

To cite this article: Alran Rony Rinaldho, Erzi Agson Gani and Ade Bagdja (2022). ERGONOMICS IN MILITARY PLATFORM DESIGN: A REVIEW, International Journal of Education and Social Science Research (IJESSR) 5 (1): 362-372

ERGONOMICS IN MILITARY PLATFORM DESIGN: A REVIEW

Alran Rony Rinaldho¹, Erzi Agson Gani² and Ade Bagdja³

¹Postgraduate School, Faculty of Defense Technology, Indonesia Defense University, Jl. Sentul - Citeureup, Sentul, Kec. Citeureup, Bogor, Jawa Barat 16810, Indonesia

^{2,3}Program in Motion Technology Studies, Faculty of Defense Technology, Indonesia Defense University Jl. Sentul - Citeureup, Sentul, Kec. Citeureup, Bogor, Jawa Barat 16810, Indonesia

DOI: <http://dx.doi.org/10.37500/IJESSR.2022.5129>

ABSTRACT

Design is a very important process in the creation of a product, included in a military platform design process. The role of a design and a product designer is very important to determine the right design according to the design requirements and objectives in the field. A product designer must consider various aspects including ergonomics, because ergonomics is a very important and dominant factor in a military platform design to reduce injuries to soldiers. This study examines the role of ergonomics in a military platform design, namely in soldiers' backpacks. From the results of the research that has been done, it is found that the Indonesian military soldiers backpack is currently still not ergonomic because it still uses the Korean military standard size as a production place for the backpack used. Therefore, it is necessary to redesign the backpack that meets the ergonomic aspects of Indonesian army. It was found that the configuration of the Indonesian soldier's backpack that should be used is a backpack that has the 5th percentile with 51 cm for the length of the backpack and 30 cm for backpack width as in the 5A configuration. Or can use the 95th percentile size with 57 cm for backpack length and 39 cm for backpack widths like those in configuration 3B. The maximum load a soldier can carry based on this research is 10% of body weight so that the soldier's posture remains normal and does not cause musculoskeletal injuries or musculoskeletal disorders.

KEYWORDS: Design, Military Platform Design, Ergonomics, Indonesian Soldiers Backpack

1. INTRODUCTION

Design is a very important process in the creation of a product. Because design is a process of translating ideas or market needs into detailed information where a product can be

made. The general definition of design theory based on a study of Best and Phillips is a company strategy to manage design activities and processes [1,2]. In order which is an integral part of the system design to achieve company goals. The implementation of this strategy can be in the form of a design policy [1] or incorporated into a design reference (design brief) [2].

The same is true in the design in the field of military or the so-called military platform design. In a military platform design, a good design process is needed. So that a military platform is obtained that is in accordance with the principles of its design requirements and objectives. Understanding the design of a military platform means understanding the user requirements of the military platform which is an integral part of the system design and is critical to the success of the system. It is now widely understood that successful systems and products begin with an understanding of user needs and requirements. As specified in the ISO 13407 standard [3].

Military systems are very complex in nature. Many aspects of the combat environment are also highly dynamic which adds to its overall complexity. The physical conditions of the environment can range from moderate to extreme in terms of weather, danger, activity, etc. In addition, the number of tasks and task difficulty varies from mission to mission. With so much variation in the working environment, the technologies that are employed during combat must be highly versatile and human factors principles and guidelines must be applied to ensure the safety and effectiveness of the system. This is best achieved when human factors engineering is considered at the beginning stages of product or system development. This ensures that the systems and artifacts implemented will accommodate the human users, and thus enhance the total system performance.

Understanding user needs and military systems that are very complex, which is an integral part of a military platform design, cannot be separated from and is closely related to ergonomics. This is because ergonomics in the design process is a very important and standard aspect. Basically, ergonomics is applied and considered in a planning process as an effort to obtain a harmonious and optimal relationship between product users and the products they will use. This is because Ergonomics (or human factors engineering) is a multidisciplinary science concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance [4].

