Designing Passengers Cabin Of Carrier Vehicles Of 6x6 Armour Personnel With Principles Of Ergonomic

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Abstract. Anoa is one of the primary weaponry defense system of Republic of Indonesia, however the original design Anoa adapted from a similar vehicle from France, whose inhabitants have a different body postures from Indonesian people. This research is aimed to find out whether the Anoa design is ergonomic for Indonesian Army. The research was formed with review the shoter cockpit and passenger cabin at Anoa Panser 2 and then redesign according to percentil 5% & 95% of Indonesian Army personnel anthropometric. In addition to accordingly fitting to personnel anthropometric, improvement also formed based on personnel complaint through Nordic questionnaire. The questionnaire result was processed using QFD method to find out improvement needs that should be prioritized. Based on QFD analysis, improvement that should be prioritized are comfortable seating, appropriate and comfortable doors, safe shooting position, seating for shooter. The next is the design result was simulated using Software Jack to get the value LBA, OWAS, and RULA which used to search the value of PEI of existing and improved design then compare them. According to compared result of PEI value is known that after adjusting the anthropometric size of Indonesia Army the value of PEI becomes smaller.

1. Introduction

The Master Plan for the Acceleration and Expansion of Indonesia's Economic Development (MP3EI) constitute the first step to push Indonesia entered into the world's top ten countries by 2025 through high, inclusive and sustainable economic growth level. One of the accelerating rides of economic growth that mentioned in MP3EI is the defense industry with the target of achieving self-sufficiency products and defense industry systems.

The defense industry in Indonesia was developed by State-Owned Enterprises (SOEs) as the main producer supported by several subsidiaries and other SOEs as raw material suppliers. This industry has been able to design and make by own several primary weaponry as a superior product, among other special vehicles in the form of a panzer.

Associate with the design of products to suit the needs of the market, should consider also ergonomic factors moreover if the product is use in a long time span and in an emergency conditions. Ergonomics is a discipline related to the interaction between humans and other elements in a system. This discipline is responsible for the design and evaluation of jobs, products, environments and systems to fit human capabilities, needs and human limitations. The appropriate use of ergonomics in the design will improve welfare, health, comfort and security (Pheasant, 1998 in Widyanti, 2012) which is indispensable in product design.

To implement the principle of ergonomics in the design of combat vehicles, the collection of user anthropology data in this case The Indonesian National Armed Forces and Indonesian National Police personnel is indispensable. The anthropometric data will be use so that design the combat vehicle products according to the conditions, capabilities and limitations of The Indonesian National Armed Forces and Indonesian National Police personnel so they will be comfortable, effective and efficient using them. However, so far the availability of anthropology database of The Indonesian National Armed Forces and Indonesian National Police is still very limited. As far as the researcher's knowledge, has not been existence found database of anthropometry of The Indonesian National Armed Forces and Indonesian National Police when looking for in cyberspace. The creation of
anthropometry databases will not only be use for the design of combat vehicles, but also for other combat equipment.

2. Method and materials

2.1 Sample preparation

Data collection showing the data collected from direct observation in the field and data documentation provided by a related enterprise, among others form:

2.1.1 Indonesian National Armed Forces Anthropometry Data

Anthropometry data collection who conducted as much as 38 dimensions of the body of the Indonesian Army members amount 125 people. A research conducted on 20 June 2016 was conducted at Battalion 203 Kemuning Area Tangerang on 21 June 2016 conducted at Battalion 202 Tajimalela Bekasi on 23 and 27 June 2016 conducted at Ergonomic Center Indonesia University with measurements who conducted on members of Battalion 201 and Brigif I and on July 25 to July 28, 2017 have been done in Kikav 2 located in Sleman.

2.1.2 Anoa Panzer Design Data

The data is an initial design of three-dimensional Anoa Panzer that will be using as a writer reference in manufacture design Anoa panzer based ergonomic.

2.1.3 Documentation of Anoa Panzer Conditions

The documentation in the form of picture of the actual condition of Panser Anoa. As for data that has been collected will be doing data processing in the following way:

2.2 Method

2.2.1 Pre-Processing Data

a. Data Normality Test

The data normality test was intended to show that the sample was derived from a population data of anthropometric dimensions of the Indonesian National Armed Forces body that is normally distribute. Data processing was formed by using SPSS software.

b. Data Uniformity Test

From the results of uniform data processing aim to prove the data is at the lower limit and upper limit from every dimension of anthropometry. Processing was formed with Minitab Software. Where it was formed iteration 2 times, before the data is finally declared uniform.

c. Data Adequacy Test

The data adequacy test is need to determine whether the amount of data was taken enough. Test data adequacy processed manually by comparing the results of N' with N. If N'> N then the data is declare not enough. To get the value of N' calculation with by using microsoft excel.

