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Performance's Analysis of the VIMS System in Order to Optimize the Durability and Reliability of the Mechanical Components of Rolling Stock: Case of a 785C Dumper

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Abstract

The VIMS system, which was the subject of our study, is an autonomous system for the management, prevention and maintenance of Caterpillar machines. It is the synthesis of electricity, electronics and mechanics and has as its core an operating system developed and installed by Caterpillar with permanent updates. With the VIMS system, you can be sure to fully benefit from your investment (on a 785C dumper, for example, the value of which is estimated at approximately 1.2 billion FCFA), because the VIMS system warns and takes the necessary measures to prevent Components such as the engine do not break, which component of a 785C dumper cost around 700 million FCFA. Like any system that remains to be perfected, the VIMS system also has its weaknesses. Indeed, it is vulnerable to dust and humidity. These two phenomena generally cause it to lose the parameters and signals that the sensors must supply. However, remarkable efforts have been made by the dealer to protect the components of the VIMS system from the dusty environments in which their machines are used. In addition, the VIMS turns out to be a very complicated system and a real headache for "classic" mechanics and electricians. The evolution and complexity of production systems as well as the need to produce quickly and well, have forced manufacturers to structure and organize maintenance workshops. Above all, they created new organizational concepts and new ways of working with production equipment. Thus, this

leads us to conduct a study on their performance in a real environment. The results show that the analysis of the performance of a VIMS system is an appropriate solution to eradicate weather-related failures on gold sites.

Keywords

Performance, Vital Information Management System (VIMS), Durability, Reliability, Mechanical Components

1. Introduction

Maintenance is one of the constraints encountered by any operator of a good, a service, or an industrial installation. Building a factory or a workshop is a waste in the absence of significant production, qualified personnel, and an organizational system allowing the maintenance of the installations. Installations and equipment tend to deteriorate over time under the action of multiple causes such as wear, deformation due to operation or the action of corrosive agents (chemical agents, atmospheres, etc.). These deteriorations can cause the stoppage of operation, reduce the performance of the equipment and production capacities, jeopardize the safety of goods and people, cause problems or reduce quality and increase operating costs.

The 785C mining dumper, commonly known as the 785C dump truck, is a guarantee of performance and comfort. Specifically designed for heavy-duty mining and construction applications, the 785C Mining Truck hauls large volumes of material [1] [2]. Its robustness makes it a durable machine. Its ease of maintenance ensures high reliability and extends service life while reducing operating costs. It is a very essential piece of equipment for the proper functioning of the mine. In addition, any technician wishing to ensure their maintenance must have knowledge of the equipment itself and its operating system. The objective of this work is to analyze the performance of the VIMS system. This analysis will allow perfect control of the system to optimize the durability and reliability of the mechanical components of rolling stock. The transmission is a set of components that transmit engine power to the rear wheels [3]-[6]. Thus the power passes from the engine to the torque converter then via a drive shaft, to the transfer case, to the transmission and to the differential. The role of the electronic transmission/chassis control module is to select the gear ratio by energizing solenoids to change from one gear ratio to another based on information from the machine or the operator. It receives information from various input components such as the gear selection lever, the transmission output speed sensor, the gearbox position switch [7]-[11], the tipper lever sensor. Technicians working on machines equipped with the system must be seasoned in order to be able to access information through the keyboard of the dashboard and its message center and also must be able to use the "VIMS pc" and the "ET" (Electronic Technician) [12] [13] which are diagnostic software, to perform other tasks such as system configurations.

2. Methodology

The analysis of the performance of the VIMS brings us to the exploitation of the information system service (SIS) that Caterpillar makes available to all these customers who use this equipment.

In addition, we use the software "CAT ET" and "VIMS Pc" which are appropriate analysis and diagnostic tools for Caterpillar brand equipment. The VIMS system is designed to alert the operator to an immediate or imminent abnormal operating condition of one or more modules and components of the machine he manages. Two types of events are recognized and recorded by the VIMS. The conventional maintenance methods that we apply, the operation of the VIMS system play a very important role in increasing the durability and reliability of the mechanical components of a 785C truck. Also, it is important to know that the parameters of the VIMS system take into account the canvas of maintenance preventive and corrective methods known to all technicians.

