DEVELOPING OF A MONITORING SYSTEM OF CUTTING, CARRYING, AND TRANSPORTATION OF SUGAR CANE IN ORDER TO MANAGE FLEET

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ABSTRACT

In the productive process for obtaining ethanol from sugar cane, the costs associated to the activities of harvesting (cut), carrying and transport (CCT), represent great part of the final cost of the product. In order to reduce this costs new technologies should be adopted in the agricultural mechanization using precision agriculture methods. The use of the information technology combined with the use of intelligent components can help to improve the performance of machines and equipments and managing efficiency. The present research project aims to develop a system to monitoring the sugar cane CCT. The CCT monitoring system can be divided into three parts. The first one refers to *data acquisition*. In order to do that a harvester was instrumented to collects, display and stores in the PC monitor located in the harvester cabin all the information related to the harvester performance. The second part refers to *data transmission* to the mill. So the information stored in a XML file extension is sent by GPRS or Satelital Iridium to the mill. The third part is related to analysis information and corresponding diagnosis for fleet management. In order to handle all the information that gets to the mill, a software PIMS-SIG-CCT was developed. For each one of the three parts laboratory and field tests were conducted. The field tests were carried out during 2008/09 sugar cane season at São Martinho Mill, Pradópolis-SP. The results demonstrated that the proposed technology is appropriated and can significantly improve the agricultural management and transportation logistics.

Keywords: GIS, precision agriculture, agriculture machines, logistics

INTRODUCTION

The increase of the cost of oil has provoked a worldwide interest for biofuels.

Nowadays, Brazil is the leader in the production of ethanol from sugar cane and has the lowest cost of production. With 30% of the planted area in the world, it is the country where the best weather conditions and the best territorial space for the production are found, besides having the biggest technological knowledge.

During the 2008/2009 season, it was harvested about 600 million tons of sugar cane, and produced 34 million tons of sugar and 25 billion liters of ethanol (CONAB 2009). Cerqueira Leite et al. (2009) presented a study report showing that Brazil has a potential to increase the ethanol production up to 104 billion liters in 2025, which means multiply by 4 the actual production. The authors also mention that to active this target it will necessitate the reduction of production costs. In addition, as one adds more advanced technology to gain greater productivity per unit of land and provide better environmental performance the complexity of the production process necessarily increases. Now, 60% of the production cost of ethanol is associated to the agricultural sector (producing and delivering the raw material to the mill) and approximately 50% of this cost is due to the mechanical operations of harvesting, transporting and distribution. It is possible to use the modern technologies that associate the information sectors with the mechanic and electronic ones, to substantially reduce the operational costs of the agricultural sector. Therefore, it is necessary that the new mills adopt these modern technologies and that the others adequate themselves to these new procedures. Kutzbach (2000) had already foreseen these new technologies. The author mentions that to check the demand of agriculture, the agricultural machines tend in the next years to not only increase their power and capacity of harvest, but mainly to incorporate electronic technology in order to facilitate the operation, reducing the load demanded to the operator. Solutions that allow increase the operational capacity of the machines, improving their operational performance or reducing the idle time, must be incorporated. The management of the machines must receive special attention, where rigorous controls of maintenance and operations must be developed and to operate together with the technology within the machines, contributing for the increase of income and reduction of cost. The technology of telecommunication associated with the global positioning system (GPS) will have an increasing importance in this area, assuring the efficient use of the equipment. Auernhammer (2001) mentioned that fleet management is a practical tool that will result in less traffic and a decrease in the number of trips, more adequate co-ordination of transport vehicles. Additionally, fleet management involves the process of supervising the use and maintenance of vehicles and the associated administrative functions including the coordination and dissemination of tasks and related information for solving the heterogeneous scheduling and vehicle routing problem (Sørensen and Bochtis, 2010).

