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WEARCHECK
CONDITION MONITORING THROUGH OIL ANALYSIS

How to calculate the effect OIL ANALYSIS has on the BOTTOM LINE

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> ***"The only things that evolve by themselves in an organisation are disorder, friction and malperformance."***
>
> -
>
> Peter F Drucker,
> US management consultant

Over the last ten years there has been a paradigm shift that has seen maintenance become almost synonymous with achieving reliability. Let's start by looking at a few definitions.

Maintain (verb): to hold, preserve or carry on in any state; to sustain, to keep up; to support, to provide with means of living; *to keep order, proper condition or repair*; to assert, to affirm, to support by reasoning, argument, etc.

Reliability, in its mechanical sense, can be defined as the probability of a device performing its functions adequately *for the period of time intended under the operating conditions encountered.*

The role of the maintenance professional is to maintain equipment at peak operating reliability in the most cost-effective manner. Equipment manufacturers make machines for really only one purpose - to make money - and customers generally buy them for that same reason. The cost of purchasing a piece of equipment tends to be relatively fixed. The actual cost of operating the equipment can be highly variable. The main aim of the maintenance department is to ensure the operating costs do not exceed income received by minimising downtime and repair costs.

Maximum output is now required from minimum input and this has resulted in reliability being optimised rather than maximised. This must be a strategic and discriminating process that considers both the cost of reliability and the consequences of unreliability. Companies that have achieved this optimisation have invested heavily in people and equipment for effective asset management. Fundamental to this is education throughout the whole company.

As technology has advanced, machines have become more complex and expensive to build. Maintenance engineering has had to develop along with the technology. From being non-existent, maintenance has developed from a passive to an active philosophy. Proactive maintenance techniques now give some organisations their only edge over their competitors.

Oil analysis is both predictive and proactive and is probably the most cost-effective maintenance technique available. It is not, however a panacea. It is merely a tool, a very effective one, but still only a tool. To carry the analogy further, a tool needs a tool box.There is no point in trying to implement an oil analysis programme if there is not a mature overall maintenance programme already in place.

EVOLUTION
of maintenance philosophies

The evolution of maintenance philosophies has been covered in several technical bulletins over the last twelve years and in many of Wearcheck's training courses but let us recap to see where oil analysis fits into the overall picture.

BREAKDOWN MAINTENANCE

This involves fixing things if, and only if, they break. This was common enough 50 years ago but with the current cost of equipment, labour and downtime it is no longer a commonly viable option; it is very cheap to implement but the consequences are dramatic. It should be pointed out, however, that all maintenance philosophies have their proper place. Each piece of equipment should be treated on its own merits and the most cost-effective (optimal) combination of philosophies and techniques employed. The factory manager does not schedule to have all the light bulbs in the plant replaced on a calendar basis; they are replaced when they blow - this is breakdown maintenance and is the optimal strategy in this case.

PREVENTIVE MAINTENANCE

This philosophy evolved because it was soon realised that breakdown maintenance was not the best way to look after most pieces of machinery in industry. Preventive maintenance involves the servicing, overhaul and replacement of items of plant based on a scheduled time interval such as operating hours/kilometres, or on a calendar basis. This was certainly a step in the right direction but problems arise because the 'maintenance interval' is based on an average. This means a percentage of machines will fail before receiving attention and a percentage of normally functioning units will be disturbed. There is a lot to be said for the maxim 'if it ain't broke, don't fix it'.

PREDICTIVE MAINTENANCE

Predictive maintenance evolved from preventive maintenance for the reasons outlined in the previous paragraph. This is also where condition monitoring techniques come into their own because this philosophy involves using as many non-destructive testing methods as is necessary to determine the health of a piece of equipment, then making maintenance decisions based on these results. This practice originated in the aircraft industry during the early sixties and was known as maintenance 'on condition'.

