EVALUATION OF THE MAINTENANCE PRACTICES IN MECHANIZED AGRICULTURE – SADC REGION

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Abstract: The Southern Africa Development Community countries have embarked on mechanizing their agriculture. It is envisaged on the factual basis that it leads to increased labour productivity, reduction in drudgery, creation of employment in Agriculture and other support sectors and increase in farm income. Given that the SADC Governments’ rural development focus is based on Agriculture at both small and medium scale level, this research was undertaken to uncover research based information that will inform policy during the resurrection of the agricultural mechanization endeavours. This study assessed the maintenance practices in Namibian, South African and Zambian mechanized agriculture and used the Czech mechanized agriculture maintenance practices as a benchmark. Tribotechnical Analysis was used to monitor component structural changes based on the fact that wear deteriorates mating functional surfaces of machine elements leading to poor component functional that negatively impact on the environment and the non-cost effectiveness of mechanization in SADC primary agriculture. A fleet of Massey Ferguson and Zetor tractors were sampled at 100-1tir diesel consumption interval. Oil total contaminants and Cleveland open cup flash point method was used to evaluate the condition of the lubricant while Direct Reading Ferrograph assessed the ratio share of Small wear particles (Ds), Large wear particles (DL) and the Total Wear Particle Concentration (WPC). Extreme value showing samples from the Direct Reading Ferrograph were further investigated using the Ferrograph Analyzer. Data were analyzed to generate a baseline based nomogram that is being used as a maintenance support tool. Upon recommendation of this study, Ferrography has been introduced as a cost effective proactive maintenance tool at the Tractor maintenance center in Zambia.

Keywords: AGRICULTURAL PRODUCTIVITY, MAINTENANCE SUPPORT TOOL, MECHANIZATION, TRIBOTECHNICAL ANALYSIS

1. Introduction

Machinery maintenance, as a support function, has played an important role in mechanized agriculture. The importance of the diesel engine in Mechanized agriculture is indisputable. Condition based maintenance (CBM) technology has gained preference over time based maintenance technology, today. The Success of CBM hinges on the ability to develop accurate diagnosis/prognosis models for diesel engines [10].

Mechanized agriculture has helped, in the last 50 years, few economies to overcome the challenges of development and become truly competitive. In those few cases, there are concrete indications that industrial development, including agro-industrial development, has played a key role. Agricultural mechanization is part of agro-industrial development, and it has either stagnated or retrogressed in many countries of sub-Saharan Africa (SSA). This has occurred despite strong support for mechanization from African political leaders and heavy investments in both animal traction projects and mechanically powered mechanization, such as in tractors, pumps and post-harvest processing equipment [1]. Mechanization does not mean simply the introduction of tractors (tractorization), it includes the improvement of all tools and equipment used in agriculture from clearing and cultivating the land to planting, harvesting and also transport, storage and processing [9].

In the 1970s and 1980s, believing that they could make a positive contribution to agricultural development in Africa, international aid agencies provided literally thousands of tractors and implements to a number of countries under tied-aid government ‘ploughing fleet’ programmes [2]. These programmes failed to provide sustainable mechanization services; all that was left was broken-down, neglected machinery. There seem to have been no maintenance technology in place to sustain these programmes. [6].

It is evident that tractor use in Africa is on the decline (Fig.1); giving rise to the general picture which shows that yields of maize and other staple cereals typically remain at about 1 tonne per hectare (1 000 kg/ ha), which is about one-third of the average achieved in Asia and Latin America (Table 1).

<table>
<thead>
<tr>
<th>Region</th>
<th>Cereal yield kg/ha</th>
<th>Fertilizer use kg/ha</th>
<th>Irrigation% irrigation of arable land</th>
<th>Tractors per 1 000 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>1 040</td>
<td>13</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>Average of 9 selected countries</td>
<td>3 348</td>
<td>208</td>
<td>38</td>
<td>241</td>
</tr>
</tbody>
</table>

Adapted from: FAO and UNIDO 2008: Time for action [1].

The motivation for this study was to contribute towards improving machinery availability for mechanized agriculture. The resulting objective was to arrest the ever increasing mechanization cost for agricultural mechanization. As shown in Figure1, despite past and current investment into mechanizing agriculture in the SADCC region, this sub-Saharan region has not performed very well in terms of installed tractor-kW per hectare arable land.