Different from other crops, the harvesting season comprehend a management of a great quantity of biomass which the successes depends on a good logistic program. A typical sugar cane mill usually crashes 10 thousand tons of biomass a day during a harvest season of around 200 days. This meaning a daily management of more than 200 trucks, 20 harvesters and 34 tractors with 2 wagons, all divided usually in 5 different fronts which are located a distance which varies from 1 up to 60 kilometers from the mill. Considering that the mill should not stop crashing cane 24 hours a day; it is not possible to stock harvested sugar cane in the mill yard; and the system should guarantee raw material independent of the water conditions; the logistic of CCT is a great task.

The presented research report aims to present a system develop for monitoring the cutting, carrying and transporting (CCT) of sugar cane integrated to the database of the mill in order to supply necessary information that allows optimum management of the fleet, better field efficiency and reduction of the operational cost.

MATERIAL AND METHODS:

The corresponding CCT system includes: harvesters, infield wagons with low load capacity to transport the raw material between harvester and high capacity transport road trucks, and unloading equipment located at the mill (Figure 1). All these comprise a complex system in which the individual efficiency of each machine unit depends on the performance of the system as a whole or the supply chain (Sørensen and Bochtis 2010). The parameter to be monitored in the CCT system has been identified in worked presented by Cerri et all. (2005).

CCT on-line monitoring system (Figure 2) can be divided into three parts. The first one refers to field *data acquisition*. The second part refers to *data transmission* to the mill, and the third part is related to analysis information and corresponding diagnosis for fleet management. CCT system works on the following way:

a) The instrumented harvester collects, display and stores in a monitor located in the cabin the following information: engine rotational speed, oil level, pressure and temperature; hydraulic oil tank temperature and level, pressure on several hydraulic sectors (to identify leaking and pump performance), hydraulic motors pressure and rotational speed; from the cooling system, water level and temperature; airflow filter restriction; base cutter height; battery tension; fuel consumption; harvester inclination angle; sugar cane yield and number of worked hours.

Fig. 1. CCT operation: harvesting (cutting), hauling (caring) and transpotation of sugar cane from fielt to the mill.

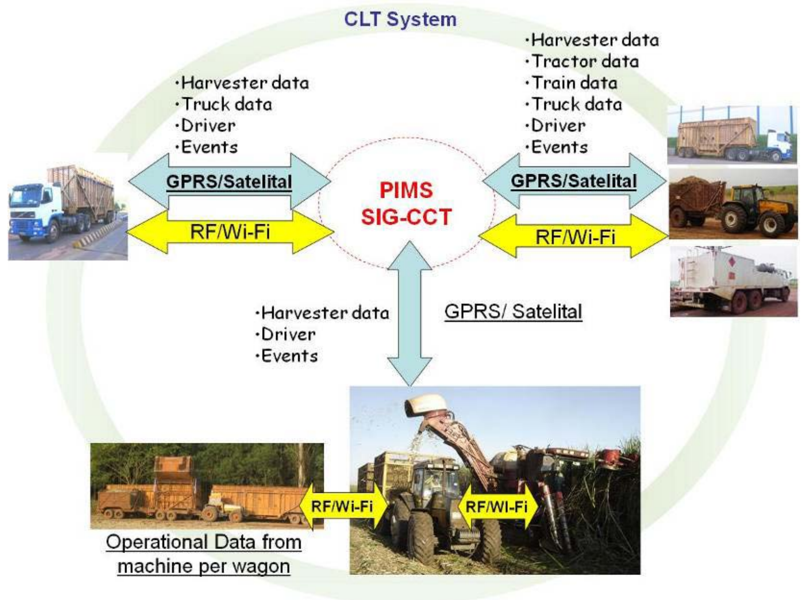

Fig. 2. Working project of the proposed system.

b) Those information are stored in a XML file extension and sent via GPRS or Satelital Iridium when working on-line to the mill. In the heading of this file there are important parameters for data identification such as day and period, name of the operator and its registration number, number of the harvesting front and the harvester and number of the farm and plot area. In cases where GPRS system can be used, all this information is sent on-line to the mill headquarters. In cases where there is no GPRS covering signal Satelital Iridium system is used. The harvester also sends some information; such was total weight in the wagon, automatically to the tractor and this to trucks which transport the sugar cane until the mill. Each tractor and truck has an Automotive Digital Controller (ADC), which can receive and store those data. When the truck arrives in the mill scale, the information is transmitted to the main computer.