Therefore, a product designer must understand how to apply ergonomics in every design that will be made. Especially on the military platform, a designer must understand what the needs of the user are and how to interpret the user's needs into a military platform design that is appropriate and meets the ergonomics of the user so as to reduce the risk of injury. Product designers must integrate all information about processes, tools, machines, tasks, and human operators to generate a design that is acceptable to all parties involved. As most important activities are performed by product designer, issues related to human factors/ergonomics (HFE) should be considered in the whole design [5].

2. RESEARCH AND METHOD

In this study, the researcher used a qualitative approach. As stated by Moleong that Qualitative research is research that intends to understand the phenomena of what is experienced by research subjects such as behavior, perception, motivation, action, etc., holistically, and by way of description in the form of

words and language, in a particular context of nature and by making use of various natural methods [6].

Tesch suggests that qualitative research is a type of research whose attention is focused on understanding the meaning of texts or actions, which directs research on observing themes and interpretations [7].

Meanwhile, according to Sugiyono, qualitative research views the object as something dynamic, the result of the construction of thoughts and interpretations of the observed phenomena, and is holistic because every aspect of the object has an inseparable unity [8].

Data collection and Analysis

In this study, we used the type/approach of research in the form of Library Research. Literature study is a study that is used to collect information and data with the help of various materials in the library such as documents, books, magazines, historical stories, etc. [9].

The librarian study contains a systematic study of literature and the results of previous research that are related to the research that will be carried out and endeavored to show the current state of the field of science "the state of the art", a literature study conducted before conducting the research [10]. Meanwhile, according to Sugiyono, library research is a theoretical study, references and other scientific literature related to culture, values and norms that develop in the social situation under study [11].

Literature studies can also study various reference books and the results of previous similar studies that are useful for obtaining a theoretical basis on the problem to be studied [12]. Literature study also means data collection techniques by reviewing books, literature, notes, and various reports related to the problem to be solved [13]. Meanwhile, according to other experts, literature study is a theoretical study, references and other scientific literature related to culture, values and norms that developed in the social situation under study [14].

The data analysis technique used in this research is content analysis method. This analysis is used to obtain valid inferences and can be re-examined based on the context [15]. In this analysis, the process of selecting, comparing, combining and sorting various meanings will be carried out until the relevant ones are found [16].

3. RESULT AND DISCUSSION

3.1 Design

According to Archer, B. & Jones, J.C. the nature of design can be equally compared to the nature of technology both equally complex in their own way [17,18]. Design is skill and knowledge concerned with people's ability to shape their own environment to suit their own material and spiritual needs.

Design can also be summarized as Charles River Media describes it in their book “Visual design fundamentals: A digital approach (3rd edition)” (2009) with seven elements, shapes, lines, negative space, volume, value, color and texture. Design can also be described as: “A plan for arranging elements in such a way as to best accomplish a particular purpose” [19].

The definition of design can be seen from various perspectives and contexts. Design can also be interpreted as an artist's creation to meet certain needs and in certain ways. Design can also be a problem solving with a clear target [20].

Meanwhile, according to Alexander (1963) design is the most objective finding of physical elements. Or design is an act and initiative to change human work [21].

Based on the definition above, it is clear that the design is not merely a design on paper, but also the overall process until the work is realized and has value. Design does not stop at the top, but is a practical activity that includes economic, social, technological and cultural elements in their various dynamics.

3.2 Military Platform Design

Military platform design is a design used to design a military platform, both military support equipment and land, water and air military vehicles. Various experts are involved so that a military platform can actually be produced.

Whole design process of an military platform is presented considering material and structural integration with preliminary studies. Initial design stages while balancing the requirements, suitable materials and technology are detailed. Manufacturing the prototype as final step with performance tests cannot be provided in details since belonged information is commercially confidential and trade marked [22].

