ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

TRUCK CABIN OPTIMIZATION DUE TO INCREASED AXLE LOAD REGULATION, USING VIRTUAL ANALYSIS TOOL

Anand Deshpande[*1], Vikash Tiwari [2], Jagdish Saini [3]
[*1, 2, 3] Dept. of Mechanical Engineering, BM College of Technology, Indore, Madhya Pradesh, India

DOI: 10.5281/zenodo.1414057

ABSTRACT
Commercial vehicles are least considered for the occupant safety, even if the norms are in place. It's because of the fewer occupants in cabin. Although truck occupants are the most effected people as far as the accidents figures are concerned. AIS029 talks about occupant safety in commercial vehicles as well and the norms derived from the vehicle GVW and axle weights. Although with new axle weight and GVW norms in force existing vehicles and available designs needs to be relooked. In this paper we have studied the effect of the increased axle load norm on current designed cabins and evaluated the updation in current design with least modification in design, so that existing cabins can be carried forward. At the same time customers can also get their vehicles updated with the small modifications to meet the safety norms. Paper majorly focuses on 3 aspects of crash test i.e. frontal impact test, roof test and rear impact test. Same has been performed virtually with the manikin placed in the virtual model. Clearances after impact have been evaluated before and after modification. Outcome of the paper will give ease to the OEMs to follow the approach, helping them to save the huge cost involved in making new design and tooling.

KEYWORDS: Increased axle load regulation, Crash test. Commercial vehicles, occupant safety, safety standards and norms, virtual simulation

1. INTRODUCTION
Truck occupant safety being the least considered matter; even if we see the figures of accidents heavy vehicles will top the numbers. Considering same fatalities of truck occupants are definitely are on the higher side. With improvement in infrastructure in India road transport is the most favorable type of transport for goods carrying and hence number of trucks on road is increasing drastically day by day. And also commercial vehicles are the wheels of any economy. With all these facts safety of the occupants of truck is also being crucial. Keeping same in mind government has introduced AIS-029, which talks about vehicle norms to ensure occupant safety in trucks. Same is derived from the Gross vehicle weight (GVW) and axle loads. With new norms of increased front axle load and GVW, in which front axle load has been increased by 25% and GVW has been increased by approx 20%, all the current vehicles and finalized designs need to be relooked. Government has also allowed the existing vehicles to be recertified and re-permitted as per the new regulation. That means existing cabins needs to pass the regulations with existing structure, which is fairly not possible. Even, it's not possible to replace the existing cabin as it will lead to huge cost to customer as well as OEM. OEMs also can redesign the cabin as cost and time of developing a new cabin is huge. Hence now the need is to found out the optimized solution which can be easily adopted without making much change in current design and without or least cost impact. So we took reference of the previous studies and the work done by the publishers in past and optimized the cabin structure in such a way that at minimum cost impact, updation in design met the regulation. The approach used to derive same is virtual simulation. Same has saved cost as well as time. Same is being discussed in detail in next topics.

2. LITERATURE RIVEW
Summary of Various papers Studied: A very detailed study has been conducted and presented in 2003 by Vasanth Krishna swami and Daniel Blower [22] which has been sponsored by The University of Michigan

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Transport Research Institute regarding feasibility of Heavy Truck Occupant Protection Measures. In this a very detailed study has been presented which covers effect of various safety measured during crash.

Analysis of crash data showed that while the majority of truck crashes involve collisions with smaller vehicles, the most serious injuries to truck occupants occur in collisions with either other trucks, or fixed roadside objects. Berg (1997) undertook a comprehensive study of truck usage statistics and truck crash Figures in Germany from 1970-1995.In this study it has been observed that collisions of trucks against the rear of the other vehicles is the topics which has not been given required focus and has been neglected so far, it has been observed that about 29% of crashes are of this category. It has been observed that rear of the cab is inadequate to take care of deformations in the safer way, even at low vehicle speed these crashes imparts severe injuries.

Kubaik (1997) [23] presented a detailed dynamic testing based analysis of the effectiveness of a three point seat belt coupled with an air bag in heavy trucks.
Physical tests have been conducted with a 50th percentile dummy and data were presented, this gives very good inside on effectiveness of seat belts and air bags. As per this study if seat belts are used by truck drivers some of the injuries can be protected but not all, for example head injuries cannot be protected, if we use only air bags head injuries can be avoided but lower posture injuries cannot be avoided.

The results obtained are summarized in following table

	Seat Belt+ Air Bag	Seat Belt Only	Air Bag Only	Unrestrained
Head-injury Criteria [HIC]	83.7	94.1	148.4	100
3msResultant-Chest Acceleration	72.5	70.8	81.2	100
Chest deflection	96.1	97.6	87.4	100
Chest-viscous injury	76.7	84.9	68.3	100
Positive-neck shear	25.2	91	814	100
Negative-neck shear	43.1	54.3	41.7	100
Neck Tension	64.1	67.3	137.8	100
Neck Compression	1	84.2	2.6	100
Neck Flexion	23.9	68.5	335.3	100
Neck Extension	30.7	51.3	27.5	100
Right Femur Load	35.5	87.8	52.7	100
Left Femur Load	65.1	111.1	80.4	100

Mr. Uwe Schramm [36] and Harold Thomas [36] and Detlef Schneider [36] of Altair Engineering GmbH, Germany presented a paper on structural optimization for crash analysis using non liner software (Paper no 374). In this methodology of using software, which is programmed for various iteration, has been used and present a method for further time saving.

