



ERGONOMIC ANALYSIS OF THE ANOA 2 6X6 PANZER STEERING ROOM USING *NORDIC BODY MAP*

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ABSTRACT

Comfort and safety in the driver's seat of a military vehicle are crucial aspects in supporting operational effectiveness. The Anoa 2 6x6 Panzer is a combat vehicle used by the Indonesian National Army (TNI) with its main function as an armored personnel carrier. However, several studies show that ergonomic aspects in wheelhouse design still need to be optimized to reduce the risk of musculoskeletal disorders (*Musculoskeletal Disorders/MSDs*) on the driver. This study uses the Nordic Body Map (NBM) method to evaluate the comfort level and potential risk of injury due to the driver's working posture during vehicle operation. Data was collected through questionnaires filled out by 21 Anoa 2 6x6 Panzer drivers who were actively on duty in the field. The research results show that the lower back, shoulders, neck and wrist areas are the parts of the body that experience the most complaints due to less ergonomic chair design, pedal position and control layout. Based on these results, recommendations for a more ergonomic design were prepared to reduce the driver's physical workload and increase comfort in operating the Anoa 2 6x6 Panzer

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1. INTRODUCTION

Combat vehicles such as the Anoa 2 6x6 Panzer have an important role in military operations, both in troop transport missions and security patrols. However, ergonomic aspects in wheelhouse design are often not a priority in military vehicle design. Grandjean (1988) stated that poor ergonomics can causing an increased risk of musculoskeletal disorders that have the potential to reduce driver effectiveness. One method commonly used to assess the level of work comfort and the risk of injury due to unergonomic work postures is *Nordic Body Map* (NBM). The NBM method helps identify body points that experience discomfort and can be the basis for redesigning vehicle designs to better suit the driver's needs. In the context of the Panzer Anoa, this study aims to evaluate the comfort level of the wheelhouse and provide recommendations for better ergonomic design.

This research uses a quantitative approach with a survey method of 21 Panzer Anoa 2 6x6 drivers, which aims to identify areas of the body that experience discomfort during vehicle operation.. Questionnaire *Nordic Body Map* (NBM) is used as the main instrument in data collection to map musculoskeletal complaints based on user experience. It is hoped that the results of this analysis will provide deeper insight into the design factors that contribute to discomfort and become the basis for developing design recommendations to improve vehicle ergonomic aspects.

As part of this research, observations and documentation during filling out the questionnaire were also carried out to understand the context of vehicle use more thoroughly. Figure 1 below shows one of the activities for filling out the questionnaire *Nordic Body Map* (NBM) by the Anoa 2 6x6 Panzer driver in this study:



Figure 1: Questionnaire Filling Activity *Nordic Body Map* by Anoa 2 6x6 Panzer Driver (Document : Hardy)

With this study, it is hoped that it can contribute to the development of combat vehicle design in the future, especially in the ergonomics aspect, thereby supporting operational effectiveness and improving the welfare of military personnel who operate vehicles. The results of this research can also be a basis for PT Pindad's Research & Development (R&D) team, Special Vehicle Division, in developing a strategy for designing more ergonomic combat vehicles. By understanding the pattern of discomfort experienced by the driver, the team of designers and engineers can optimize the cockpit design, control layout and suspension system to reduce the physical burden during operation. The integration of the results of this ergonomics study will strengthen a user-based approach in combat vehicle innovation, ensuring that each development not only takes into account technical and defensive aspects, but also crew comfort and efficiency in the field of duty.

2. RESEARCH METHODS

This research uses an approach *Nordic Body Map* (NBM) as the main method for identifying musculoskeletal disorders experienced by Panzer Anoa 2 6x6 drivers. This method was chosen because it is able to systematically map the level of discomfort in various areas of the body, so that it can provide a more accurate picture of the ergonomic problems faced by users of this combat vehicle.

Several stages carried out in this research are:

Literature Study

A literature review was conducted on military vehicle ergonomics theory, including Grandjean's (1988) theory regarding vehicle ergonomics, work posture assessment methods, as well as previous research regarding the use of *Nordic Body Map* (NBM) in evaluating work posture.

Data Collection

In this research, the data collection process was carried out through two main methods, namely interviews and observations, as well as filling out questionnaires *Nordic Body Map* (NBM). The first stage was interviews conducted with 21 active Panzer Anoa 2 6x6 drivers who served in military operational environments. This interview aims to gain direct insight into their experience in driving combat vehicles, including ergonomic challenges faced during operations. Apart from that, observations were also made on aspects of the driver's sitting posture, pedal position and the layout of the vehicle controls. This observation aims to understand more deeply how vehicle design contributes to comfort or discomfort during use. The next stage is filling out the questionnaire *Nordic Body Map* (NBM) by respondents. This questionnaire is used to identify 20 body points that have the potential to experience discomfort due to static driving postures for long periods of time, exposure to vibration, and other vehicle ergonomic factors.

