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ERGONOMIC ANALYSIS OF A BAJA VEHICLE: BEYOND ANTHROPOMETRIC CONCERNS

Brenda Ktherinne de Oliveira Souza: brenda_kso@hotmail.com; UNIFEI
Raoni Rocha: raoni@unifei.edu.br; UNIFEI

ABSTRACT

Despite the relationship between ergonomics and performance of vehicles, even note a great scarcity of studies geared toward the area, and still under Baja SAE studies are based solely on anthropometric analysis. With the introduction of ergonomic analysis it is possible to analyze the diversity of factors involving the activity, since the user until the organization, providing more effective results. Based on this point, a case study was performed with the accompaniment of a Baja team, which sought to assess the man-machine-environment system of a competition vehicle, with the central objective of demonstrating how the ergonomic analysis of the work can contribute to propose and implement improvements in vehicle design. By means of the results one could observe how the introduction of this science was fundamental to identify latent problems of the team, as well as demonstrate the importance of the pilot project and propose improvements that could contribute so much in the comfort, howcar safety and performance in the competition.

KEYWORDS: ergonomic analysis of the work; baja; anthropometry.

1. INTRODUCTION

The automotive industry is considered one of the largest industrial activities today, and to stay on top, it is in constant development. As a way to encourage and strengthen studies in automobile development, the Society of Automotive Engineers (SAE) created the Baja SAE Project competition, which is considered one of the largest programs to train future professionals for the automotive industry (SANTOS, 2015, p.13).

The BAJA SAE competition emerged in 1976 in the USA, as a university project, with the aim of designing and manufacturing an off-road vehicle, providing participating students with the opportunity to apply academically acquired knowledge in practice (SAE BRASIL, 2018, p.4).

Ergonomics applied to the automotive industry is aimed at making the vehicle safer and more suitable, considering the interfaces with the driver and the environment. In this context, ergonomics is essential because it determines the best way to adjust the system for human use (TANABE, 2015). This aspect becomes even more evident when it comes to competition vehicles, as any aspect below expectations can affect the pilot's performance (SILVA et al., 2013).

Despite the relationship between ergonomics and performance in competition vehicles, in the Baja SAE context, there is still a significant scarcity regarding studies focused on the area. Furthermore, the vast majority of studies found associate ergonomic improvements solely with anthropometric factors. According to Añez (2001), anthropometric data remains important; however, it only makes sense when analyzing the activities carried out, the peculiarities, and the individual's perception of carrying out those activities.

To achieve its objectives, ergonomics, through Ergonomic Work Analysis, studies a variety of factors, namely: the individual and their physical, physiological, and psychological characteristics; the machine; the environment, which includes temperature, noise, vibrations, light, colors, and other factors; work organization; and the consequences of work for the worker (IIDA, 2005).

3. OBJECTIVE

The identification and understanding of ergonomic factors in the context of Baja vehicles can contribute to the improvement of the project, as well as future projects, both in terms of safety and performance enhancement during competitions. Therefore, the present study aims to evaluate the man-machine-environment system and demonstrate how

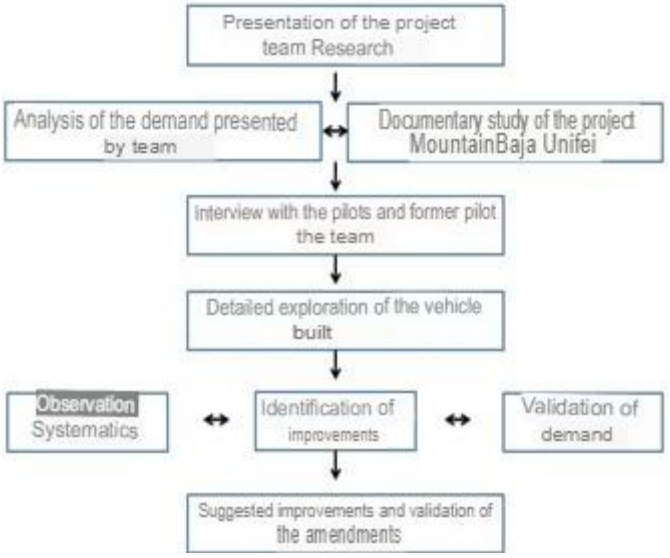
Ergonomic Work Analysis can be used in a technical aspect to propose and implement improvements in the vehicle project, based on the researcher's interaction with team members.

4. METHODS

The present research is characterized as a case study conducted through monitoring activities in the different sectors of a Baja team. The research began with the demand indicated by the team itself for ergonomic improvements related to the comfort of the driver and the need to comply with Baja SAE BRASIL regulations.

The research development occurred in nine stages: 1) it began with the presentation of the research to the entire team, explaining what Ergonomic Work Analysis is, its importance, and how it would apply to the study; 2) followed by the analysis of the demand presented by the team's Design sector to identify possibilities and limitations; 3) studying the project documentation; 4) interviews with team drivers and former drivers about limitations, strengths, and possible improvements in the vehicle, aiming to compare with the demand presented; 5) detailed exploration of the already built vehicle through direct observation of vehicle driving activity (notes and photographs); 6) systematic observation (comparison between those involved through vehicle analysis, individual interviews, and conversations between members of different sectors); 7) identification of improvement points; 8) validation of the demand; and finally, 9) suggesting improvements for the comfort and safety of the drivers, while also complying with organizational standards, followed by the validation of the changes.