c) In order to handle all the information that gets to the mill, a software PIMS-SIG-CCT was developed. This program is responsible for the real time monitoring (GPRS signal or Satelital Iridium) of the fleet (trucks and machines) for programming of preventive maintenance, planning of parts acquisition, elimination of the time lost in the operations and automation of the data entries of the field, for the real time monitoring of the amount of sugar cane in transit, in the agricultural area and in the yard, necessity of trucks/cart to attend the harvest front, changes of route of the trucks in real time and other information to be specified for checking and sending to the modules in field. This information treated by the responsible ones in the mill allows the necessary monitoring, fast and integrated to CCT, and, consequently, offering immediate decision-taking and better control of the factors that affect this important process of the production, thus raising, the chances of financial return for the mill.

For each one of the three parts (data acquisition, communication and management) laboratory and field tests were being carried out. The laboratory tests were carried out in order to get the largest possible amount of information on the system, in order to save time and to prevent possible problems in field. The field tests were carried out at São Martinho Mill, Pradópolis-SP. The final monitoring test of CCT in field consisted of evaluation of functioning as a whole, that is, since the data acquisition until the decision taking based on them. For this, the equipment, sensors and software in the headquarters of the mill were installed all, in the harvesters, tractor, truck and convoy. Inside these tests, the first one related with the harvester consists of simulating an imperfection or a value above or below of the established limits for a determined sensor and verify in the embedded software of the central PC setup in the machine and to the management program (PIMS-SIG-CLT) if this problem was detected. In this way, either the instrumentation of the harvester, or the communication and the management system were under test. This type of test will be performed for the trucks and convoy, but instead of the central PC, the ADC was evaluated.

RESULTS AND DISCUSSION

The present research generates the following products: a) Instrumented sugarcane harvester to monitor electric, mechanical and operational parameters of the machine, besides the crop yield; b) Data-communication system between the front of harvest and the mill; c) CCT software, resident in the mill, capable to generate information for the taking of decisions in the fleet management, in order to provide economic benefits, where the reductions of the final costs of the system can be got by means of consultations in real time with immediate decision taking. Figure 3 show the harvester with associate instrumentation.

Data was acquired and stored in the harvester onboard computer, and field operation parameters were transmitted to the mill every 1 minute or immediately when the harvested has stopped for some reason such as part replacement or mechanical help, routine maintenance, rain and others.. The information in this case consist of average operational speed, field position, harvested area, total sugar cane harvested, yield and parameters of the machine.

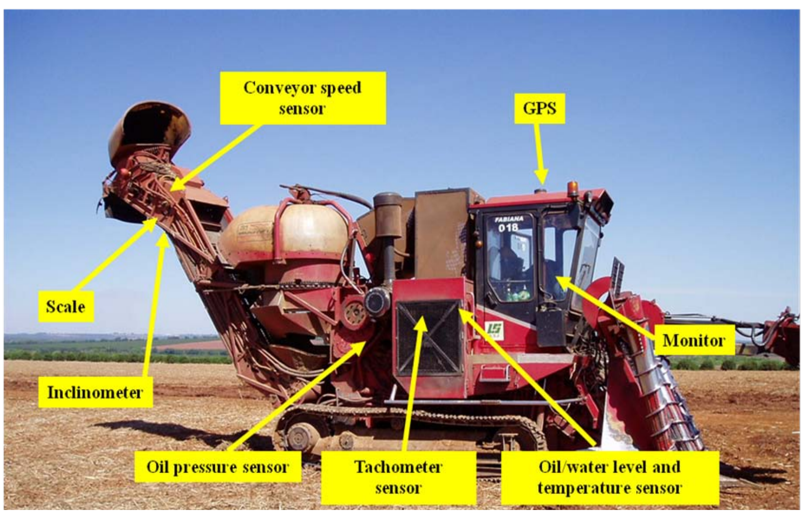

Fig. 3. Sugar cane harvester with the necessary instrumentations adapted to this research.