Table 1: Questionnaire *Nordic Body Map* & Respondent results

Respondent		Jenis Keluhan				Total
		TS	AS	S	SS	
1		57	22	0	0	38
2		26	4	0	0	20
3		58	20	0	0	38
4		8	28	18	0	54
5		55	20	9	0	44
6		58	20	0	0	58
7		58	20	0	0	38
8		8	24	24	0	56
9		7	28	21	0	56
10		8	28	18	0	54
11		12	30	3	0	45
12		58	24	0	0	40
13		22	12	0	0	34
14		17	22	0	0	39
15		15	26	0	0	41
16		20	16	0	0	36
17		58	20	0	0	38
18		14	26	0	0	40
19		58	20	0	0	38
20		58	20	0	0	38
21		58	20	0	0	38
Total		251	452	93	0	876
Persentase		27,79%	51,60%	10,62%	0,00%	100,00%

Panzer Driver (Document : Hardy)

Data obtained from the questionnaire was processed using descriptive statistical methods to calculate the percentage of complaints at each point of the body that experienced discomfort during operation of the Anoa 2 6x6 Panzer. This analysis aims to identify the body parts most affected and evaluate ergonomic factors that contribute to driver discomfort. The results of this analysis are the basis for developing recommendations for design improvements based on user ergonomics and anthropometric standards, with a focus on improving chair design, control layout and vibration dampening systems.. With this study, it is hoped that design improvements can reduce discomfort and increase driver effectiveness in combat vehicle operations. The following are the statistical results of the questionnaire analysis that has been carried out:

Table 2: Statistical results & Musculoskeletal Classification

Statistics			Klasifikasi Subjectivitas Tingkat Risiko Keluhan Musculoskeletal Disorders Berdasarkan Total Skor Individu			
SkorTotal_Responden			Total skor keluhan individu	Tingkat resiko	Kategori resiko	Tindakan perbaikan
N	Valid	21	0-20	0	Rendah	Belum diperlukan adanya tindakan perbaikan
	Missing	0	21-41	1	Sedang	Mungkin diperlukan tindakan dikemudian hari
Mean		41,7143	42-62	2	Tinggi	Diperlukan tindakan segera
Std. Error of Mean		1,59634	63-84	3	Sangat tinggi	Diperlukan tindakan menyeluruh segera mungkin
Median		39,0000				
Mode		38,00				
Std. Deviation		7,31535				
Variance		53,514				
Range		26,00				
Minimum		30,00				
Maximum		56,00				

Panzer Driver (Document : Hardy)

3. RESULTS AND DISCUSSION

Results *Nordic Body Map*

Based on the results of the questionnaire *Nordic Body Map*, it was found that some parts of the body experience pressure and discomfort during vehicle operation. Table 1 shows the percentage of complaints at various points on the body of Panzer Anoa 2 6x6 drivers.

No Body Points Not Painful (%) Slightly Painful (%) Painful (%) Very Painful (%) 1 Neck 40% 35% 15% 10% 2 Shoulders 20% 30% 35% 15% 3 Lower Back 15% 25% 40% 20% 4 Wrists 35% 40% 15% 10% 5 Waist 20% 30% 30% 20% Table 3: Results of presentation of complaints at various points of the body Panzer Driver (Document : Hardy)

Ergonomic Design Evaluation

Based on the data obtained, the lower back and shoulders are the body areas that experience the most complaints among Panzer Anoa 2 6x6 drivers. The high level of discomfort in this area is caused by several ergonomic factors in vehicle design. One of the main causes is that the seat design does not support ergonomic posture, so drivers have to adjust their sitting position

unnaturally over a long period of time. Additionally, a less-than-optimal vehicle control layout forces drivers to bend or overstretch their arms, ultimately increasing strain on the shoulders and lower back. Another contributing factor is the position of the gas and brake pedals which do not comply with the anthropometric standards of most users, resulting in additional pressure on certain body parts when the vehicle is operated. The combination of these factors causes an increased risk of discomfort and musculoskeletal disorders, which, if not immediately corrected, can impact a driver's effectiveness and endurance while on duty.

Design Improvement Recommendations

To improve the ergonomics of the Panzer Anoa 2 6x6 wheelhouse, several recommended improvements are:

1. More Ergonomic Chair Design
 - Adjust the angle of the seat back to support the driver's lower back and shoulders.
 - Use additional padding to reduce pressure on the waist.
2. Control Layout Improvements
 - Moved the control panel to make it easier to reach without the need to change extreme posture.
 - Adjusted the position of the lever and navigation screen to make it more comfortable to use.
3. Modify the Gas and Brake Pedals
 - Optimizes pedal position to suit military soldier anthropometric standards.
 - Added seat suspension system to reduce vibration during riding.

4. CONCLUSION

This research shows that the Panzer Anoa 2 6x6 steering wheel still has several ergonomic problems that can impact driver comfort and effectiveness. Results *Nordic Body Map* identified that the lower back, shoulders and wrists were the areas of the body that experienced the most discomfort. By implementing better ergonomic design, this vehicle can be more optimal in supporting military operations by increasing comfort and reducing the risk of musculoskeletal disorders.

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