
Ergonomic Study in Indian Mini Trucks Cabin

¹Senthil Arul and ² Subhashini

¹M.Sc. - Product Design, ² B.O.T

ABSTRACT

Mini trucks are known for cargo transportation in intra-city and narrow village roads. It's holding 61% (April 2012 -2013) of sales share in Indian truck market. Mini truck driving is profession for many drivers and they drive the vehicle minimum 5hrs per day. While riding, driver facing various discomforts like prolonged sitting postures, significant stress to neck, upper, lower back and uncomfortable environment. These discomfort factors lead to work related musculoskeletal disorders (WRMSD).

Research is concerned on safety, comfort and productivity. Driver fatigue and discomfort lead to many accidents. Inadequate mini truck cabin environment invites WRMSD and it will cause less productivity. All these issues influence this research to find a human factor engineering design intervention. Objective is to find an optimum driver comfort and reduce health hazards.

The study conducted on Tata Ace, Mahindra Maxximo and Ashok Leyland Dost. Task analysis carried out with set of different dimension people in various brand mini trucks. Techniques used are literature survey, user study, interviews, ethnography, RULA, REBA, and benchmarking.

New ergonomically designed layout enhances the driver comfort, safety and ease of use. It will bring better driver healthiness, safety, performance & productivity.

INTRODUCTION

In India 60% ^[1] of the goods has been transported by road. The shipment has transport to large cities through the Golden Quadrilateral by large truck trailers. Secondary transportation between towns has done by medium-duty trucks. Inner city transportation needed much smaller vehicles, there mini trucks coming in to subject. Mini trucks are known for intra-city and narrow village roads cargo transportation. Mini truck driving is profession for many drivers and they drive the vehicle minimum 5hrs per day. Truck driving is not an easy occupation, it's one of the hazardous professions, many time truck drivers fatigue is one of the key factor for highway accidents and local city traffic violations. The accidents are classified as Traffic Related and psycho-physiological. Traffic related is such as fatalities and injuries in various traffic situations. The second type is psycho-physiological, it's evidently belongs to general ergonomical issues and working condition of truck drivers.

Truck driving is the occupation requires concentration, alertness and vigilance with high quality operations which can be performed by professional drivers in an expedient as well as a safe and secure working environment. While riding, driver facing various discomforts like prolonged sitting postures, significant stress to neck, upper, lower back and uncomfortable environment. These discomfort factors lead to work related musculoskeletal disorders (WRMSD).

MOTIVATION AND OBJECTIVE

This research started with designer social responsibility, because the driver fatigue and discomfort lead to accidents, sometimes the accidents make high loss to common public. Also driver fatigue leads to absenteeism, health issue and reduce the productivity. Long duration of driving without rest and inadequate truck cabin environment is key factor for driver fatigue. Now day's Indian car & SUV human comfort is better than bygone days. But focus on commercial vehicle in the point of ergonomics is less. Mini truck human factor consideration is almost null, also the driver's income is not sufficient to go for treatment of WRMSD. This is the reason to select mini truck for this study. All these issues influence this research to find a human factor engineering design intervention on safety, comfort and productivity. So this research objective is to find the optimum driver comfort and safety.

MACHINE AND METHODS

Machine

The study conducted on mini truck with Gross vehicle weight of less than 3 tons. The products come under this segment are Tata Ace, Mahindra Maxximo and Ashok Leyland Dost.

Methods and Tools

Literature survey to understand the mini trucks history and current scenario. Task analysis was carried out to understand the human and machine interaction. User study, interviews and ethnography are carried out to understand the customer need, want and desire. RULA and REBA are used to understand posture difficult. Benchmarking is used to understand product feasibility.

STUDY PROCESS FLOW

The ergonomic design process flow has been defined by us called as PLCEF. This process flow is presented in International ergonomic conference too. This process flow steps are Planning & Assessment, Layout Design, Concept Design, Evaluation and Final Design.

Planning and Assessment

The ergonomic assessment and user interview is performed with 22 people. They are fall in the age group of 24 to 47 and male gender. Task analysis carried out with three different dimension people. Refer the fig 5, 6, 7, 8 and 9 in APPENDIX. Due to page constrain the figure are placed in APPENDIX.

Task analysis outcome:

- o Physical Human Machine Interaction (HMI) areas are door handle, seat & adjustment, seat belt, Key insertion for ignition, steering, pedals (accelerator, brake and clutch), hand brake, gear shift knob, horn switch, light switch and wiper.
- o Driver road vision is good, rear view mirror which is located inside the cabin has the issue when the truck is fully loaded, rear view side mirror mounting having issue. Dash board cluster panel visibility is good.