2.2.2. Questionnaire

a. Nordic Questionnaire

The nordic questionnaire constitute a specially craft questionnaire to find out if any complaints or pain are feel by members in some body parts. There are 28 types of complaints and 4 parameters to measure the level of complaints that is not sick (A), a bit sick (B), sick (C) and very sick (D).

b. Passenger and shooter perception Questionnaire level on Passenger Cabin, Cockpit Shooter Operator. The questionnaire contains 15 points on the passenger cabin, six points on the operator's cockpit, and 20 points on the rider's cockpit which in it states the types of ergonomics when located in these three conditions, the types of ergonomics will be assess based on the level of importance and level of satisfaction on the actual conditions. It is then attach to the propose improvements filled by Inodenesian National Armed Forces personnel to fix the user's comfort within APCA Anoa.
2.2.3 Making QFD (Quality Function Deployment)
The matrix diagram of QFD was made to connect the customer's desire (customer requirement) by realizing the customer's desire (technical requirement). In addition QFD also helps to show the technical requirement that must be considered to achieve the desired goal. Then after the matrix diagram QFD created, the next step is to create a table of customer requirements vs technical requirements that function to analyze the results of the QFD matrix.

2.2.4 APC Existing Condition Simulation (Software Tecnomatix Jack 8.4)
a Making Virtual Human Modeling (Manikin)
Making virtual human modeling based on percentile data 5% and 95% of anthropometry of Indonesian Army personnel is collected. This was collected so that the virtual human will be simulate in Jack software will presenting the state of actual condition at the lowest and highest percentage of the body so that the analysis of the influence of the Panzer design on the performance of the personnel of Indonesian Army. Along with risk of musculoskeletal disorder in personnel could be formed accurately performed on the condition of Indonesian National Armed Force personnel sitting in the passenger cabin, firing position inside and outside the cabin.

b Analyze Virtual Human Model Performance
In analyzing the effect of posture shooting and sitting on the body, especially the upper body, used some tools available in the Task Analysis Toolkit (TAT) contained in software Jack 8.4. Tools use to analyze the performance of human models in this study amounted to four pieces of tools. Four tools are as follows:
1) Static Strength Prediction (SSP)
2) Low Back Analysis (LBA)
3) Ovako Working Posture Analysis System (OWAS)
4) Rapid Upper Limb Assessment (RULA)

3. Results and discussion
3.1.1 Result

Statistical Test Analysis and Descriptive Statistics Calculation
From the results of preprocessing data preprocessing is known that 125 samples tested all valid, no missing data and garbage. This result also applies across the measured body dimensions. The statistical analysis were conducted and the results is that data are normal, homogeneous and sufficient. The descriptive statistics as mean, standard deviation, percentile were calculated then.

QFD Analysis
From the result of matriks diagram QFD can be known that the value of weight / importance that has the greatest value of the technical requirements of ergonomics of 389.4 with the value of customer requirements in a comfortable seat, the appropriate door and comfortable, comfortable steering wheel safe shooting positions, seating for shooters, enough vision space, and ample space and relative weight of 33.3. It shows that in improving the design of APC tanks, research should pay more attention to ergonomic points. As for the value of weight / importance is lowest on the points of addition of space in the engine room in order to provide spare parts with a value of 38.3 and relative weight of 3.3. That means, the addition of space in the engine space isn’t too influential on the achievement of the desired research objectives.

Design proposal analysis
The design process of APC's proposed APOS "Anoa" design was made through consideration of the application of anthropometric concepts, QFD analysis results, standards set by the Directorate of
Standardization, The Ministry of Defense Agency, and various related liaison of Human Factor, Driving and Safety:

a. Passenger seating design

Dimensions of passenger seating dimensions are as follows:
1) Holder : Space Display Personnel Space x popliteal bottom 5% : 230 cm x 40 cm
2) Backrest: Space Display Personnel Space x shoulder height sitting 95%: 230 cm x 63,65 cm
3) Holder Height : popliteal height 5% until 95% : 42,04 s/d 50,86 cm (adjusable)
4) Thickness of Cushion : 7,5 cm