2.1. Motor Case

The monitoring and maintenance of the engine of the 785C dumper are ensured by a maintenance strategy In the section of conditional preventive maintenance, there is the analysis of oils and coolant as well as the analysis and interpretation of data from the VIMS system downloaded to the equipment: events, histograms; as shown in Figure 1 & Figure 2 and Table 1 & Table 2.

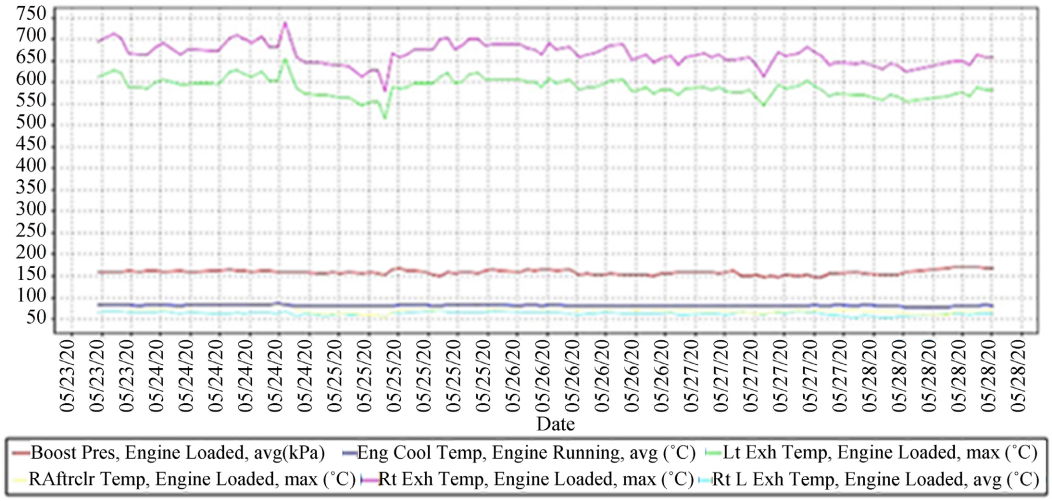

Figure 1. 785C TRUCK engine parameter trends.

Table 1. Interpretation of Figure 1 trends.

Description of anomalies	Recommendations
Low coolant temperature	Check temperature and plan to replace thermostats
High temperature difference between the right and left exhausts	Perform a visual inspection (leak of any kind on the engine); adjust injectors and valves; check the status of the sensors.

Table 2. Interpretation of **Figure 2** trends.

Findings made	Recommendations
Pressure boost 182 Kpa	OK
Coolant temperature	OK
Air filter pressure	OK
The exhaust temperature on the left side (543˚C) is lower than that on the right (625˚C). The temperature difference must not exceed + or −20˚C	Check for leaks of any kind on the engine and adjust the valves and injectors

