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Redesign of Transjakarta Bus Driver's Cabin

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Abstract. Ergonomic risk at work stations with type Seated Work Control was one of the problems faced by Transjakarta bus driver. Currently "Trisakti" type bus, one type of bus that is used by Transjakarta in corridor 9, serving route Pinang Ranti – Pluit, gained many complaints from drivers. From the results of Nordic Body Map questionnaires given to 30 drivers, it was known that drivers feel pain in the neck, arms, hips, and buttocks. Allegedly this was due to the seat position and the button/panel bus has a considerable distance range (1 meter) to be achieved by drivers. In addition, preliminary results of the questionnaire using Workstation Checklist identified their complaints about uncomfortable cushion, driver's seat backrest, and the exact position of the AC is above the driver head. To reduce the risk level of ergonomics, then did research to design the cabin by using a generic approach to designing products. The risk analysis driver posture before the design was done by using Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA), and Quick Exposure Checklist (QEC), while the calculation of the moment the body is done by using software Mannequin Pro V10.2. Furthermore, the design of generic products was done through the stages: need metric-matrix, house of quality, anthropometric data collection, classification tree concept, concept screening, scoring concept, design and manufacture of products in the form of two-dimensional. While the design after design risk analysis driver posture was done by using RULA, REBA, and calculation of moments body as well as the design visualized using software 3DMax. From the results of analysis before the draft design improvements cabin RULA obtained scores of 6, REBA 9, and the result amounted to 57.38% QEC and moment forces on the back is 247.3 LbF.inch and on the right hip is 72.9 LbF.in. While the results of the proposed improvements cabin design RULA obtained scores of 3, REBA 4, and the moment of force on the back is 90.3 LbF.in and on the right hip is 70.6 LbF.in. This indicated improvement cabin design can reduce ergonomic risk with lower scores on several parts of the body.

1. Introduction

Transjakarta Busway was first operated on January 15, 2004 and was the flagship program of the Government of Jakarta to the development of bus-based public transport. Transjakarta Busway was a pioneer of public transport reforms that prioritize the comfort, security, safety and affordability for the city communities. Transjakarta Busway consortium operated 12 corridors of routes. Corridor 9 was serving Pinang Ranti - Pluit and Pusat Grosir Cililitan - Grogol 2 route. It started the operation on December 31, 2010. Operator of this corridor was PT. Bianglala Metropolitan (BMP) and PT. Trans Mayapada Busway (TMB). This research focused on the buses of PT. TMB that operate route Pinang Ranti - Pluit. The route length of Pinang Ranti - Pluit route is 28.8 km, and has 29 number of shelter stops. Transjakarta bus operation since 05.00 until 22.00 pm.

Safitri et.al (2015) mentioned that According to Indonesian National Committee on Transportation Accidents (NCTA), 73% of transportation accident was caused by human error. Transjakarta Busway is a bus rapid transit service in Jakarta, Indonesia operated by the consortiums of PT. Transjakarta Busway. According to Swaen (2002), there were evidence that both fatigue and need for recovery are independent risk factor for being injured and occupational accident. Mozafari (2014) found that Work-related musculoskeletal disorders (WMSDs) are common among drivers and official workers. Musculoskeletal disorders are frequent causes of absenteeism in many countries.

Driver comfort can be determined by several things that exist, such as the position of the hand flexibility, free legs, sitting posture and seating comfort. The four things that will determine the durability driver in work and will that will determine the cause operator fatigue. (Azmi, et.al, 2013). Conformity between work stations with driver is one of the important factors that could affect work productivity and the level of health risk to workers. With a long operation time, many complained of discomfort from driver due to bus cabin design. Driver were sitting for long periods in one position of the workplace by using equipment such as steering, levers, accelerator and brake pedals, and panels can be classified as work-seated control work and had the risk of physical strain due to the time control of work. They also often did bending or twisting to get a better view in driving. Azmi et.al (2014) stated that based on energy expenditure, the job of Transjakarta bus drivers in corridor 2 and 3 can be classified as moderate work and heavy work. This study is one of the solutions to reduce the physical workload of the driver and reduces human error in the operation of Transjakarta Bus ini corridor 9.

From preliminary research by interviewing driver, it was concluded that the bus type of Trisakti has a cabin design that is uncomfortable. Analysis using Ergonomic Workstation Checklist concluded that the main factor of the uncomfortable design was due to the reach distance range (1 meter) between the seats with a panel operation of the bus. It also complained that not ergonomic seat design it was not adjustable, setting forward the resignation seat and position above the right air conditioner driver head so that it can interfere with concentration work. Givi (2014) explained that the error rate begins to increase as a consequence of fatigue.