- o Seat has only linear adjustment, back support of seat doesn't have adjustment and Lumbar Pad is not available.
- o Hand brake and gear shift knob is too closer in Tata ace, the fig 1 will show that. This cramp packing has operational access issue.
- o Head room size is lesser.
- o If people stature is more than 1850 mm, steering is hitting on leg.
- o No head rest in Tata Ace and Ashok Leyland Dost.

Outcome of User Interview:

- o Periodical back pain, neck pain and shoulder pain
 - o Seat is not comfortable as well as they want driver and Co-passenger seat need to be combine when they want to sleep and relax.
 - o Hand rest is needed.
- Head and roof clearance need to increase



Fig 1: Hand brake

After literature survey, Assessment and user interview, basic input is ready. Based on the input of preliminary study, ergonomics carried out part by part to optimize the mini truck cab comfort.

Seat

The vehicle ergonomics start from seat. In vehicle ergonomics, manikin H-point is the reference origin point ($X=0, Y=0, Z=0$) all the dimension will derive from this. Refer the figure 9 in APPENDIX. Many human factor and work related musculoskeletal disorders issue origin is inappropriate seat design. Driving a truck for longer period and poor sitting posture will lead to disorders of the skeleton, muscles and connecting tissues. Seat design should provide the appropriate comfort, ensure a safe performance of the task and give protection against intolerable mechanical vibrations. Perpetual Vibration of the body over the course of years can damage the gastro-intestinal tract and produce premature degenerative changes in the lumbar vertebrae of drivers.

Improper sitting and musculoskeletal disorders

A prolonged period or uncomfortable or incorrect sitting position, especially when both the seat and the backrest are rigid, imposes a great strain on the human body. Continuous awkward sitting posture will lead to chronic back pain. Improper sitting abusing has different segments of the body such as back, neck, shoulder and arms. The cervical spine is also influenced by sitting, as the field of vision needed to perform a task may require the head to be in a certain position. The increased risks of low-back pain in subjects who work in a predominantly sitting posture has been confirmed in many studies [2]. A restriction in freedom of movement while driving a vehicle increases the risk of tense muscles, damage to the intervertebral discs from improper positioning of the spinal column. Circulation difficulties caused by pressure on the tissues and discomfort will lead to performance decrement [3].

Seat headrest

Headrests are necessary for properly supported neck posture. Also the headrest protects your head from rear-end collisions. It will protect whiplash injury to the neck. So it is one of the safety features that need to be kept in the vehicle. Currently Mahindra Maxximo have this feature, other Tata Ace and Ashok Leyland Dost don't have.

Cabin size

The following table will show the current available Indian mini truck cab dimension, green highlighted dimension are better than other.

CAB	TATA ace	Ashok Leyland Dost	M&M Maxximo
Weight (mm)	1400	1520	1440
Length (mm)	1260	1785	1360
Height (mm)	1845	1835	1900

The effective headroom is the distance between the H-point and the headliner. Task analysis and user interview are evidence the current effective headroom is not sufficient. The Fig 2 will show that. H-point to headliner height should be more than 95th percentile dimension and head clearance as per SAE J1100. The knee block dimension is fine but shoulder room is too less. It's need to be redefined to fit the 95th percentile.



Fig 2: Headroom

Handbrake

In mini truck handbrake needs more ergonomic design intervention than passenger vehicle & long haulage trucks, because many time mini truck used for short distance delivery. Due to short distance, handbrake task performed frequently than other vehicle. The TATA ace handbrake location is incorrect. The following fig 3 will show that. While performing the task analysis we understand the posture is awkward. We want to understand this posture is how much awkward, so we performed RULA (known posture analysis tool). This posture RULA score is 6, it indicates action required. So handbrake location packaging needs to redesign.



Fig 3: Handbrake operation

Place for relax

As per our study, mini truck drivers are spending minimum 8 hrs with the vehicle, they are not driving all the time. If they don't have work, they want to relax inside the vehicle, the combined seat will be better. Currently Mahindra Maxximo and Ashok Leyland Dost come closer to this option but still the handbrake location recharge will full fill this.

RESULTS AND RECOMMENDATION

Improvement areas are identified with this research. Areas of improvement are classified with discomfort and safety severity.

Seat back support needs to protect the lower lumbar intervertebral discs and lumbar region. Mini-truck drivers need to get in and get out of the vehicle frequently, so seat height is higher than other vehicle. Hence we are recommending trunk and thigh angle 100 - 110 degrees will give better comfort. Easy adjustable.

- o Adjustable seat headrest is recommended to protect the 95th percentile people also.
- o The cab overall dimension need to be change to fit the 95th percentile people. Indian erect sitting 95th percentile will be 905mm [5] with this 102 mm need to add for clearance as per SAE standard. This dimension is recommended for effective headroom.
- o Handbrake location need to change near to dash panel within reach zone, like as shown in the fig 4, It will help to reduce RULA score less than 4.