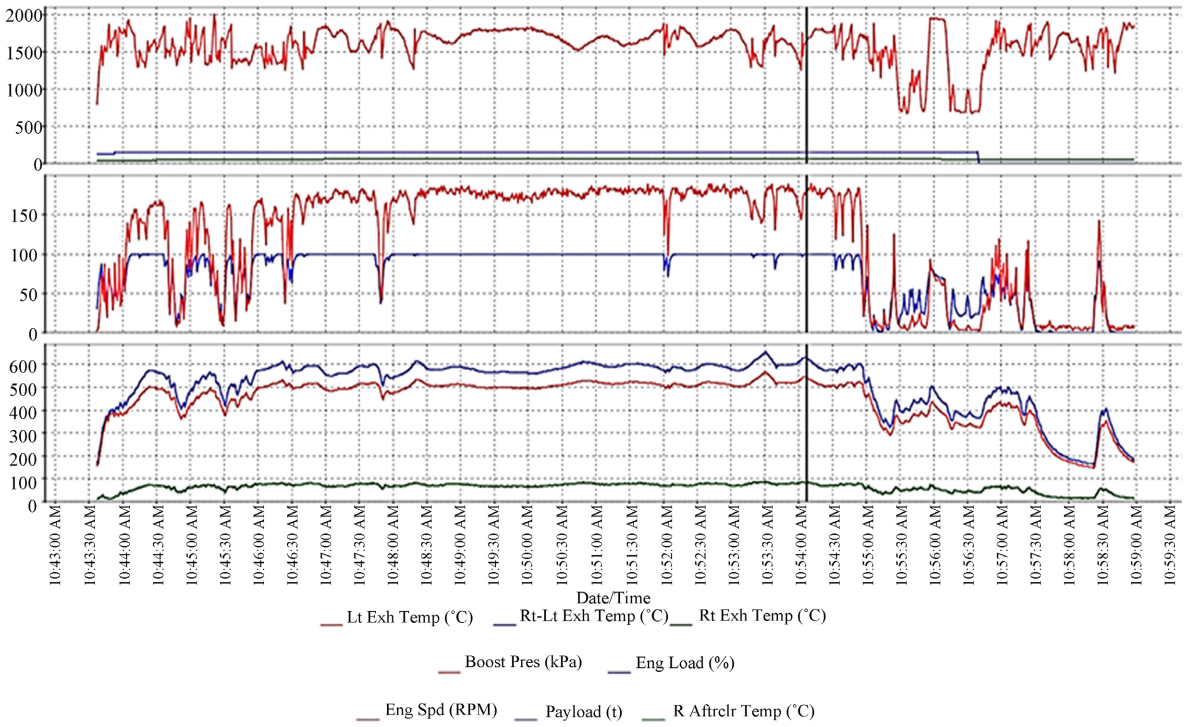

Figure 2. 785C TRUCK engine parameter trends.

While the manufacturer CATERPILLAR has set the absolute limit for the operating life of a 785C dump engine at 18,000 hours of operation before being replaced; with a better monitoring of the fault codes present in the memory of the machine, a good operating policy of the VIMS system and a rigorous application of the recommendations made, we can increase the duration of the hours.

2.2. Transmission Case

As far as the transmission is concerned, monitoring is done in conjunction with the preventive maintenance schedule from 500 hours of operation and more, either by analysis of oil samples or by oil replacement. The diagnosis of the transmission is made through the analysis of the data, logged codes and active codes and by the exploitation of the functionalities of the VIMS system: events, histograms; as shown in the **Figure 3** & **Figure 4** and **Table 3**.

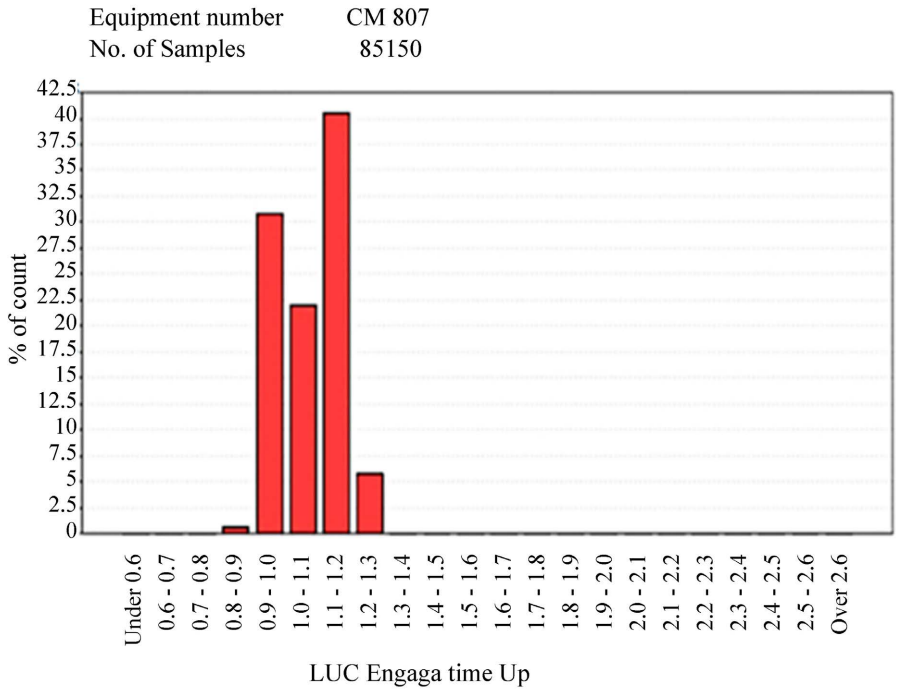

Figure 3. Converter clutch time histogram for time down for time up.

