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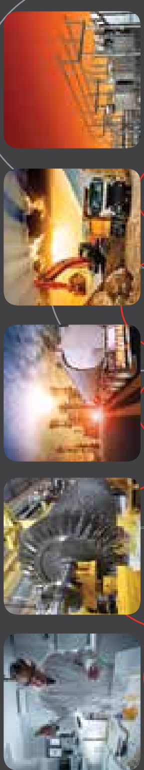

OIL ANALYSIS EXPOSES FLEET OPERATIONAL CHALLENGES: AGRICULTURAL INDUSTRY

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INTRODUCTION

The challenge facing the agricultural industry is the need to meet high production targets for the agricultural season versus an unpredictable length (climate change impact) of the wet season. In some cases, this leads to the agricultural season starting off during wet weather, thus exposing the fleet to a considerable amount of operational risk. This operational risk is noticeable on the WearCheck oil analysis reports through the following:

1. Repeat or high PQ levels (ferrous density or large wear metal particles) especially in unfiltered drivetrain components.
2. High concentration of wear particles observed through the Microscopic Particle Examination (MPE) and ICP (inductively coupled plasma) wear metal test results.

The correlation of the high wear levels with the high incident reports of equipment stuck in the fields as well as the high failure rate mainly on differentials and final drives are indicative of the operational risk affecting equipment.

The oil analysis programme runs throughout the productive season and

action plans are implemented through an iterative process of regular oil sampling, development of trends, problem identification, investigation and troubleshooting, corrective action, feedback and review. Trends are analysed on a regular basis with a view to come up with sustainable solutions to any challenges affecting the fleet.

THE IMPACT OF WET WEATHER OPERATIONS

Wet weather operations have posed several challenges with the fleet drive trains. The high failure rate on drive trains during the wet season and period following the wet season poses a high risk and therefore provides a compelling reason for a case study and a formulation of strategies to protect the axles/drive trains, minimise failures and improve equipment reliability.

This case study is an analysis of this phenomenon. A number of techniques such as the 5-Why analysis are used to try and get to the bottom or root cause of the problem. Some of the questions asked in this analysis are:

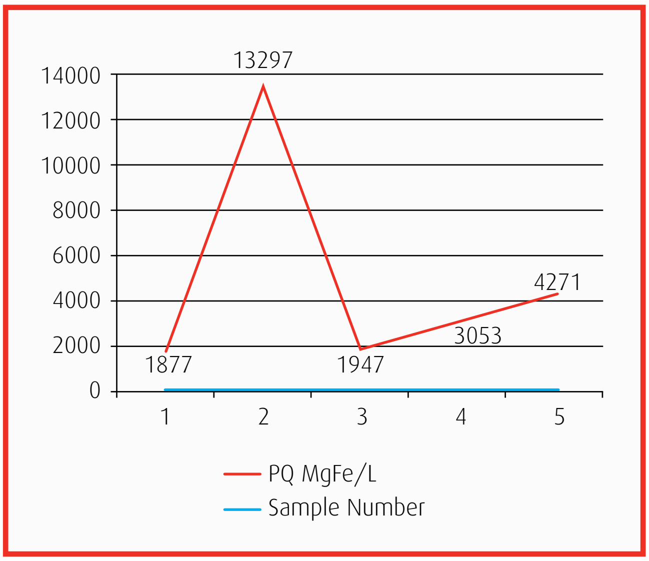
1. How are wear patterns spread throughout the year?
2. Any seasonal trends?
3. Any changes in the lubricant in use?
4. Are there any changes in tonnage ferried by the fleet per load?
5. Any changes in intensity of operation?
6. Is this a fleet-wide problem or only affecting a few machines of the same make & model?
7. Are there any changes in operating conditions/ road conditions/field conditions and so on?

Where the answer is yes, the 5-Why analysis principle and other techniques are applied to test and critically analyse the aspect or factor, in order to establish the root source of the problem.

ANALYSIS OF MPE AND WEAR ON DIFFERENTIALS AND FINAL DRIVES: CASE STUDY OF ZT49 DIFFERENTIAL (AUGUST 2017)

For simplicity of analysis, the case of ZT49 differential is used to illustrate the findings characterising the phenomenon, though the challenges are spread across the fleet.