PROACTIVE MAINTENANCE

This naturally grows out of the other three philosophies and is concerned with the analysis of all maintenance and condition monitoring techniques to determine what causes failures and how these situations can be prevented in the future. Root cause failure analysis is central to proactive maintenance and it is certainly the way of the future if organisations want to become world class players.

Oil analysis has one foot firmly rooted in the predictive camp, the other in the proactive camp. Proactive maintenance delivers value where the failure rate can be effectively reduced and is most productive when we can easily and inexpensively improve control over the root causes of failure. Predictive maintenance delivers value when early warning systems can substantively impact on the severity of the failure event.

Proactive maintenance benefits:
Reduce failure rate and reduce operating cost.

Predictive maintenance benefits:
Reduce the severity of failure and plan activities.

COST SAVINGS
and how to calculate them

Once an effective oil analysis programme is up and running, one very important question needs to be answered: *How is the oil analysis programme affecting the bottom line?*

Up front money has been spent and there are ongoing costs to run the programme and pay for the service, so what are you getting in return? What is the Return On Investment (ROI)? It is a failing in the engineering, scientific and technological communities that scientists, engineers and technologists do not speak the same language as the financial gurus. Unfortunately, these are the people that control the purse strings and they are the ones that will have to approve the up front and running costs for the oil analysis programme.

The fact remains, however, that there is always money available for investments that produce a healthy profit. The failure to obtain such funding more often lies in the presentation. So, let's learn to speak the one truly universal language . . . money! It is a lot easier for an engineer to talk rands and cents than it is for the financial manager to talk technically. Scientists still have to balance cheque books, accountants do not need to know how to change the CV joints on their cars.

Unfortunately, finding a ready formula for calculating ROI is surprisingly difficult. There appears to be a dearth of information on the internet and even the condition monitoring wizards have very little to say on the matter. The reason for this is that, like so many other aspects of oil analysis, each case or organisation has to be treated on its own merits.

Wearcheck has realised that a handy formula or computer programme would be a tremendous boon to many of its clients but canvassing various customers who do these calculations reveals that everyone has a different way of doing it. What we propose to do here is to lay down some guidelines and present some ideas that will hopefully allow you to formulate your own methods for calculating the ROI on your oil analysis programme.

There are three main costs that need to be considered: labour, parts and downtime. The first two are easy, the third one almost impossible to calculate. There are, however, secondary costs involved as well. These costs include lubricants, energy consumption, quality, production and risk-based costs.

We will only consider labour and parts and try to put a realistic figure to downtime costs in this exercise. As is so often the case, it is easier to do this for fixed plant because many of the variables that apply to mobile equipment do not usually apply to machinery that does not move around. We will look at the fixed plant scenario first and then try to apply it to buses, trucks and bulldozers.

As has already been mentioned, there are two maintenance philosophies associated with oil analysis: proactive and predictive. Proactive maintenance attempts to control the forcing function or root cause that leads to failure and can be used to preemptively reduce the failure rate of a component or system. Quantifying this simply amounts to dividing the current failure costs by the life extension factor. Proactive maintenance makes money because it reduces the number of failures over a given time period. Loss of production or downtime costs are easier to calculate for fixed plant too. This will be the retail value of the total products not produced less the operating costs for the same period of time.

For example, if it has been determined that reducing the amount of dirt in a conveyor gearbox by a certain factor will double the lifetime of a particular bearing, then every rand spent on that particular type of failure per year is reduced by 50%. *(See Table 1 on page 4)*

This is a highly idealised example but shows that for this particular failure mode every rand spent on oil analysis represents R7.60 saved.