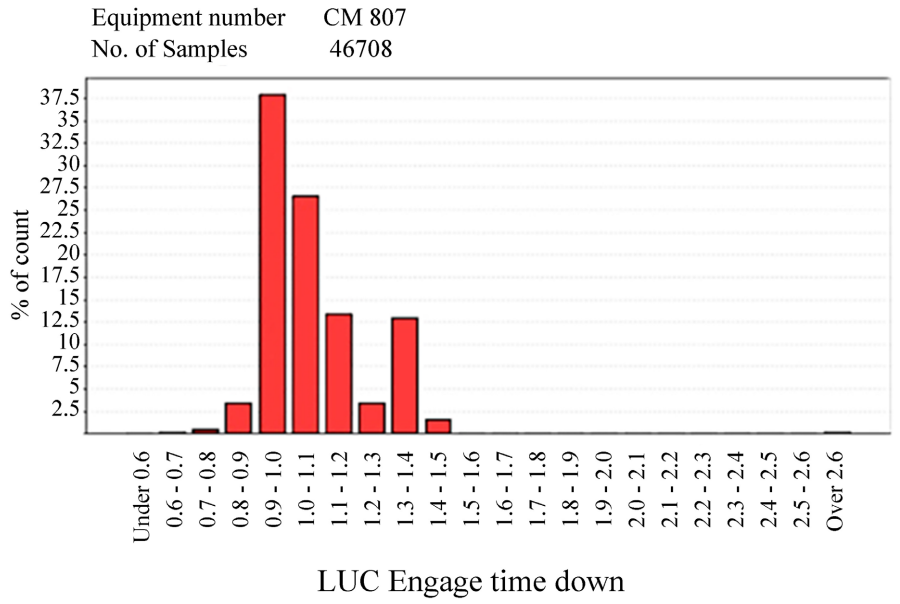

Figure 4. Converter clutch time histogram for time down.

Table 3. Interpretation of **Figure 3** & **Figure 4** (histogram of torque converter engagement time).

Findings made	Recommendations
Converter Slip Time Below Normal : Up shift = 1,01s instead of 1,1 – 1,25 seconds. Down shift = 1,03s instead of 1,1 – 1,5 seconds	Check pilot pressures and Adjust

2.3. Management of Operational Problems

Operational troubles are troubles or faults that occur as a result of improper handling of the equipment by the operator. The management of operational disturbances consists in ensuring good operational availability for all production equipment. It is the possibility of knowing that the fault reported by the VIMS system is a fault resulting from an incorrect operation on the part of the equipment operator. The most important thing to know in managing operational disturbances is this: when you move to operational excellence, you reduce equipment failures by 40%.

2.4. Management of Technical Problems

It is the possibility of restarting equipment quickly after a breakdown in order to increase its reliability. In this approach, which aims to be qualitative, the need to use advanced diagnostic techniques via software is an imperative. Among this software we have in particular the "CAT ET" (CAT Electronic Technician) and the "VIMS Pc". They are applications that are used to make in-depth and accelerated diagnoses in order to carry out a quality repair following a failure that has occurred on an equipment.

The VIMS system is a very important and essential system in the process of equipment maintenance at Caterpillar. It is a system that has been perfected over the years to meet production, operational and maintenance requirements. This led us to identify these shortcomings with a view to making recommendations for a much more efficient use of the data from the VIMS system.

2.5. Use of the Tool QQOQCP

For an objective analysis, we will use the QQOQCP approach, also called the method of questioning: Who?—What?—Where?—When?—How ?—Why?

