Design, Analysis, Optimization and Fabrication of Conductor Berth for Commercial Vehicle

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Abstract
The berth must be strong enough to hold the weight of driver and conductor. The berth must have proper shape and size in the heavy load truck vehicle so that person of any height and weight can withhold a proper sleep on upper berth. During an accident, berth of vehicle should not break and get damage. It should be strong enough too to prevent any harm to sleeping person. The berth must have good antedate characteristics, their effectiveness should not decrease with prolonged time. Also manufacturing cost of berth should be less and thus it demand reduction in cost with good efficient berth.

Keywords: Berth, Optimization, Design, Analysis, Shaft.

1. Introduction
The present paper work is the modification in the design of conductor berth of TATA MOTORS, Truck Division. AMA Enterprises, JAMSHEDPUR is a supplier of conductor berth to TATA MOTORS. We are undertaking a detailed optimization of this berth. This optimization process will involve developing the CAD model of existing TATA design and modifying it in accordance to ARAI specification. Subsequently this optimization will benefit the AUTOMOBILE industry in large specifically heavy commercial vehicle. An exhaustive market survey is carried for and specifically visited AMA Enterprises, Jamshedpur. The company is carrying out a LIVE PROJECT. We are dealing with Upper Berth of heavy load truck. Apart from doing LIVE PROJECT of optimizing the model of upper berth to reduce cost, it needs fabrication as well as making design of truck upper berth.

2. Berth
A berth is a bed or sleeping accommodation on vehicles. Space accommodations have contributed to certain common design elements of berths i.e. Berths of long-distance trucks. Long-haul truckers sleep in berths when required by regulations to rest. The sleeper-berth must meet size and location requirements specified on the truck regulations.

3. Classification
3.1 Lower Berth
Lower Berth means sleeper berth which is on the lower side/ deck, where conductor or driver can sleep and also sit on it.

3.2 Upper Berth
Upper Berth means sleeper berth which is on the upper side/ deck, where driver or conductor can only use for rest and sleeping purpose.

4. Objective
4.1 To make an optimized model in accordance with standard specification.
4.2 To reduce the weight of berth.
4.3 Reducing manufacturing cost.
4.4 Improving the portability.
5. LITERATURE REVIEW

Chinnadurai, V., Venna, H., and Banthia, V., "Design of Safety System for Sleeper Berth of Heavy Duty Truck Cabin," SAE Technical Paper 2015-26-0158, 2015, doi: 10.4271/2015-26-0158—Expanding and improving road network in India has been a catalyst for increased use of road transport in both passenger and goods sector. With improved road quality, bigger commercials vehicles have entered the market. These provide a larger cabin area and better amenities in the truck driver cabin. One of the most welcome features is berths for lying down and sleeping. In most designs though, only the functionality of the berth has been taken into consideration. Safety of the occupants of the berths in the event of panic braking or collision of the vehicle has not been given adequate consideration. In this work, design of such berths from occupant safety point of view has been assessed. Kinematics of occupants, sleeping in different typical postures, during frontal impact, has been simulated and resulting critical injury levels have been estimated.

Parkinson, M. B., Reed, M. P., Kokkolaras, M., & Papalambros, P. Y. (2006). Optimizing Truck Cab Layout for Driver Accommodation. Journal of Mechanical Design, 129(11), 1110-1117. doi: 10.1115/1.2771181—One important source of variability in the performance and success of products designed for use by people is the people themselves. In many cases, the acceptability of the design is affected more by the variability in the human users than by the variability attributable to the hardware from which the product is constructed. Designing for human variability as an inherent part of the product optimization process can improve the overall performance of the product. This paper presents a new approach to artifact design that applies population sampling and stochastic posture prediction in an optimization environment to achieve optimal designs that are robust to variability among users, including differences in age, physical size, strength, and cognitive capability. A case study involving the layout of the interior of a heavy truck cab is presented, focusing on simultaneous placement of the seat and steering-wheel adjustment ranges. Trade-offs between adjustability (an indicator of cost), driver accommodation, and safety are explored under this paradigm.

Fathallah, F. A., & Cotnam, J. P. (2000). Maximum forces sustained during various methods of exiting commercial tractors, trailers and trucks. Applied Ergonomics, 31(1), 25-33. doi:—They Investigated the effects of stooped work on the spine in both field and laboratory settings. Documented physical and visual mismatches between agricultural tractor driving and adolescents’ characteristics and capabilities and their implications to adolescents’ safety showed the importance of investigating the simultaneous occurrence of risk factors related to occupational low back disorders. Investigated forces in the body experienced by truck drivers when exiting commercial vehicles and the potential for slipping and falling after exiting. The majority of injuries to truckers are caused by falls during the descent from the cab of the truck. Several studies have shown that the techniques used to descend from the truck and the layout of the truck’s cabin is the principal cause of injury. The goal of the present study was to measure the effects of the descent techniques used by the trucker and the layout of the truck's cabin on the impact forces absorbed by the lower limbs and the back. Kinematic data, obtained with the aid of a video camera, were combined with the force platform data to allow for calculation of the lower limb and L5–S1 torques as well as L5–S1 compressive forces. The trucker descended from two different conventional tractor cabin layouts. Each trucker descended from cabin using either “facing the truck” (FT) or “back to the truck” (BT) techniques. The results demonstrate that the BT technique produces greater ground impact forces than the FT technique, particularly when the truck does not have a handrail. The BT technique also causes an increase in the compressive forces exerted on the back. In conclusion, the use of the FT technique along with the aids (i.e., handrails and all the steps) help lower the landing impact forces as well as the lumbosacral compressive forces.