If the new layout designs follow recommended ideas will help to eliminate existing driver cabin environment discomforts.

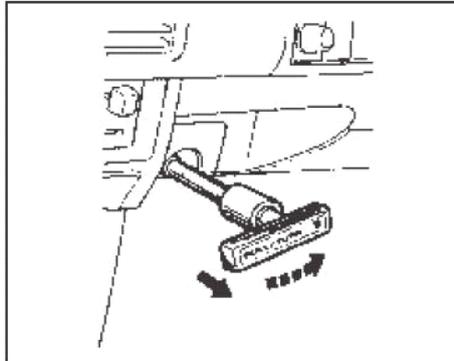


Fig 4: Dash panel parking brake

CONCLUSION

The driver seat must be design according to human body. This should have adjustment features. Ergonomical design intervention is must for truck driver seat, because they spend more time in the vehicle. Every vehicle design needs to consider the premier and secondary function human factor requirement at the time of design execution. If the new layout designs follow recommended ideas, will bring better driver healthiness, safety, performance and productivity.

REFERENCES

1. Dieter Becker (2011). Competing in the Global Truck Industry- Emerging Markets Spotlight, KPMG INTERNATIONAL.
2. Rani Lueder(2004), Ergonomics of seated movement a review of the scientific literature, Allsteel.
3. Diebschlag, W., Heidinger, F., Dupuis, H., Hartung, E. and Meiller, H. (1995). Seat Ergonomics. Aspects of Industrial Medicine and Technology Relating to Seat Design. Germany.
4. Stuart Macey and Geoff Wardle, H-point the fundamentals of car design & packaging.
5. Debkumar Chakrabarti (1997), Indian Anthropometric Dimension, National Institute of Design.

APPENDIX



Description: He is the mini-truck driver for last 7 years. He is shorter than Indian average height. His body weight is less than Indian average weight. He is better subject fall in 40th percentile
Stature: 1620 mm Span: 1662mm
Maximum body breadth (relaxed): 443mm
Maximum body depth (relaxed): 259mm



Description: He has experience with different vehicle. Also he is tall and fall in 95th percentile, so he better subject to do Task Analysis
Stature: 1820 mm Span: 1789mm
Maximum body breadth (relaxed): 483 mm
Maximum body depth (relaxed): 273 mm



Description: it's myself, I will be better subject to check the body breadth & depth, because my size is fall on 75th percentile.
Stature: 1710 mm Span: 1690mm
Maximum body breadth (relaxed): 540mm
Maximum body depth (relaxed): 350

Fig 5: Task analysis subject

The fig 6 shows the task analysis details. This analysis help to understand the basics first phase analysis.



Fig 6: Task analysis-1

The second self-analysis (Fig 7) will help to explore the many discomforts in the point of ergonomist. Self-analysis has more importance, unless some time user feedback will bias the result. Also my body breadth and depth will flow under 75th percentile. So it helps me to understand the above average weight or overweight people's discomfort.



Fig 7: Task analysis-2

The 3rd analysis (Fig 8) helped to understand the above 75th and 95th percentile people discomforts.



Fig 8: Task analysis-3

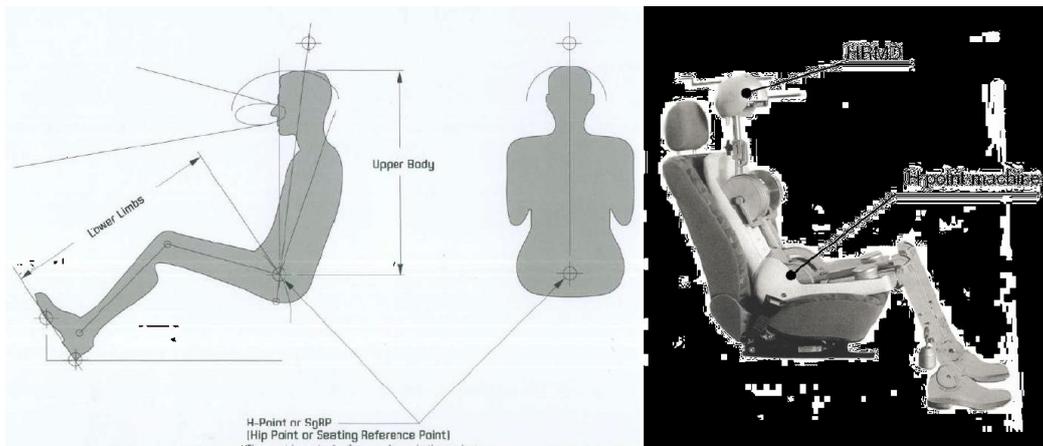


Fig 9: H-point