Workstation Checklist results showed that the main causes of the bad cabin design is the far-reaching distance between the driver seat with panel operation of the bus which is about 1 meter so as to make driver back pain because often bent to reach the dashboard panels. It also complained the uncomfortable seat and the position of air-conditioning just above the head driver so that can distract the driver's concentration during driving. Shoulder pain was reported by the respondents because there were no arm rest.

Viikari-Juntura (2015) stated that work modification was considered as an essential element in enhancing return to work among persons with musculoskeletal problems. Therefore, it was necessary to improve the cabin design of Transjakarta bus using an ergonomic approach. The aim of this study was to analyze the ergonomics risks of cabin design Transjakarta in corridor 9, to design and propose improvements of Transjakarta bus cabin in the form of 3-dimensional models, and evaluate cabin design with biomechanical approach. The working position of Transjakarta bus driver is shown below in figure 1.

Fig. 1. Working Position of Transjakarta Bus

2. Methods

Rapid Upper Limb Assessment and Rapid Entire Body Assessment has been used to asses the risk level of the working position of Transjakarta driver. McAtamney and Corlett in Stanton, (2005)

stated that Rapid upper-limb assessment (RULA) provides an easily calculated rating of musculoskeletal loads in tasks where people have a risk of neck and upper-limb loading. The tool provides a single score as a "snapshot" of the task, which is a rating of the posture, force, and movement required. While Hignett and McAtamney in Stanton, (2005) said that Rapid entire body assessment (REBA) was developed to assess the type of unpredictable working postures found in health-care and other service industries. Data are collected about the body posture, forces used, type of movement or action, repetition, and coupling. The measurement of driver working position showed that the angle of the upper arm was 100°, the forearm was at 30°, the wrist was 20°, the neck was 130 °, the angle between the buttocks to the knee by 145°. It can be seen on Fig 1 that the back should be very bent to reach the button panel located on the left side of the driver. RULA score was 6 which means it needs further investigation and repair immediately (further investigation and change soon) while REBA score was 9, which means there is a high risk, need further investigation and apply the changes (high risk, investigation and implement change).

QEC questionnaire was given to all driver in corridor 9 and also to observers who see working posture of the operator. Li and Buckle in Stanton, (2005) stated that the quick exposure checklist (QEC) quickly assessed the exposure to risks for work-related musculoskeletal disorders (WMSDs). The calculation of exposure level was 57.38%, which was in the range of 50% - 69%. This showed the need to study further the holding and carried out a change in cabin Transjakarta.

Identification complaints of discomfort on the part of the driver's body was conducted using questionnaires Nordic Body Map. Nordic Body Map questionnaires was given to 30 Transjakarta bus drivers at corridor 9. Respondents identified the uncomfortable in their neck, arm, wrist, back, hips, and buttocks. From further analysis using causal diagram, it was known that the cause of the uncomfortable posture on Transjakarta drivers was caused by management factors , human (driver), machinery, and working methods. Evaluation using software Mannequin Pro V10.2 was done to get the calculation of body styles moments of driver at work. The calculation was done to determine the moment of force of body part while maintaining the position of work. The greatest body moment value was considered for the improvement.

From the calculation of the moment of force on Mannequin Software Pro V10.2, it was known that the greatest moments was on lower back or spine. Rated torque on the lower back (spine) at 247.3 LbF.in. The value of moment of force on the back of the body was due to the position of the back bent at the time wanted to hold a panel button or reach far enough. This bent position causes the weight is concentrated on the back. In addition to the back, the moment of the right hip (right thigh) is also quite large. Rated torque on the style in the right thigh by 72.9 LbF.in, this was because the right foot which controls the gas pedal and brake, so that the position of the ankle always bent upward. Figure 2 shows the existing driver cabin of Transjakarta Bus.