The other maintenance aspect of oil analysis is predictive. There is an inherent complexity in quantifying this aspect of oil analysis in that its objective is either the production of a non-event or to reduce the impact or severity of a particular failure. This is achieved either by early repair before catastrophic failure occurs or by being aware that alternative plans need to be made. One cannot assume the worst outcome in every situation; water entering the above gearboxes will not always result in that catastrophic failure. There is a statistical way of working around this problem as long as it is borne in mind that: *proactive maintenance saves money by reducing the number*

FACTOR	ITEM	COST
A	Number of gearboxes in the plant	10
B	Average failures per year	*0.85*
C	Cost of parts per failure	*R2 500*
D	Cost of labour per failure	*R1 750*
E	Lost production per failure	*R35 000*
F	Cost of production	*R20 000*
AxBx(C+D+(E-F))=G	Annual cost of failure mode	*R163 625*
H	Annual failure reduction factor	*0.5*
G-(GxH)=I	Annual savings using oil analysis	*R81 812.50*
J	Cost of oil analysis on gearboxes *(including administration but not start up)*	*R9 500*
(I-J)/J	ROI	*7.6:1*

TABLE 1

of failure events, while predictive maintenance saves money by reducing the impact of each event that remains.

A similar costing exercise can be performed as above but outcome probabilities need to be considered and weighted accordingly. *(See Table 2 overleaf)*

Again, this is a highly idealised situation but does act as a starting point to illustrate how cost savings and ROI can be calculated in a reasonably realistic manner. The same exercises can be performed with mobile plant but two other factors need to be brought into the equation. Firstly, what is the age of the component that might have failed? If the component is brand new then the savings in terms of parts is the full new value whereas, if the component was very close to overhaul or replacement, then the parts savings would be negligible. The other factor that needs to be considered is, could this problem have been detected by other means?

Loss of production is a lot harder to quantify. What is the total impact of one motor grader being out of action for two shifts on a road building project involving three such units and another ten items of plant? How do you factor in penalties if the job is not finished on time? What about loss of good will? ('I will never use that construction company again, they finished the job six weeks late.') It is almost impossible yet it represents the major cost saving in using oil analysis.

One way to apportion some cost of downtime is to simply look in a copy of Plant or Hire SA and find out what it would cost to rent an equivalent piece of equipment. *(See Table 3 overleaf)*

There are a couple of points to watch out for in this example. If the component had reached 25% of its expected lifetime then the parts only need to be multiplied by a factor 0.75 which represents 75% of the remaining lifetime of those parts. Once the total parts, labour and downtime bill has been calculated, then this total also needs to be multiplied by 0.75, which represents the likelihood that oil analysis would have been the only way that this impending failure could have been detected.

At the risk of sounding like a broken record, once again this is an idealised situation but it can be used as a model for calculating realistic savings and ROI. If an oil analysis programme is best-in-class then the overall ROI should be of the order of 10:1. Ten rand saved for every rand invested - where else you can get a rate of return like that?

COST CENTRE	SEVERE FAILURE	MODERATE FAILURE	MINOR FAILURE	WEIGHTED TOTAL COST
Lost production less cost of production	R25 000	R10 000	R0	
Parts	R5 000	R2 500	R1 000	
Labour	R7 500	R3 500	R1 500	
Total cost	R37 500	R16 000	R2 500	
Probability of failure without oil analysis	15%	55%	30%	
Weighted cost	R5 625	R8 000	R750	R14 375
Probability of failure with oil analysis	5.00%	10.00%	85.00%	
Weighted cost	R1 875	R1 600	R2 125	R5 600
Savings per event				***R8 775***

TABLE 2

COST CENTRE	WITHOUT OIL ANALYSIS	WITH OIL ANALYSIS	SAVING
Parts	*R10 000*	*R2 500*	*R7 500*
Labour	*R7 500*	*R2 000*	*R5 500*
Downtime	*50 hours*	*5 hours*	*45 hours*
Cost to hire a replacement	*R250 per hour*	*R250 per hour*	*R11 250*
Age of of total life component as %	*25%*	*25%*	
Probability that only oil analysis will work	*75%*	*75%*	
Cost of oil analysis	*R0*	*R500*	*-R500*
Total cost	*R20 625*	*R5 125*	*R15 500*
Total Saving			**R15 000**

TABLE 3

The measurement of ROI not only proves to the accountants that the system is working and is cost-effective; it can also act as a Key Peformance Indicator (KPI). KPIs are useful management tools in that they can be used to make staff aware that their time and effort are having a positive effect on the company's bottom line. A poster on a notice board showing the current state of affairs along with targets that need to be met can be highly motivating for the work force.