Figure 1: Explanatory Diagram of the Method



Source: Own work (2018)

5. RESULTS AND DISCUSSION

Through primarily collecting data from the current and former drivers of the team, several relevant aspects related to the vehicle's structure were raised and found to be present and recurrent in the interviews and observations, as can be observed in the following verbalizations:

> *"(...) so, one thing that really bothers is the pedal height, sometimes the race is long, we can't rest our foot and it's hard to maintain." (Team pilot).*
>
> *"In terms of issues like that, that I see, it's the pedal's issue, its travel and everything, the steering wheel being too small, it's hard to grip, the seat, if it could be improved it would be good because the race is long and it becomes quite uncomfortable after a while." (Former team pilot).*

The gathered data was categorized according to its nature and consequence for the project and presented at the team's general meeting, listing the most important aspects with a real possibility of change and requiring immediate improvements. The categorization of these aspects can be observed in the following Table 1.

Table 1: Categorization of Raised Demands

Pilot Comfort			
Brake pedal height and heel support	Steering wheel height and size	Arm restricter placement	Seat improvement
Vehicle safety			
Button reachability		FAB (limitations in vehicle entry and exit)	
Vehicle efficiency			
Steering box sizing		Curvature and travel of the accelerator pedal	

Source: Own work (2018)

After interviews and observations regarding the raised factors, the team members themselves identified critical aspects with real potential for improvement, namely: 1) Brake pedal height and heel support; 2) Steering wheel height and size; 3) Seat improvement; 4) Accelerator pedal curvature and stroke. Tests were conducted with the members of the specified sectors along with the team's driver to assess the changes and the efficiency of these improvements applied to the driver. The tests were conducted by the researcher in a manner that analyzed the possibilities for each point within the competition regulations and the team's capabilities (especially financial) in conjunction with the driver's comfort and safety needs. At the end of the analyses, the necessary modifications were defined, as well as how they would be implemented.

5.1 Brake Pedal Height and Heel Support

The following image shows that the brake pedal height has been adjusted so that the driver's heel can make direct contact with the floor, both in resting position and when pressing the pedal.

Figure 2: Brake Pedal Adaptation

Source: Own work (2018)

5.2 Steering Wheel Height and Size

In Figure 3, you can observe that the height of the steering wheel has been marked to meet both the driver's requirements and the safety standards of the car, allowing for a good grip and maneuverability while ensuring good visibility for the driver.

Figure 3: Steering Wheel Adaptation

Source: Own work (2018)

5.3 Seat Improvement

As depicted in Figure 4, the seat foam has been adapted to ensure compliance with competition regulations, providing a minimum comfortable and safe space for the driver while also meeting the necessary distances in relation to other controls within the cage.

Figure 4: Seat Adaptation

Source: Own work (2018)

5.4 Accelerator Pedal Curvature and Stroke

Due to the need for adaptation of the pedal base, a flexibilization system was developed using screws, and the pedal stroke was adjusted to ensure better foot support and fixation during driving.

Figure 5: Before and After Adaptation of the Accelerator Pedal

Source: Own work (2018)

6 RELEVANCE OF USING ERGONOMIC ANALYSIS

The use of anthropometric analyses is important in various contexts, as every instrument, machine, or workstation should be suitable for any individual, regardless of their characteristics. However, when it comes to Baja competition vehicles, their use should not be done in isolation. Instead, by integrating them with ergonomic work analysis, which incorporates human and organizational factors, it is possible to achieve the expected objectives, enabling greater effectiveness in the system's operation.

The researcher's interaction with different team sectors was crucial for the study's insights, as well as the pilot's participation in the different phases of the project modification. The pilot, being the user themselves, possesses knowledge about the activity's execution and its impacts during the competition. This aligns with Medeiros's (2004) assertion that humans are an essential part of system performance, hence they should be considered in all stages of ergonomic study. If the user is not comfortable, the system will not operate with the expected efficiency.

Although the project's reality only allows for specific modifications to the vehicle, including the pilot made it possible to identify and categorize aspects that would have a greater impact on the car's performance during the competition. This demonstrates how these actions, if properly addressed and contextualized within the sector, can lead to significant improvements in user comfort and safety, directly impacting the vehicle's performance.

7 CONCLUSION

The research presented demonstrated the importance of not limiting Baja vehicle studies to anthropometric aspects. It proved that through the integration of ergonomic work analysis, which allowed for an examination of the real situation of the vehicle and the team as a whole, it was possible to effect improvements in the vehicle, directly impacting the comfort and safety of the pilot, and consequently the performance of the car.

The results of the article highlighted the wealth of information related to the pilot's activity. Only through the analysis of their activity was it possible to identify the true aspects in need of transformation, substantiating the necessity of using ergonomic analysis in Baja vehicles.

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