The differential oil analysis results showed a repeat problem on the Microscopic Particle Examination (six times). Large wear metal particles rose from 1 877 MgFe/L (sample 1) to 13 297 MgFe/L (Sample 2) towards the end of the rainy season, see following graph:



Feedback provided by the customer indicates that when the tractor was stuck in the field, the operator repeatedly tried to drive it out, resulting in differential damage before the tractor was eventually pulled out of the field. It was also reported that the tractor had experienced a broken propeller shaft. The differential was then scheduled for replacement.

Oil analysis results show that this trend is commonly experienced across the fleet during periods of wet weather operation as well as periods following the wet season. An analysis of feedback submitted indicated the following common observations:

- High concentration of wear particles
- Chipped gears
- Broken planetary gear carriers
- Broken thrust washers and so on

These are observed upon draining oil or upon inspection, leading to regular differential and final drive overhaul. In some cases, tractors end up losing drive, and broken half shafts are often discovered as a result.

The incident chart below illustrates the distribution of differential failures during the 2017-2018 agricultural season:

Incident Chart Showing Differential Failures		
	Wet Season	**Dry Season**
Differential Failure Incidents	● ● ● ● ●	● ●

As shown in the incident chart, 71% of differential failures occurred during the wet season while 29% occurred during the dry season. In all these failures, broken planetary gear carriers/spiders were discovered upon inspection. All failures were linked to wet weather challenges and/or post wet weather impact of abrasive wear.

The introduction of wear particles in the differentials and final drives resulted in accelerated wear or **abrasive wear**. The end result is a **spiral effect**: as more wear particles are generated, the wear rates increase (advanced wear) and in some cases resulting in failures which are costly, especially in terms of downtime and lost production.

It must be noted that the above are only symptoms, not the root cause of the problem at hand. To get to the root source of this phenomenon, we invoked the 5-Why analysis technique:

Toyota's **5-Why strategy** is a good trouble-shooting tool, which can be used in conjunction with the WearCheck oil analysis programme to discover the root cause of a phenomenon. This involves asking a series of "why?" questions until the root cause of the problem is discovered as illustrated below:

Problem – High differential failure rate

1. **Why?** High concentration of wear particles in the oil.
2. **Why?** Abnormal wear of components.
3. **Why?** Chipped gears/broken drive train components.
4. **Why?** Tractors stuck in the fields/axle spinning.
5. **Why?** Wet weather operating conditions, slippery roads and fields.

Applied solutions:

A trend in operational challenges has been noticeable over the years. To counter the problem, several strategies have been applied to remove (avoid wet weather operations where possible) or minimise impact (where wet weather operations cannot be avoided.) These strategies are discussed below:

Assess the level of risk
Pay attention to oil analysis severity status and PQ levels.
Pay attention to repeat problems.
Pay attention to ICP results as well in view of holistic analysis.
This is a good guide to determining level of risk.
Report severity: **Normal** – Low risk. **Borderline** – Moderate risk. **Urgent & Critical** – High risk.

Low Risk
Strategy – Minimise impact and monitor.
See minimise impact section below.

High Risk
Further troubleshooting required.
See diligent approach section below.

Minimise Impact
Drain oil and refill with new oil.
It may be necessary to open the component and clean all parts.
This reduces risk of further abrasive wear.
However it does not address root cause.
Plan further action to address root cause.
If parts are worn overhaul component.

Diligent Approach
High risk cases call for a more thorough approach in investigation and troubleshooting.
In cases of high risk procedure below suffices.
Check for discolouration of oil.
Inspect the drain plug for presence of excessive particles.
Check end-play.
If excessive particles are discovered, open unit for further investigation.
Cases with high copper levels, open component and inspect straight away.
Excessive endplay is indicative of advanced wear.
It may be necessary to overhaul unit at this stage.

Maintenance Planning & Management
There has been a continuous assessment of component change patterns over the years, this has provided a guide to determining optimum stock requirements for differentials and other commonly affected parts.
This has facilitated a smooth and swift component change process in response to failures thus minimising downtime and enhancing cost savings. The failed component can be overhauled while the equipment is back in operation.
Critical trends and fault repeats are noted as the productive season nears the end and are used as a guide to budgeting for off-crop maintenance.
Inspect the drain plug for presence of excessive particles.

