

Operation of mechanical sugarcane harvesters: an ergonomic approach

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Abstract

This article demonstrated the role of the operators' competences in carrying out task and performance at Brazilian plants. Through the application of the ergonomic principles, the activity in real work situation was analyzed the main competences required for satisfactory operation were identified.

Keywords: Ergonomic Work Analysis (EWA), regulation, sugarcane harvest.

Introduction

Brazil is the largest producer of sugarcane in the world (BRASIL, 2009). According to Ministry of Agriculture, Livestock and Supply (BRASIL, 2011), Brazilian production in 2009 was 690 million tons of sugarcane in a planted area of 9.6 million hectares. Therefore, the sugar and alcohol sector occupies an important role in the national economy, including being one of the agricultural activities that employs more hand labor in the country (PETTI; FREDO, 2009).

With the advancement in mechanization process of cutting in the country, new occupations emerge, such as driving tractors, electronics maintenance, mechanical maintenance and operation of the harvesting machines (combines), which occupies a central role in the whole process.

The agricultural machinery operation in general has been the subject of several studies. In international literature, there are studies about noise, vibration and design control panel of agricultural machinery (DEPCZYNSKI *et al.*, 2005), wheat harvester (SÜMER *et al.*, 2006), forest machine (REHN *et al.*, 2009) and mainly tractors (FRANKLIN *et al.*, 2006; DRAKOPOULOS; MANN, 2007; MAYTON *et al.*, 2008; MEHTA *et al.*, 2008; AYBEK *et al.*, 2010).

Regarding specifically the work of operators of sugarcane harvesters machines, there are few studies available. Silva *et al.* (2011), for example, evaluated the characteristics of a sugar cane harvester, and Scopinho *et al.* (1999) described the workloads that the operators of these machines are subjected.

Therefore, this study aimed to comprehend the operation of harvesting machines from the standpoint of activity, contributing to the understanding of the work process in its entirety.

Method

The study had as methodological approach the qualitative research, which focuses on the perspective of the subject that is studied. This approach considers relevant subjective reality of the individuals involved, and this element is the main contributor to the research development. Thus, the object of study is represented in its entirety, within their everyday contexts and guides the choice of method (FLICK, 2009).

As a research method, it was used the multi-case study and the activity analysis, an assumption of the Ergonomic Work Analysis (EWA) approach.

The case study is an empirical study that investigates a current phenomenon in the context of real life (YIN, 2005). For the author, this type of study is the preferred strategy when issues such as "how" and "why" arise and when there is little control over the events. And by analyzing deeply the case(s) in question, this method allows, according Voss *et al.* (2002), relatively complete understanding of the nature and complexity of the phenomenon studied.

EWA, in turn, consists of a methodological approach of intervention that furthers the global understanding of the work situation. According to Assunção and Lima (2003), EWA aims to analyze the operators' behavior, their reasons, motivations and goals, comprising the activity on the inside and reconstructing its logic on its own course of action.

For Abrahão *et al.* (2009), EWA refers to a set of steps and actions that maintain an internal coherence, especially regarding the possibility of questioning the results obtained during the data collection, validating them through the process and bringing them closer to the reality researched.

Were studied harvesters machines operators from three sugar and alcohol mills located in Piracicaba, São Paulo State. To conduct the study, the following methods and research techniques were used:

- open and systematic observations;
- video footage;
- photographs;
- open and semi-structured interviews;
- self-confrontation interviews (individual and collective with different workers of the mechanical harvesting teams).

To understand the operators' prescribed work for subsequent confrontation with the real work, interviews with harvest team leaders were conducted. These interviews also helped to understand the environmental, technical and organizational determinants of the task.

For activity analysis, systematic observations were carried during the course of work, totaling 150 hours, covering seven months of harvest (early, peak and late harvest) and a full offseason. The visits were performed on different days of the week and different times of day: morning, afternoon and evening. The observations occurred mainly inside the cabins of the harvesters, but the activity was also observed in the field, at a distance of the machines in operation.

For the data analysis of interviews and footage, transcripts were made, which allowed the selection of keywords in order to realize the interpretation and description of the results. These keywords were selected and added according to the understanding of the work situation, from what was deemed important considering the study's objectives.

At the end, a diagnosis was formulated based on data obtained through the articulation of the results from observations, analysis and clarifications provided by the operators.

Results and discussion

In the operation of harvesting machines, the workload regulation process is influenced by the demands of height cutting, the high variability present in the activity, the cooperation relationship with tractor operator and organizational aspects such as work on shift and payment by production. These are the main determinants of activity, which are articulated with the conditions and with the knowledge developed by operators to develop the operative strategy. This strategy aims to simultaneously maintain their physical and mental integrity and meet the demands of the task, managing the unexpected.

Because it is an activity that requires a continuous adjustment, sugarcane harvester machine operation is marked by an intense cognitive demand, dependent on attention, perception, information processing, representation, diagnosis and problems resolution (NARIMOTO; CAMAROTTO, 2011).

By analyzing the real work, it was observed that operators pay attention to perform some operations in the correct sequence in order not to waste sugarcane or damage the machine.

Furthermore, there is great demand for attention to avoid collisions with transshipment and to capture information about the cut quality. The operators constantly seek evidences that show them the results of their work, paying attention to the lines of sugarcane already harvested, to the line that he is reaping (machine alignment, height cutting adjustment and cutting of the tips), for machine's displays (levels of temperature, pressure, rotation), the load transfer and its cleaning.