3.3 Ergonomics

Ergonomics is a science that discusses all things related to humans and their interactions with work and their environment which aims to improve human comfort, health and safety.

Ergonomics are concerned with the „fit,, between the user, equipment and their environments. It takes account of the users' capabilities and limitations in seeking to ensure that tasks, functions, information and the environment suit each user. To assess the fit between a person and the used technology, ergonomics considers the job (activity) being done and the demands on the user; the equipment used (its size, shape, and how appropriate it is for the task), and the information used (how it is presented, accessed, and changed) [4].

Ergonomics draws on many disciplines in its study of humans and their environments, including anthropometry, biomechanics, mechanical engineering, industrial engineering, industrial design, information design, kinesiology, physiology and psychology.

The foundations of the science of ergonomics appear to have been laid within the context of the culture of Ancient Greece, who, as early as in the 5th century BC used ergonomic principles in the design of their tools, jobs, and workplaces. One outstanding example of this can be found in the description Hippocrates gave of how a surgeon's workplace should be designed and how the tools he uses should be arranged. It is also true that archaeological records of the early Egyptians Dynasties made tools, household equipment, among others that illustrated ergonomic principles [4].

Ergonomics can also be applied to various fields such as physiology, psychology, design, analysis, synthesis, evaluation of work processes, and product design for entrepreneurs, managers, government, military, lecturers, and students [23].

In the past, human factors analysts have had to justify their roles in research and development projects [24]. Currently, human factors research is a major part of many military endeavors. All branches of the US military now have at least one human factors branch. In addition, the US Department of Defense has organized the Human Factors Engineering Technical Advisory Group (HFE-TAG) to identify and address human factors issues in both the military and civilian domains. The following section will discuss some of the efforts in terms of human factors that the US military is currently embarking on. This is intended to be an overview of just some of the human factors issues being addressed by the US military [25].

3.4 Literature Review

The literature review in this study was obtained from the results of previous research by Erlinda et. al. (2018). The research conducted a study on how the ergonomics design of the military backpack for Indonesian national soldiers using virtual environment model [26].

Most of the main military equipment and equipment which is one part of the military platform of the Indonesian Army currently still comes from foreign-made products and follows the design products based on the human body (army) from the country of manufacture. One of them is a military backpack. Military backpack is one of the main equipment that must be carried by every soldier of the Indonesian army as a means to carry equipment to support military training or military operations for war or non-war. Until now, the Indonesian Army still uses Korean military backpack designed for Korean army posture.

Based on the data obtained from the pre-research questionnaire conducted with a total of 45 respondents from the army, aged 20-35 years, it is known that 51% of soldiers feel uncomfortable and as as much as 20% are very uncomfortable when using a backpack. Then it is known that 40% of

respondents lifting military backpacks with loads more than 21% of their body weight and as much as 64.44% respondents use a backpack when exercising with a duration of more than 75 minutes, while carrying backpacks with a load of 10% body weight for 30 minutes can cause spinal cord injury [27]. The data needed for this research can be divided into two types of data, namely data on army complaints when using military backpacks and soldier anthropometric data to be used to design ergonomic military backpacks. the two data obtained by distributing questionnaires by sampling to the Army of the Republic of Indonesia with a total of 100 male respondents aged between 20-35 years.

The data are collected directly in the army Dislitbang Jakarta by using the antropometer. The measures taken in the process of collecting anthropometry data are:

- a) Height & Weight (1)
- b) Sitting Shoulder Height (10)
- c) Shoulder Elbow Length (15)
- d) Chest depth (22)
- e) Abdominal Depth (23)
- f) Shoulder Breadth (Biacromial) (26)
- g) Shoulder Breadth (Bideltroid) (27)
- h) Hip Breadth (28)

