlines have shown that their approach has resulted in greater safety, not less. It is time for the oil sector to look beyond established industry practices and take advantage of the considerable potential for improvement that exists in the field of physical-asset management.