This search for information, according to Guérin *et al.* (2001) is inseparable from human action and in light of ongoing activities, the operator explores the environment selectively. Thus, the worker is not simply an information receiver, but the main actor of information acquisition since he seeks and selects the information in the middle intentionally and actively (DESNOYERS, 2007). And it is from the acquisition of information that the employee is located in space-time system in which he acts, allowing the onset and continuation of an action, and therefore the work regulation.

According Falzon (2007), regulation is a control mechanism which comprises the detection of differences in results compared to the desired, a diagnosis and if necessary an action, an adjustment process, which is the regulation itself. Therefore, to achieve the intended purpose it is necessary that the worker formulates operational strategies, which in turn depend on the information interpretation from the environment and the use of knowledge, skills and experience (ABRAHÃO *et al.*, 2009).

Considering the amount of variables involved in the activity, experience, knowledge and representations of operators' harvesting machine are fundamental to the operational strategies development that lead to the most appropriate action. It was observed that the operators use different strategies to perform cutting in accordance with

the variability of sugarcane, ground and harvester machine, comprising a system regulation process.

Since the harvester machine it is a large and very complex machine, with different mechanisms, commands and controls, the detection of problems/disorders, and especially the diagnostic process, are highly complex.

As said, the operation involves a continuous treatment of information and depending on the signals perceived, the operators detect the abnormality and initiate a process of diagnosing the problem cause. According to the activity analysis, diagnosis considers a number of factors, such as changes in the displays, noise, dust, vibration, load, cut quality, among others. This collection of information, according to Iida (2005), is the starting point of the decision-making process, which involves then the evaluation/processing of information by comparing with the knowledge held, and finally selecting the option. It means that from the information obtained, operators construct a mental representation of the problem to generate solutions (ABRAHÃO *et al.*, 2009). So Tersac and Maggi (2004) emphasize the role of mental representations in the activity regulation, since they allow the mental simulation that is essential for the regulation action planning.

It is important to highlight that even if the operators have competences and liberty enough to adjust the pace of their work, there are several variabilities at work that they cannot predict. For example, the operator has no control over variability inherent to the work process (rain, fog, variation in illumination) as well as the variability related to the unawareness of land to be harvested (electrical network, streams if present). Likewise, operators have no control as to the variability related to the lack of ground preparation for mechanized cutting (holes, ditches, stones), hence the need for constant attention.

This lack of ground preparation for mechanized cutting, which was observed in the three plants studied, is an important point that deserves mention. Pedological accidents interfere with the height adjustment of cutting base, and damage the machine, so they represent an additional constraint to the operators' activity. However, such variabilities are managed due to the peculiarities of human behavior highlighted by Lima e Silva (2002): flexibility, adaptability, development and improvement of regulation forms.

The human behavior dynamism becomes even more evident when we observe that in mechanized cutting, operators can overcome a limitation of the harvester machine itself: the theoretical no-operation in grounds with slopes greater than 12%. The results showed that the slope is another determinant of the work situation since in these cases the operator's attention is maximized to avoid collision, overturning and accidents and strategies are developed to balancing the machine.

As cutting and loading operations are carried out simultaneously (Figure 1), the strategies adopted by operators are also based on the cooperative relationship with the tractor operator. According Guérin *et al.* (2001), the cooperative relationship implies a mutual dependence, where those involved should take into account the action of the other so that they can both adjust themselves. And, in the cutting on grounds with slopes, this setting should be even more accurate given the increased risk of accidents.



Figure 1 – Mechanical sugarcane harvesting (CASE, 2009)

The results show that this is a relation of complex influence for the operators' activity and for the regulation process. At the same time it may facilitate the work of both, may also represent an additional constraint. This is because according to Guérin *et al.* (2001), in the work in cooperation, the different people involved in the action obtains information from other's course of action so that they can adjust their operating methods in real time. This feature in itself is a constraint, which may be greater when the tractor driver is inexperienced, because it represents one more factor (among many already described) to which the operator should note.

The work regulation process of the operators takes into account further organizational aspects, especially the shift work and payment by production, since it influences the workload and health.

Night work occurs with decreased visibility over long distances by the harvester machine and tractor operators, which impacts the work, especially in unfavorable conditions, in ground rough and with slopes. Payment by production, in turn, increases the work rate (DAL ROSSO, 2008) as it requires more attention to the harvested cane cleaning and managing losses, and eliminate possible breaks during the workday.

However, it was observed that despite the existence of constraints discussed above, there is a whole knowledge involved in the activity, a knowledge that is expressed in operational methods and enabling operators to build competences. Operators not only operate the machine as well as detect problems, assist in mechanical repairs, replace the harvest team leaders.

It should be noted that knowledge to operate a complex machine as the harvester machine, as well as to develop appropriate regulatory strategies, according to the findings, is acquired through practice. This is because most of the operators studied had no access to any qualification course, which does not mean lack of knowledge and competences to perform the job.

Therefore, the regulation strategies developed by sugarcane harvester machine operators are essential to compensate for the numerous variabilities present in work activity and to allow the production in quantity and quality.

Conclusions

The results found have highlighted the operators' work in terms of activity, the factors that affect their health and how is the work regulation. Thus, the study aimed to provide a better understanding of this activity that is growing in the country, generating contributions to the work organization and training of these professionals.

It is possible to affirm that it is the operator's experience, coupled with the knowledge acquired and built by practice permit the establishment of operational methods, which in turn compensate the various variabilities, supply the lack of ground preparation, and thus ensure the quality of the product that reaches the mills. The qualification courses teach the functions and how to trigger the controls, but not to operate the machine in case of variability and ground that are not suitable. This "know-how" is only learned in practice.

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