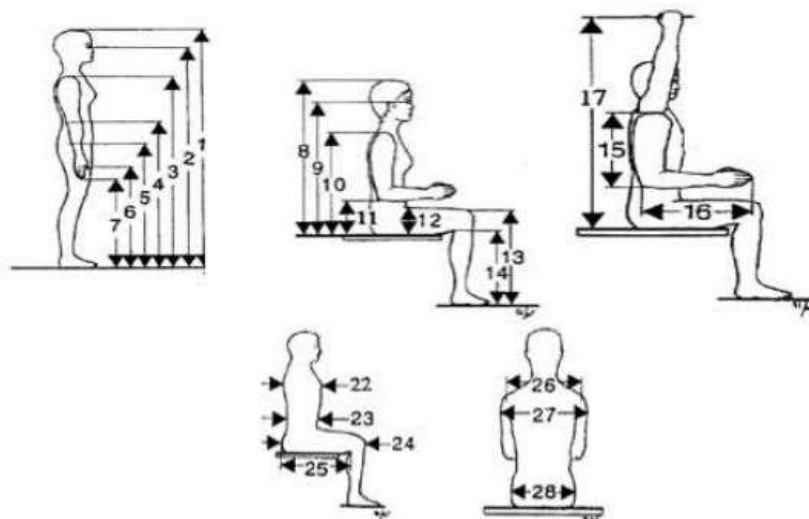


Fig 3.1 Body Part Measured in Process Data Collection Source. Erlinda, et.al. 2018

Then for data processing is done with the help of using software Jack 6.1. Through this software, it will analyze the actual posture of military personnel when carrying a backpack before the configuration and posture analysis of the reconstruction and configuration of the backpack in a virtual environment is carried out using three analyzes toolkits provided by the software are Low Back Analysis, Ovako

Working Posture Analysis, and Rapid Upper Limb Evaluation which will determine the value of PEI (Posture Evaluation Index).

In this research, there will be research scenario or configuration, the configuration of this research is based on the length and width of a military backpack. By Chris Adams, the size of the bag should be adjusted to the size of the soldiers back waist width and height of the back. Maximum size for the length of a backpack is a high back plus 5 cm, while the maximum size for a backpack width is the width of the waist plus 5 cm. Dimensions designs of backpack is based on the ergonomics reference length ideal backpack which is a measure of the shoulder to the waist or if taken from anthropometry data will be equal to the height of the back (sitting shoulder height), while the width dimension backpack design is based on ergonomics that reference backpack ideal width is the size of the waist that is equal to the width of the waist (hip breadth, sitting). Based on backpack ergonomic references by Chris Adams, the concluded configuration research as follows [28]:

Table 3.1 Configuration of Dimensions and Weight of Military Backpack

No	Configuration	Percentile	Length (cm)	Width (cm)	Backpack Weight	
					(%)	Body Weight)
1	1A	5%	58 (Actual)	44 (Actual)	≤ 10%	10% - 15%
					≥ 15%	
	1B	95%	58 (Actual)	44 (Actual)	≤ 10%	10% - 15%
					≥ 15%	
2	2A	5%	46 (+ 0)	25 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
	2B	95%	57 (+ 0)	34 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
3	3A	5%	46 (+ 0)	30 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
	3B	95%	57 (+ 0)	39 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
4	4A	5%	51 (+ 5)	25 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
	4B	95%	52 (- 5)	34 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
5	5A	5%	51 (+ 5)	30 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	
	5B	95%	52 (- 5)	39 (+ 0)	≤ 10%	10% - 15%
					≥ 15%	

Source. Erlinda, et.al. 2018

3.5 Discussion

1. Comparison of PEI 5th percentile

The value of PEI for soldier's backpack will be compared in actual and predefined configuration conditions before with each load carried by the soldier ($\leq 10\%$ of body weight, between $10\% - 15\%$ of body weight, and $> 15\%$ of body weight).