6. Problem Formulation

6.1 Basic Problem
Its optimization is the main problem because we have to do optimization such that optimized model of truck upper berth is beneficial to automotive industry especially to AMA enterprises.

6.2 Weight of Berth
Secondly we have to consider its weight, because if weight is more of upper berth then it will not satisfy the needs of supplier who have to deal with their customer/client such as TATA motors. Weight should be reduced to fulfill the AMA enterprise needs.

6.3 Cost Reduction
Weight should be reduced so that manufacturing cost is reduced. For reducing cost, we will have to use low grade material or to reduce its section up to certain limit but in accordance with ARAI specification.
6.4 limits in Specification
By reducing section or making use of low grade section there may be chance to get failure in analysis of model beyond the ARAI specification and the original existing model of TATA motors.

6.5 Failure in Strength
Though, by reducing weight we may achieve low manufacturing rate and high productivity but its strength is to be considered because reducing weight may cause some extent of failure in strength of model.

6.6 Maximum Weight Sustainable
Lastly its weight carrying capacity is also to be considered. The weight of sleeping person/driver or truck conductor may be more somewhat above 100 kg is to be considered. Hence after considering this drawback and making optimized model its productivity could be increased by AMA enterprises of our optimized model.

6. Research Methodology

6.1 DATA acquisition
6.2 Design
6.3 CAD modeling
6.4 Analysis and Optimization
6.5 Fabrication
6.6 Comparison with ARAI Specification

7. Design of Berth

7.1 Select material of shaft
7.2 Diameter of Shaft

Allowable shear stress ($\tau$) = \frac{S_{sys}}{f.o.s}

Yield tensile strength=$S_{yt}$

Ultimate shear strength=$S_{ut}$

Yield strength in shear=$S_{ys}$

Factor of safety=f. o. s

Shear stress=0.3 $S_{yt}$ (or)

=0.18 $S_{ut}$

Select minimum value from above shear stress

$$\tau = \frac{\pi \tau d^2}{16}$$

Select standard diameter of shaft from design data

Length of shaft=L

Tangential force ($F_t$)=0.5pV^2C_t

Bending moment of shaft (M) = $F_t \cdot L$

Moment of inertia (I) = \frac{\pi d^4}{64}

Y = \frac{d}{2}

Bending stress=$\sigma_b$

We have,

$$\frac{M}{I} = \frac{\sigma_b}{Y}$$

Also,

$$M = \frac{\pi \sigma_b \text{calculated} d^3}{32}$$

$\sigma_b \text{calculated} \leq \sigma_b$

Design is safe

7.4 Maximum Shear Stress

$$\tau_{max} = 0.5 \sqrt{\sigma_b^2 + 4\tau^2}$$

$\tau_{max} < \tau$

Design is safe

8. Modeling of Chain and Berth Frame
9. Fabrication
10. Comparing with ARAI Specification

The Automotive Research Association of India, PUNE had given standard specification for truck. The chairman of Automotive Industry Standards Committee is Shri Shrikant R. Marathe. The erstwhile Ministry of Surface Transport (MOST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order No.RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CTSC). After approval, the Automotive Research Association of India, (ARAI), Pune, being the Secretariat of the AIS Committee, has published this standard. Following standards for berth with whom we are comparing our fabricated berth so that design is safe, are given below--

Berth layout shall be 1x2 type or 1x1 type for berth orientation along with the longitudinal axis of the vehicle. Berth layout shall be 1x1 type for berth orientation along with the transverse axis of the vehicle. No seats shall be permitted in the lower tier in this orientation. Sleeper as well as seating layout shall be 1x2 type or 1x1 type.

Length of the berth shall be minimum 1800 mm. Width of the berth shall be minimum 600 mm for 1x2 layout and 560-750 mm for 1x1 layout. The minimum thickness of berth cushion shall be 75 mm. In case of berth orientation along with the transverse axis of the vehicle, the distance between two opposite berths shall be 400 mm minimum. Height of lower berth including uncompressed cushion from the floor should be 300 ± 50 mm. Minimum clear distance between uncompressed lower berth and lower face of upper berth shall be 800 mm minimum. Clear distance between uncompressed upper berth and inner panel of the roof of the bus shall be minimum 800 mm. In case of Air-conditioned Sleeper coaches it will be minimum 500 mm near the sidewall and 800 mm near side of the gangway. The berth shall be able to withstand a total load of 300 kg, wherein 100 kg load is applied on the area of 400 mm x 400 mm at three places namely one at center and two at extreme ends. After the test, there shall not be any visual deformation of the berth structure as well as breakage of berth anchorages.

There shall be provision for the passengers to reach the upper berth with ease from the floor, for which a ladder shall be provided with at least two steps. The height of first step from the floor shall be at a distance of 250 mm to 350 mm and the second step shall be at a distance of ≤ 250 mm from the first step. At least one handhold at suitable height along with ladder shall be provided for easy reach to upper berth. Handholds shall be rounded and free from sharp edges to reduce risk of injury to the occupants of the vehicle.

11. Conclusions

Thus reduction in manufacturing cost of industry will benefit further and an efficient model with good strength of material having high breaking point value is achieved. This will improve weight holding capacity and comfort, which ultimately improve life of berth. This will be beneficial for automotive industry.

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References