By Wi-Fi the total wagon load was also transmitted to the tractor and from the tractor to the truck. The accumulated weight in the truck was controlled by an onboard computer. When filled up the truck computer transmitted to the mill its position, time of departure, and load. Upon arriving to the mill at the balance the load value were confirmed and the traveled distance and time informed to the management program (Figure 4).

Fig. 4. Reception radio installed on weighing site of sugar cane mill

Same information available in the PIMS-SIG-CLT program screen can be seen in Figure 5.

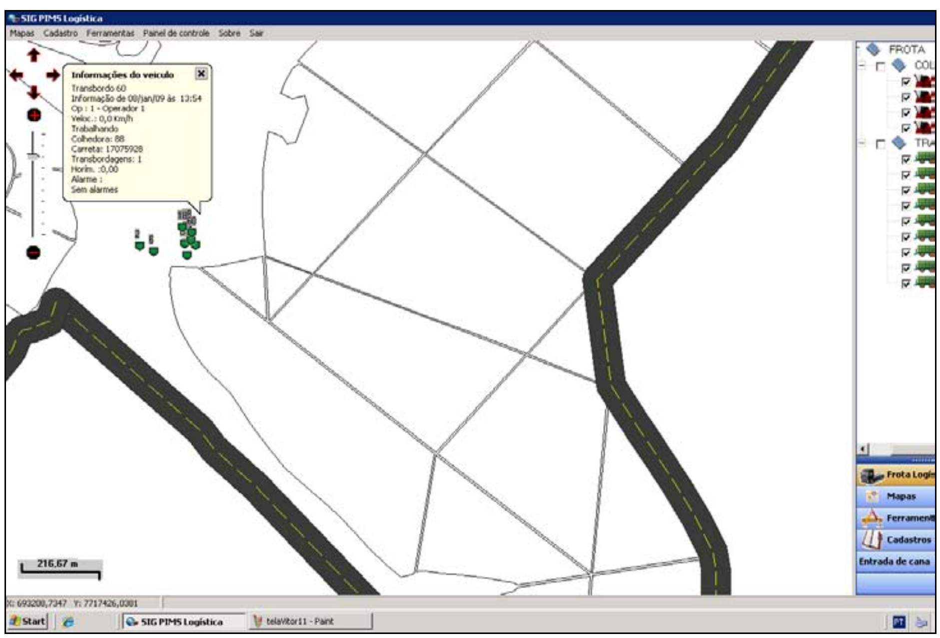

Fig. 5. Program screen of PIMS-SIG-CLT.

The program is able to calculate the performance of the system, the necessary sugar cane to be harvested to attend the daily crash target, and based on harvesters' performance field location available machines of the fleet, cycle time, etc. calculated the number of trucks to be sent to the harvest front in order to attend the local production flow. The program also takes into consideration the meteorological conditions.

The algorithms for scheduling, task allocation, machinery assignment, area coverage and route and path planning was developed in partnership with Enalta and Proxima, (both private enterprise which has been working with PA for sugar cane) using the information provided by the centralized Geographic Information System (GIS). The plans were frequently revised taking into consideration the local observations and operators knowledge of the system.

CONCLUSION

This research has shown the potential benefit of using dedicated system for CCT management in the sugar cane production. The proposed system involves a data acquisition and transfer to a central computer at the mill where a PIMS-SIG-CCT software which support real-time management decision- making is used to schedule field operations and transport logistic. The principal benefits of the system were: The system reduces the time of trucks waiting at the mill yard to be unloaded; the number of trucks waiting in the field to be load also reduced, daily working hours of the harvesters increase as well as the field efficiency. Maintenance time and time delay for part replacement also reduced. Indirectly machinery operators were benefited since part of their salary is based on productivity.

The system was well evaluated by the mill and should be extended to all harvest fronts in the next season.

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