Figure 1. Dimensions of passenger seating size

Figure 2. Passenger seat design, shooting position and folded

Full seat holder bearings recomended have a slope of about 4° - 6° horizontally to prevent the bottom of personnel slipping forward, the backrest is make as high as back of the seat can be fold into a half-set with the slope of the backrest recomended between the angle of 105° - 110°, the holder and headrests are make to be fold into the back of the chair to save space is being require when unnecessary. To support the shooting process in the passenger cabin, seat holder were designed to be ajustable back and forth with a lock so that the seat can be used in 2 positions that is face to face position and backs together so that personnel can condition the seat position according to the field being faced.

b. The driver's door

The door is capable to be opened and closed and manually locked by personnel from inside and outside. The driver's door design improvements were designed like a ladder with a vertical position down when opened. The door design is designed like a mini plane door. Such a placement can be say quite ergonomic because it can optimize the reach of personnel foot when entering the APC Panzer steering room. ((upright high sitting 95% + knee height 95%)) x elbow to elbow range = (94.3 + 58.5) x 95 cm)).
c. Window position and shooting hole

Window position improvement and shooting hole according with anthropometric posture of TNI-AD personnel that can be closed. Elevated place of window position according with height eyes sitting 50% (76 cm) with broad according to eye view range capable from personnel anthropometric. Shooting hole position according with shoulder height sitting personnel using percentile 5% (54.9 cm).

![Figure 3. Window position shooting hole](image)

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d. Shooter Station

Design improvement of shooter station designed as in form dome who can spinning 360° bulletproof windows which installed with a shot so the shooter can more safety and be spared from enemy shoot target.

![Figure 4. Shooter station design improvement](image)

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**Design Analysis Using Human Simulation Software Jack 8.4**

Based on result human simulation using Jack Task Analysis Toolkit can it can be concluded that the improvement of the design configuration on the personal space and firing station is able to lower the level of exposure received at the body and can categorized as ergonomic because PEI value is close with number 1 so Indonesian National Armed Forces personnel can be spared from WMSDs risk. Here is a comparison of the recapitulation of the actual design ergonomic assessment and design of the proposal.

| No | Posture | PE1 | LE1 | OWAS | EUL1 | PE1 |
|----|---------|-----|-----|-------|------|-----|
| 1  | Forehead Strain (eye strain) | 5   | 3   | 1     | 5    | 1/41 |
|    |         | 95  | 10  | 1     | 2    | 1/21 |
| 2  | Forehead Strain (eye strain) | 5   | 3   | 1     | 4    | 1/21 |
|    |         | 95  | 10  | 1     | 4    | 1/21 |
| 3  | Forehead Strain (eye strain) | 5   | 3   | 1     | 2    | 1/21 |
|    |         | 95  | 10  | 1     | 2    | 1/21 |

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**Table 1. Design ergonomic assessment and design of the proposal**

| No | Posture | PE1 | LE1 | OWAS | EUL1 | PE1 |
|----|---------|-----|-----|-------|------|-----|
| 1  | Forehead Strain (eye strain) | 5   | 3   | 1     | 5    | 1/41 |
|    |         | 95  | 10  | 1     | 2    | 1/21 |
| 2  | Forehead Strain (eye strain) | 5   | 3   | 1     | 4    | 1/21 |
|    |         | 95  | 10  | 1     | 4    | 1/21 |
| 3  | Forehead Strain (eye strain) | 5   | 3   | 1     | 2    | 1/21 |
|    |         | 95  | 10  | 1     | 2    | 1/21 |
4. Conclusion

From the works, we can conclude as below:

a. From statistical data processing, the data overall obtained uniform and sufficient. There are some data falling outside the upper/lower limits of data uniformity, but because the data is indeed data belonging to Indonesian National Armed Forces personnel, then we keep put it.

b. Customer voice for design in the QFD method was obtained from both the Nordic questionnaire, the perception questionnaire of importance and the satisfaction of TNI personnel towards Anoa panser and their suggestions. Customer voice includes comfortable seating, safe shooting place, ample space, small vibration and shock and others that can look in matrik house of quality QFD.

c. Current condition, sitting position in passenger cabin has a value RULA, LBA, and PEI who need improvement.

d. The proposed proposals are to the seating design in the passenger cabin by adjusting to the Indonesian National Armed Forces anthropometric size and designed so when firing positions in the cab, personnel do not turn their backs on to the firing holes. In addition it proposed an additional protector for the shooter who fired from the firing room, the front door make it easy when up and down the position of the shooter in firing space.

As our suggestion is should to increase cooperation with the Indonesian National Armed Forces in a higher level so taking data more comprehensive and can be taken the advantage by Indonesian National Armed Forces. thereby, cooperation with the producer may be conducted primarily on the use of anthropometry databases as a consideration in the design process of the company.

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