Fig. 1 Tractor use per 1000 ha arable land. [12]
2. Materials and methods

The approach method was to measure wear of wetted friction components of the engine and analyze wear impact on the overall condition of the engine. Using tribotechnical methods, lubricant’s physical properties were investigated in order to establish the lubricant capability. Ferrographic examination was used to determine the condition of the lubricated components of the engine [5,13]. Two types of ferrographs were used namely the Direct Reading (DR) Ferrograph and the Analytical Ferrograph [3],[4],[8],[11].

Oil was sampled from engines 20 minutes after engine shut down. Water by Crackle % method (at 165°C) was used to investigate presence of water in the engine oil. Percent contaminants (%CN) were determined using a TCM-U apparatus. It works on the principle of light permeability that determines the amount of insoluble in technical benzene. Fuel dilution in the engine was investigated using the Cleveland Open Cup method [10].

Wear debris investigation was carried out using a PMA-90 DR Ferrograph. The D_L and D_s readings from the DR were used to derive the values of Wear Particle Concentration (WPC) and the ratio D_L/D_s, a function of the wear predominance, was translated into Percent of Large Particles (PLP). The analytical ferrograph tests were conducted on the MA-1 Ferrograph Analyzer. The processed ferrogram were examined under a special bichromatic microscope and photographed using a 35 mm camera mounted on the microscope [4],[7].

The collected data were subjected to discriminant score analysis and the resulting alarm limits were used to design baselines for condition monitoring based maintenance.

3. Results and Discussion

Two representative engines, one from Lany tractor population and one from Mkushi tractor population were trended - results for %CN, WPC and PLP against accumulated fuel use in litres. The discriminant analysis produced the alarm values for %CN and WPC (Table 3). The limits were used to construct the baseline for CBM based maintenance. Samples from Lany were in the Green “GO ZONE” of the baseline (Fig. 2); but the Mkushi samples were found to be in the Red “STOP ZONE” of the baseline (Fig. 3) and (Table 2).

The practice of calendar based maintenance that was being practiced by farmers in Mkushi for oil change intervals, proved to be costly for farmers; higher values for %CN (Fig. 4) and alarming values for WPC (Fig.5) and analytical ferrograph examinations uncovered severe wear regimes of wetted parts (Fig. 12).
This is indicative of mixed wear regime (Fig. 6) – small metallic particles and fatigue chunk in the top right corner of the slide. The bottom part of this slide is occupied by particles that originate from bearing material. This is an indication of a severe wear mode.

The ferrogram (Fig. 7) indicates the normal condition of the engine oil-wetted parts.

This is a high magnification of the S position (Fig. 8). The L particles are absent. The center shows lubricant degradation (transparent tribopolymers). The wear level is normal.

Two big pebble like large particles present (Fig. 9). Top right shows red (pure) metallic particles. Dark metallic oxides (DMO) that are present indicate severe operating conditions (high temperature, pressure, inadequate cooling).

The ferrogram shows a high density of wear particles ranging from 5μm to several tens of microns in size (Fig. 10); including spherical particles. This manifests severe component wear.

Inadequate lubrication gives its signature through DMO- high concentration of the Fe3O4 particles (Fig. 11). The hematite particles that are indicative of corrosion wear are also present. Engine overhaul was recommended.

A STOP and repair instruction was issued to this engine, but was not acted upon. This engine ceased. Pebble like chunks (Fig. 12), deposit of oil additives and fiber material most likely from the oil filter. The DMO particles show lines of material flow enclosed in them- finger print for operating the engine under high pressure, high temperature and lubricant starvation.

4. Conclusion

The findings have underlined the important role of Ferrograph methods in CBM. DR Ferrograph and Analytical ferrography and the subsequent ferrogram evaluations provide a method for early diagnosis, progressive assessment of maintenance requirements and prognosis concerning the future trend of engine condition.

The baselines produced from this study have been made available to the custodian centers where samples were collected and study observations were done; namely Czech University of Agriculture Farm at Lany, Technical Services Branch at the Ministry of Agriculture (Zambia), Etunda Irrigation Scheme (Ongongo- Namibia) and the Limpopo Department of Agriculture (South Africa). These baselines should inform the design of the maintenance programme that should include skills impartment,
diagnostic tools and logistics formulation that should enable access to remote areas where the machinery that are given to farmers in governmental and donor developmental projects.

The researchers believe that this should help uplift the standards of diesel engine maintenance in the SADC region that as seen from this study are below required standards.

5. References