These are all questions that we must ask ourselves, in order to find the resolution that will allow us to exploit the data of the VIMS system in its fullness. Thus, we arrive at the following answers **Figure 5**.

3. Results and Discussion

The answers obtained thanks to the questions that we asked ourselves with the tool QQOQCP, we therefore arrive at the following interpretations:

Personnal: lack of control over the use of data for troubleshooting, maintenance and repair of equipment by technical personnel. Most of the technicians who work on the equipment and who are called upon to use the data from the VIMS system for maintenance and repair are not all qualified for this, because they have not received adequate training. This contributes to slowing down the work process, because the technician who is authorized to exploit the data is often very busy.

The VIMS system: the VIMS system is under-exploited because all the data is not processed with the rigor required to obtain the expected results.

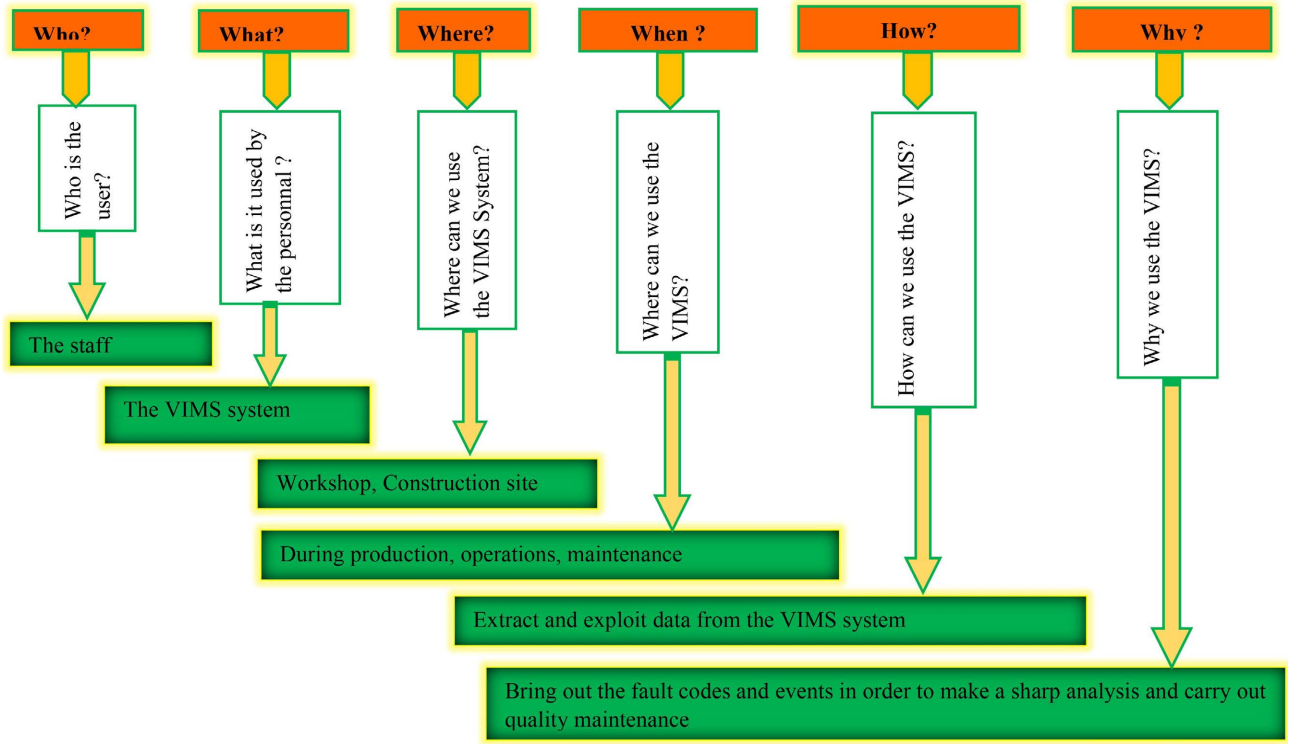

Figure 5. Deployment of the questioning method QQOQCP.

Workshop/Site: the workshop does not have enough computers to ensure the continuous use of the data from the VIMS system. As for the construction site, its environment is not at all favorable to the VIMS system, given the excess dust present there.