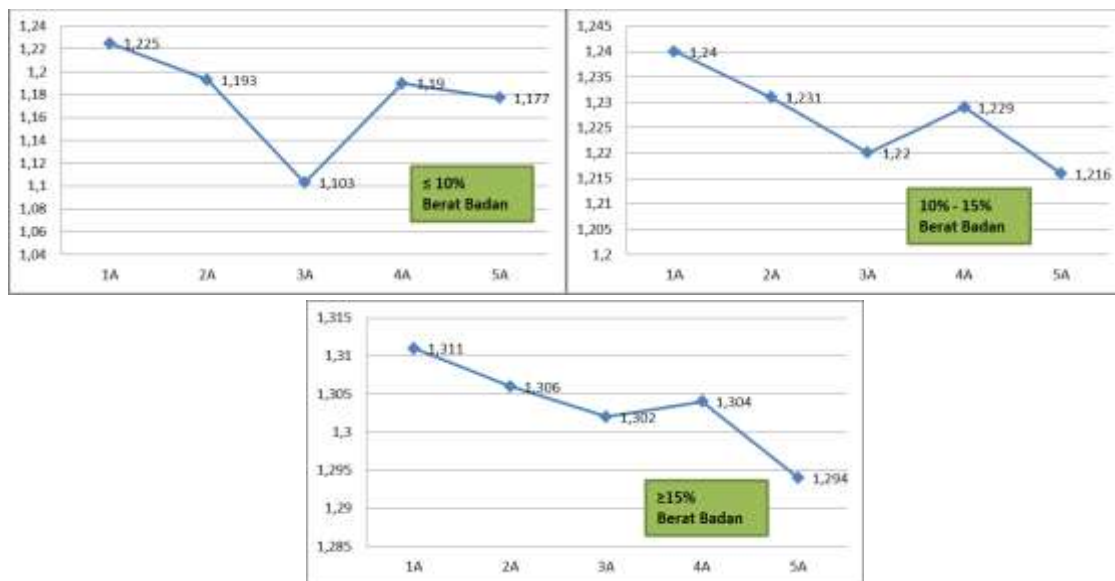


Fig 3.2 Comparison of Actual Results and Recommendations PEI Value 5th percentile Source. Erlinda, et.al. 2018

Based on the figure above, the configuration that gives the best PEI value for all loads is the 5A configuration, where this 5A configuration produces the lowest PEI value. This PEI value is obtained from the sum of the 3 analysis toolkits used, namely Low Back Analysis, Ovako Working Posture Analysis, and Rapid Upper Limb Evaluation. Therefore, the backpacks used by the Indonesian Army should be changed in size by changing the length of the backpack to the length of the soldier's back with an additional 5 cm and the width of the bag into as wide as the width of the soldier's waist with an additional 5 cm [26].