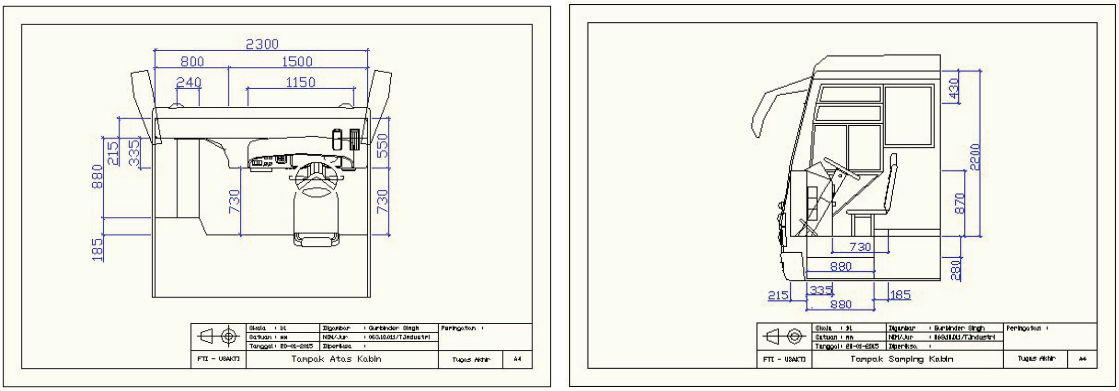

Fig 2. The Existing Driver Cabin of Transjakarta Bus Top View (left) and Side View (right)

3. Result

The product design in this research was done through the stages: need metric-matrix, house of quality, anthropometric data collection, classification tree concept, concept screening, scoring concept, design and manufacture of products in the form of two-dimensional. Identification needs was done by interviewing 30 Transjakarta bus' drivers in corridor 9.

Moldovan (2013) mentioned that QFD is methods that allows the quality design through quality characteristics identified as customer translation in product development. By defining relationships appropriately, products and processes could be developed in accordance with the desire of consumers. House of Quality is a technique of defining the relationship between the desires of consumers to the attributes of the goods or services are graphic used in the Quality Function Deployment (QFD) developed. Need Metric-Matrix is a key element in the HOQ. Based HOQ, the selected concepts was applied in the design concept. They were high chair cabin, length and width of the cabin, the cabin seat width and length of the cabin seats. Anthropometric data were used to determinate the specification and the dimension of the design. Figure 3,4, and 5 below shows the proposed concept of Transjakarta bus driver cabin.

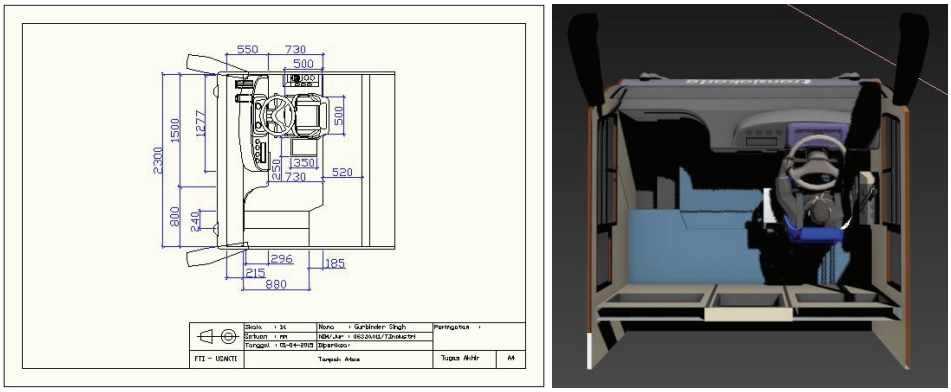

Fig 3. Proposed Driver Cabin Design (top view)

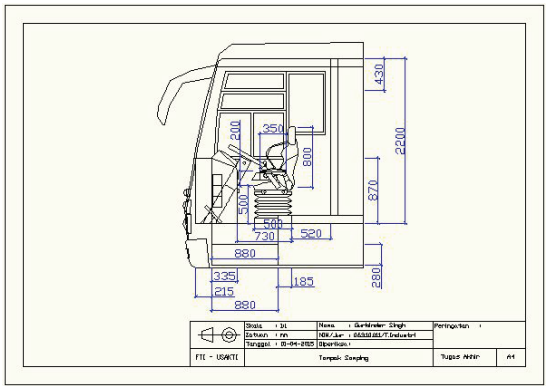

Fig 4. Proposed Driver Cabin Design (side view)

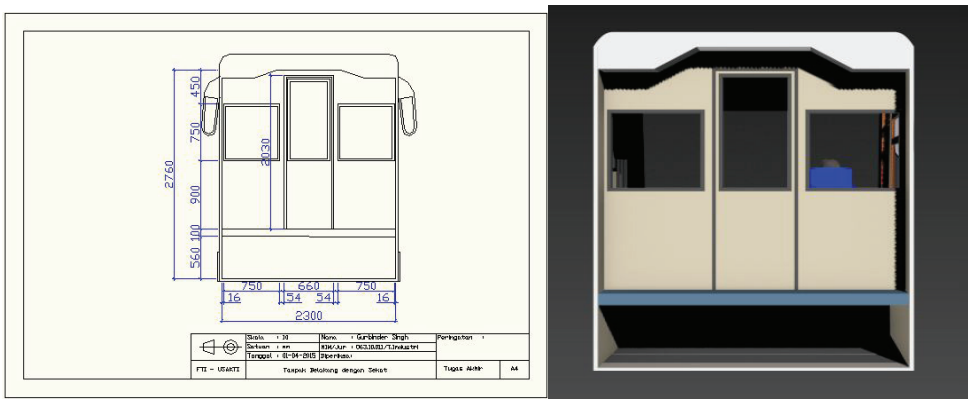

Fig 5. Proposed Driver Cabin Design (back view)