Production/Operation/Maintenance: These three (03) sections that operate the VIMS system do not work in perfect collaboration. This has a negative impact on the performance of the VIMS system. Overloads cause much greater stress on the kinematic chain (engine, transmission, axle) of equipment and drive pumps.

Extract data from system: Lack of automatic remote download system. The VIMS system has a relatively small memory for recording data of events that occur during the use of equipment. Thus, the storage memory fills up on most equipment before their preventive maintenance deadlines; because it is at this moment that the reliability technicians must download the data from the VIMS system. This causes the loss of all the data of the events which would occur on the equipment, because there is no longer any space for storage.

Carry out quality maintenance: operators are unaware of the impact of poor conduct on the durability of components. Service technicians do not treat event alerts urgently. After processing and triaging the alerts, the Reliability section forwards the information to the maintenance section for action. Unfortunately, in most cases this is done with a delay; in the worst case, this is simply ignored.

3.1. From an Operations Perspective

Operational disturbances have a negative and dangerous impact on equipment.

These are disorders that generate codes called "machine events". At this level, several event codes may occur due to improper operation of the equipment. The major problem in this case is the following: non-communication and non-follow-up of operational problems.

Recommendations: A system for communicating and tracking operational codes with truck users must be in place. This will consist in identifying all the event codes linked to a bad operation on the equipment and transmitting them to the managers of the operation department so that they can communicate and educate their operators on the risks and potential damage that their bad acts can cause on equipment. This will prevent abuse of the transmission system, and instead of the transmission breaking before its nominal time, which is 15,000 hours, the transmission will be able to perform its function beyond its nominal time. We must therefore work to let operators know that if we manage to achieve operational excellence, we reduce equipment breakdowns by 40%; therefore operational availability will increase by 40%.

3.2. From a Maintenance Point of View

In the maintenance section, we can ask ourselves the following question:

Is the maintenance department operating the VIMS system to its maximum capacity?

Objectively, the answer is: NO. This negative response leads us to make recommendations to remedy it.

Recommendations: Install an automatic remote download system to download data from the VIMS system to the equipment before their storage memory is full. Effectively and professionally train the technical staff in charge of using the VIMS system data for troubleshooting, maintenance and repair of equipment. Communicate with the supervisors so that they sensitize the technicians in charge of the site, so that they become aware and deal with all rigor and without delay the alerts which are communicated to them. This will permanently remove the planned downtime for downloading data from the VIMS system; and efficient and rapid management of equipment that breaks down.

3.3. From a Production Point of View

The use of VIMS for production has an impact on the durability of components. Indeed, in order to achieve the production objectives assigned by the hierarchy, the equipment operators indulge in certain practices which, in a prolonged or immediate way, will adversely affect the durability of the components. Faced with this situation, various problems have been observed. It is the resolution of these problems that leads us to the following recommendations.

Recommendations: It is necessary to bring out the history of the overload data periodically and transmit it to the persons in charge of the operation so that they can communicate and sensitize the operators for the respect of the rules of load of the equipment in order to avoid cracks on the chassis, suspension problems, and

premature wear. Set up a monitoring system that will identify equipment that is overconsumption in order to take corrective maintenance measures to be able to bring the consumption of this equipment back to normal. This will give long life to equipment components while optimizing fuel consumption during production.

4. Conclusions

The VIMS system has significantly improved machine management. It is a technology that both manages the functions of the machine, stores and processes information, and presents critical information. Also, this system monitors the vital parameters of operation while giving a warning. An action should be taken by the machine operator but also by the maintenance technician through a screen in the cabin. The technician can use it for various diagnoses. When the technician, still active or not, faces a logged fault and the first step will be to review all the saved data for probable clues.

Having a good knowledge of the onboard VIMS system and its capabilities will allow the technician to effectively diagnose Caterpillar machines. Generally, the technician will have to be assisted by the diagnostic computer, in which the "ET" (Electronic Technician) software and the VIMS pc are installed.

Conflicts of Interest

The authors declare that they have no competing interests.

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