2. Comparison of PEI 95th Percentile

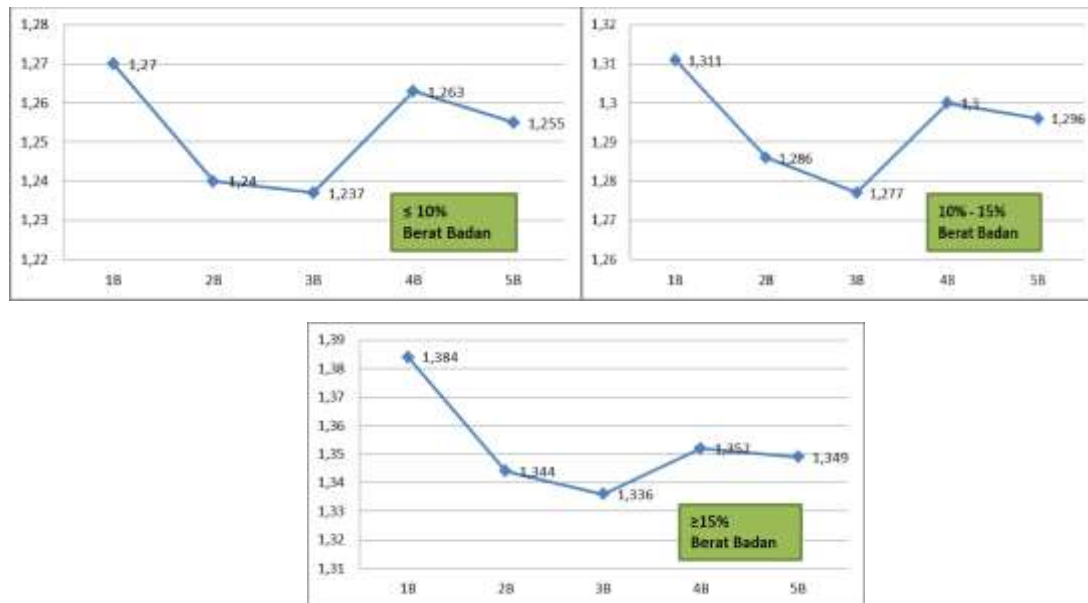


Fig 3.3 Comparison of Actual Results and Recommendations PEI Value 95th Percentile
Source. Erlinda, et.al. 2018

Based on the figure above, the configuration that gives the best PEI value for all loads is the 3B configuration, where this 3B configuration produces the lowest PEI value. Therefore, the backpacks used by the Indonesian Army should be changed in size by changing the length from the bag to be as long as the soldier's back and the width of the bag to be as wide the width of the soldier's waist with an additional 5 cm.

4. CONCLUSION

- a. The relationship between a design and the concept of ergonomics is very close, because the design before being marketed should first be carried out a study/evaluation/test that concerns one of the ergonomic aspects of the product.
- b. Even in a military platform design, it is very important that there is a harmony between people and the technology they use. Human factors engineering in this case military soldiers, also known as human machine systems engineering, is the most common instrument for developing this necessary harmony due in critical products, especially on military platform designs, ergonomics plays a very dominant role. This is an effort to minimize errors and injuries caused by humans as users in this case are military soldiers.
- c. Because ergonomics is one of the requirements to achieve a design that is qualified, certified, and in accordance with customer needs.
- d. Based on the results of the analysis of the optimum PEI value generated for each change made to the configuration of military backpacks, it was found that the best size that should be used to design backpacks for Indonesian army personnel is a backpack that has the 5th percentile with 51 cm for the length of the backpack and 30 cm for backpack width as in the 5A

configuration. Or can use the 95th percentile size with 57 cm for backpack length and 39 cm for backpack widths like those in configuration 3B. The maximum load a soldier can carry based on this research is 10% of body weight so that the soldier's posture remains normal and does not cause musculoskeletal injuries or musculoskeletal disorders.