A stock of differentials as part of the maintenance planning and downtime minimisation strategy.

OPERATOR TRAINING

The people side cannot be ignored. An operator training programme was implemented to improve vigilance and foster behaviour change amongst the operators. This should be an ongoing project as new operators are employed from time to time.

CONTINUOUS IMPROVEMENT OF PROCEDURES

Operator procedures are continuously reviewed in response to current challenges. Operators to call for assistance once stuck in the fields and avoid spinning the axles in slippery conditions.

MINIMISE IMPACT

1. Drain oil to curb the risk of further abrasive wear.
2. Take further action to address the root cause of the problem.

This strategy resulted in savings amounting to ZMK363 984 (US$37 100) in cost avoidance (component replacement cost) of potential differential and final drive failures. Savings in reality are more, considering the cost of averted potential downtime which would result in huge loss of tonnage of cane deliveries.

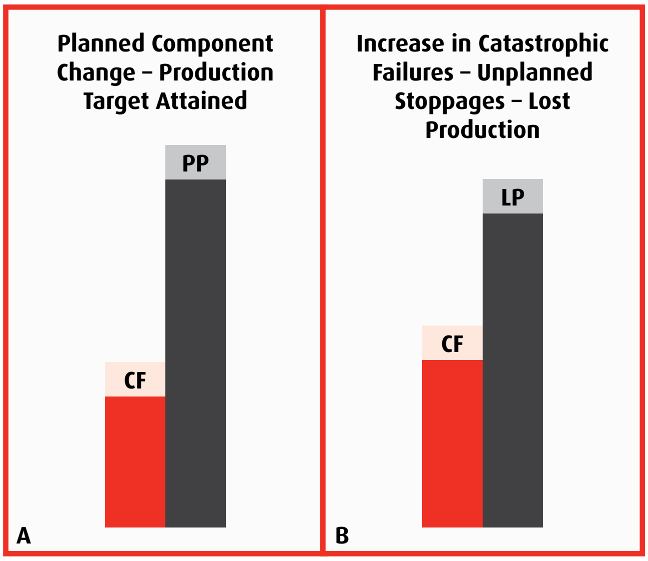
Draining oil is often done to minimise the impact of abrasive wear, thus giving a lifeline to components. It must be noted that this does not solve the root cause of the problem – further action required.

Draining oil must be carefully considered and balanced with the need to minimise oil usage and save the environment. There should be a balance between the need to change oil versus the need to reduce oil usage. From a cost perspective, it is argued that draining two litres of oil change is better than the potential cost inflicted by abrasive wear.

It is important to actually consider the real cost of oil change, including the cost of labour, administrative costs, supervision, oil disposal, warehouse overheads, inventory overheads, safety risks, environmental risks and so on.

PLANNED CHANGE VERSUS CATASTROPHIC FAILURE

The oil analysis programme is used to closely monitor equipment health and make timely and informed decisions. Planned component changes for example have resulted in huge cost savings mainly accruing from minimised catastrophic failures which are normally associated with losses as a result of unplanned downtime and lost production. This is illustrated in the following graph:



KEY:
CF – Catastrophic Failure, **PP** – Planned Production, **LP** – Lost Production

It must also be noted that these strategies have largely been successful in reducing the impact of wet weather operations. Fleet availability has been kept above an average of 95%, thus the measures have kept the wheels turning.

CONCLUSION

The rule of conversion: With WearCheck, every oil sample is an opportunity to learn and better apply engineering principles to solve any identified challenges with an endeavour to maintain and stay up to date with modern engineering best practices, striving to do better than the previous financial year or season - a continuous improvement approach. The WearCheck oil analysis programme is a dynamic tool. With recurring problems, strategies are put into place to get to the root cause of the problem and prevent it recurring or control it in cases where the challenge cannot be fully eliminated. Where necessary, maintenance procedures are modified accordingly, in line with the new trends discovered.

At WearCheck, we establish partnerships that constantly explore and seek ways of improving current systems, processes and efficiencies or breaking new ground through oil analysis and condition monitoring programmes.

Copies of previous Technical Bulletins can be accessed on WearCheck's web site: www.wearcheck.co.za

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