A Wearcheck customer has used annual savings due to oil analysis in just such a manner. The first year showed a loss due to upfront costs and time taken to establish a system that actually worked. The second year was pretty much break even. The next four years showed a steady climb in savings and after about seven years there seemed to be a plateau. However, after about ten years the inflation adjusted savings in absolute rand terms appeared to drop off. Why? *(See Chart 1 overleaf)*

What was being observed was a truly world class maintenance system of which oil analysis was the keystone. After ten years most failure modes had either been eliminated or were being controlled - in other words, maintenance had been optimised. What oil analysis was now doing was maintaining that high level of availability, productivity and, of course, profit.

Nett savings attributable to the Oil Analysis Programme

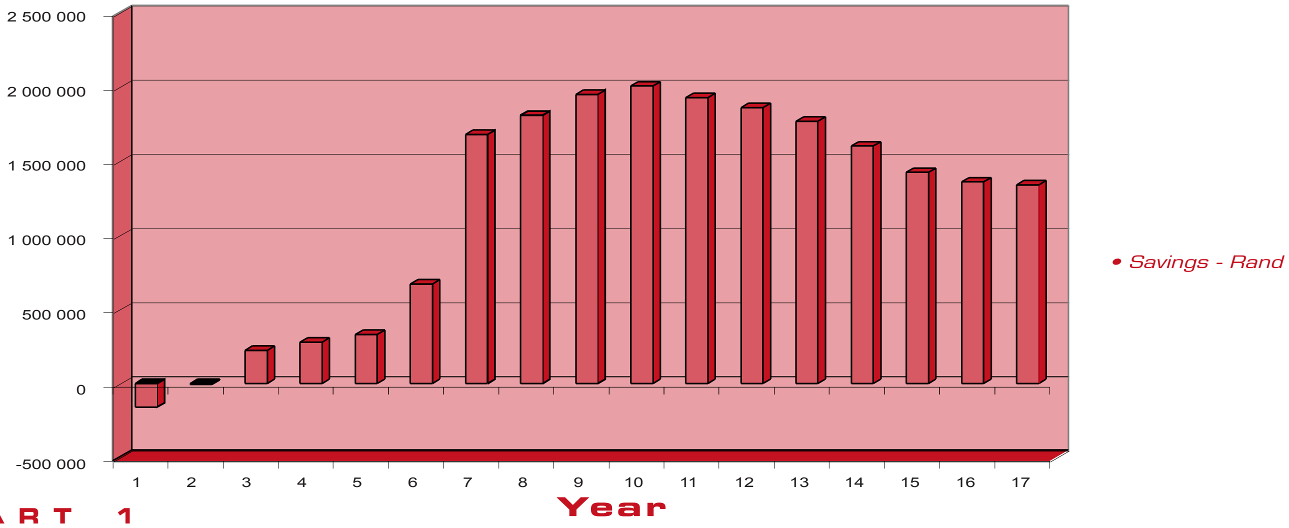

CHART 1

Unfortunately, as is the case with many aspects of oil analysis, the problems and their solutions tend to be multi-factorial and there are no clear cut or simple answers. This technical bulletin is not intended to provide those answers but to point people in the right direction and to provide some ideas that may either be applicable or can be modified to suit the individual needs of customers.

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"***Benchmarking Oil Analysis***". Rich Wurzbach (Practising Oil Analysis, Nov 2002)

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"***Charting the Roadmap to Success***". Mark Barnes (Practising Oil Analysis, Nov 2001)

"***Defining and Executing Excellence in Lubrication***". Jim Fitch (Practising Oil Analysis, Jan 2000)

"***The Buck Stops Here***". Drew D. Troyer (Practising Oil Analysis, Jan 2000)

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