REFERENCES

1. Best, Kathryn. (2006). *Design Management: Managing Design Strategy, Process and Implementation*. Britania Raya: AVA Publishing
2. Phillips, Peter L. (2004). *Creating the perfect design brief: How to manage design for strategic advantage*. Amerika Serikat: Allworth Press.
3. International Organization for Standardization. (1999). *ISO 13407: 1999 Human Centered Design Process for Interactive Systems*. Switzerland: International Organization for Standardization.
4. Mukhopadhyay, Suman., Sanjib Kumar Das, Tania Chakraborty. (2012). *Computer Aided Design in Digital Human Modeling for Human Computer Interaction in Ergonomic Assessment: A Review*. International Journal of Advanced Computer Research (ISSN) (print): 2249-7277 ISSN (online): 2277-7970, Volume-2 Number-4 Issue-6 December-2012.
5. Robert. F., Yili, L., Donn. C., Glenn. J., Brad. J. (2000). *Computer- Aided Ergonomics: A Case Study of Incorporating Ergonomics Analyses into Workplace Design*. Appl. Ergon. 31, 291-300
6. Moleong, Lexy J. (2016). *Metodologi Penelitian Kualitatif*, Bandung: Remaja Rosdakarya.
7. Rohendi Rohidi, Tjeptjep. (2011). *Metode Penelitian Seni*. Semarang: Cipta Prima Nusantara Semarang.
8. Sugiyono. (2015). *Metode Penelitian Kombinasi (Mix Methods)*. Bandung: Alfabeta.
9. Mardalis. (1999). *Metode Penelitian Suatu Pendekatan Proposal*. Jakarta: Bumi Aksara.
10. Setiawan, "Studi Kepustakaan adalah: Tujuan, Sumber, Metode dan Jenis," guru pendidikan, Sep. 10, 2020. <https://www.gurupendidikan.co.id/studi-kepustakaan/#ftocheading-1> (accessed Jan. 26, 2021).
11. M. Sari, "Penelitian Kepustakaan (Library Research) dalam Penelitian Pendidikan IPA," Nat. Sci. J. Penelit. Bid. IPA dan Pendidik. IPA, vol. 6, no. 1, pp. 41–53, 2020, [Online]. Available: <https://ejournal.uinib.ac.id/jurnal/index.php/naturalscience/article/view/1555/1159>.
12. Jonathan, Sarwono. (2006). *Metode Penelitian Kuantitatif dan Kualitatif*. Yogyakarta: Graha Ilmu
13. Nazir. (1988). *Metode Penelitian*. Jakarta: Ghalia Indonesia.
14. Sugiyono. (2012). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfabeta
15. Krippendorff, Klaus. (1933). *Analisis Isi: Pengantar Teori dan Metodologi*, Rajawali Pers, Jakarta.
16. Serbaguna. (2005). *Dalam Pusat Penelitian dan Pengabdian Masyarakat Poltekkes Tanjungkarang. Penyusunan Karya Tulis Ilmiah Penelitian Literatur (Library Research)*. Politeknik Kesehatan Tanjungkarang.

17. Archer, L. B. (1981). A View of the Nature of the Design Research. In R. Jacques, & J. A. Powell: Design:Science:Method. (pp. 30-47). Guilford, Surrey: IPC Business Press Ltd.
18. Jones, J. C. (1977). How My Thoughts About Design Methods Have Changed During the Years. Design Methods and Theories, 11(1), 50-62.
19. Eastman, C. (1970). On the Analysis of Intuitive Design Process. Cambridge, MA: MIT Press.
20. Archer, Leonard Bruce. (1965). Systematic Method for Designers. Council of Industrial Design, London
21. Jones, J Arthur. 1970. Principles of Guidance. New Delhi: Tata McGraww-Hill Publishing Company LTD.
22. Alankaya, V. (2015). Success Story of Armored Multitask Vehicle Design “New Combatant on Terrain: GEKKO”, Journal of Military and Information Science, Vol3(1), 17-23.
23. Nurmianto, E. (2008). Ergonomi Konsep Dasar dan Aplikasinya. Surabaya: Guna Widya.
24. Price, M. A., S. D Jones., G. W. Mathison and R. T. Berg. (1980). The effect of increasing dietary roughage and slaughter weight on the feedlot performance and carcass characteristics of bull and steer. J.sci.60: 349 –358.
25. Handbook of military industrial engineering / editors, Adedeji B. Badiru, Marlin U. Thomas. CRC Press is an imprint of Taylor & Francis Group, an Informa business. © 2009 by Taylor & Francis Group, LLC
26. Muslim, Erlinda., Boy Nurtjahyo Moch, Bagus Anugrah Ramadhan, Muhammad Rasyad, dan Pito Ananda Risyah. (2018). The ergonomics design of the military backpack for Indonesian national soldier using virtual environment model. IOP Conference Series: Materials Science and Engineering 508 (2019) 012108.
27. Chow, Daniel Hung-Kay., et al. (2010). Carry-over effects of backpack carriage on trunk posture and repositioning ability. International Journal of Industrial Ergonomics, 41 (2011). pp. 530- 535.
28. Caputo, F., Di Gironimo G., Marzano, A. (2006). Ergonomics Optimization of a Manufacturing System Work Cell in a Virtual environment. Acta Polytechnica Vol.46 No.5/2006.