There were a partition between drivers and passenger cabin in the new design and also the adjustable seat. The dashboard panels was set within the driver optimal reach in the right side of cabin. The driver could monitor the passenger cabin through the screen and glass partitions. Then the driver will feel comfortable working conditions and ergonomics.

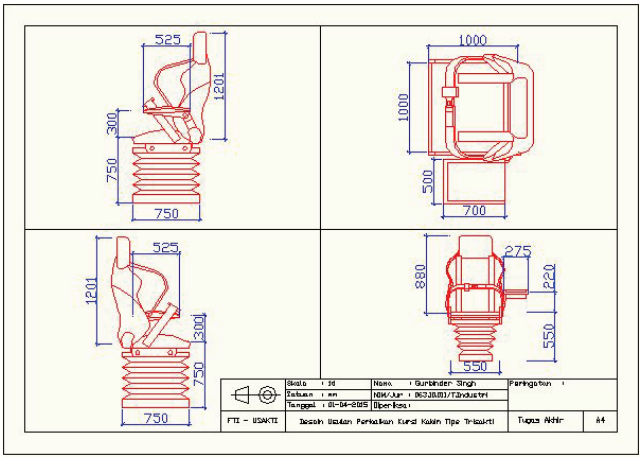

Fig 6. Design of Driver's Seat

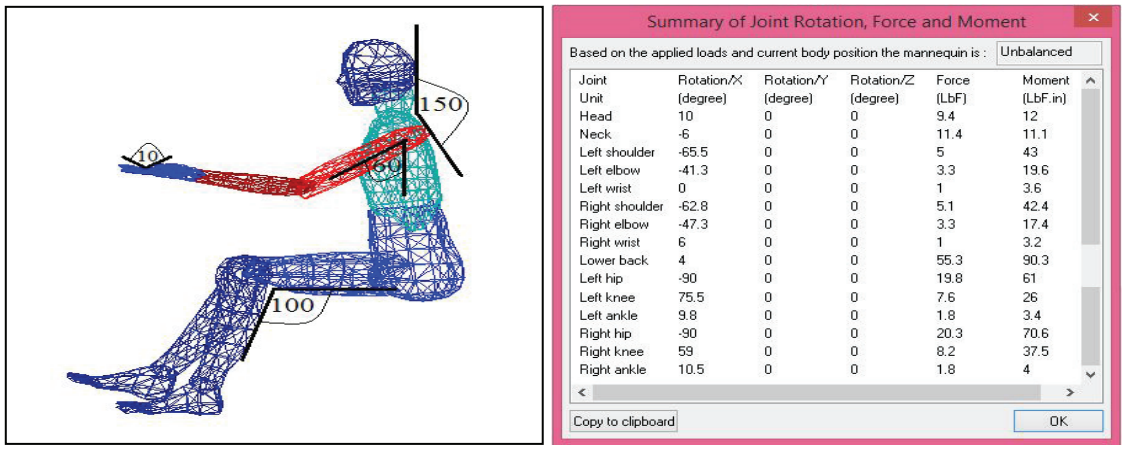

Fig 7. Driver Working Posture Improvement

Fig 8. Improvement of Working Posture of Transjakarta Bus Driver (3DMax Animation)

At work postures that have been improved, angle of the driver's arms was 40°, forearm 30° , wrist 10°, neck 150°, the angle between the buttocks to the bottom of the knee at 100°. Then final score RULA method was 3, which means further investigation, soon change may be needed (further investigation, the changes immediately if needed). Final Score REBA method was equal to 4, which means medium risk, further investigation, change soon (intermediate risk, further investigations, immediately make the change). It meant the risk level of musculoskeletal injury was significantly decreasing. Design proposals cabin design still had the disadvantages, because the redesign was limited to part of the bus driver's cabin and modeled by 3DMax so that the productivity couldn't be analyzed .

4. Conclusion

The results of the evaluation of the risk of ergonomics and body moments after improvements showed the decrease of musculoskeletal risk level. This indicated that the improvement of cabin design can reduce ergonomic risk with lower scores on several parts of the body.

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