M. J. Bayarri,[24] James O. Berger[24] has presented a very useful paper on Predicting Vehicle Crashworthiness Validation of Computer Models for Functional and Hierarchical Data in 2009 , in this paper he has presented CRASH computer model simulates the effect of a vehicle colliding against different barrier types. It is of great importance in various aspects of vehicle design, such as the setting of timing of air bag releases. The goal of this study is to address the problem of validating the computer model for such design goals, based on utilizing computer model runs and experimental data from real crashes.

Mr. Girish Patil of Maruti [25] had presented his study in a HTC seminar in 2011 regarding Design optimization of Front Door Hinge Pillar for vehicle crashworthiness, although this paper belongs to Car type vehicles but the methodology can be extended for similar analysis in other crashes also. In this paper he has presented his work done at the case of offset crash and provided methodology to improve door hinge so that it meets opening and closing requirement of regulations, he has provided various optimization methods also to accomplish this job using computer simulation.

Apart from the mentioned ones, further lot more past researches has been studied and the methodology has been derived which has been used to derive the required results, discussed in next topics.

3. METHODOLOGY

Manual calculation for predicting deformation during accidents is very difficult due to very complex geometry of cabin panels and may not be very accurate. Before making the physical prototypes these software's are used to predict behavior of cabin deformation.
As explained earlier during this test energy is actually absorbed and hence material used in structure crosses the elastic limit and goes into the plastic region. In such cases normal structural software cannot be used. For all plastic region analysis generally explicit type software's are getting used.
One of the major software used for explicit analysis is Ls-Dyna which has been designed by NASA and very popular in industry. For our project work we have used the Ls-Dyna code. In following paragraphs differences between implicit and explicit methods are described in brief:

Implicit and Explicit are two types of approaches that can be used to solve the finite element problem. The implicit approach is useful in problems in which time dependency of the solution is not an important factor [e.g. static, structural etc.] whereas Explicit Dynamics approach is most helpful in solving high deformation time dependent problems such as Crash, Blast, Impact etc.

The prime difference between the implicit and explicit scheme lies in the consideration of velocity or acceleration. We have equation relating mass (m), damping (c), stiffness (k) and force (F). In this equation, 'x' stands for displacement whereas $\dot{x}$ and $\ddot{x}$ are resp. the first and second time derivatives of 'x'. In other words they stand for velocity and acceleration respectively.

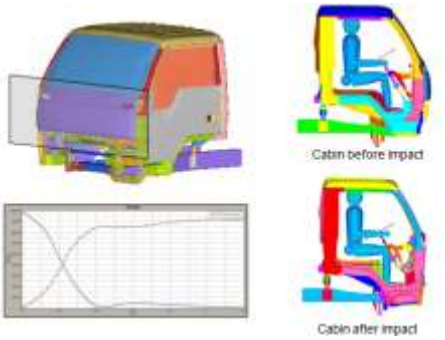
$$m\ddot{x} + c\dot{x} + kx = F$$

4. RESULTS AND DISCUSSION

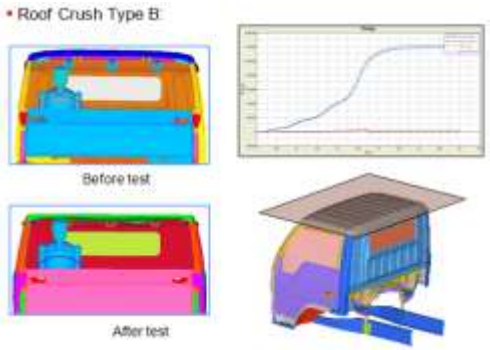
With new regulation in force following changes has been implemented.

Weight comparison before and after new regulation (for 4X2 Truck)		
Front axle load	6000 Kgs	7500 Kgs
GVW (Gross vehicle weight)	16200 Kgs	19000 Kgs

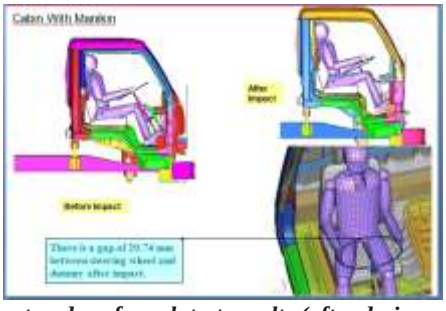
Virtual simulation has been performed according to AIS-029 on Ls-Dyna on current design (inline with old regulation) and updated design (inline with new regulation) and results had been compared before and after design modification. Same has been presented here.



Type A : Frontal impact crash test results (existing design)



Type B: Roof crush test results (existing design)



Frontal impact and roof crush test results (after design modification)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Results has been tabulated as follows:

AIS 029 TEST	Simulation results	Remarks
Type A	38mm	Passing regulation
Type B	69mm	Passing regulation

With very basic changes in design the required output has been achived. Following design changes has been performed

1. Strengthened the cab mounts and side pillars to withstand frontal impact.
2. Added crumple box at the rear mounting to withstand roof crush

5. CONCLUSION

Heavy vehicle occupant safety norm AIS-029 has been met without making any major modification in the existing design and at a very minimal cost impact. In frontal impact test 38mm clearance has been observed after impact and in roof crush test 69mm clearance is available after test with the manikin(dummy human model) placed. It shows that with modified design, regulation is comfortably meeting. That means, in case of accident physical occupant will be safe under these two impacts. Virtual simulation has provided an ease to found out precise results inline with the physical tests. Now the existing designs can be updated with same approach and same can be deployed at customer end vehicles as well. Approach can also be deployed in aftermarket. The paper has put light on the systematic approach followed to achieve results by means of virtual simulation, which not only gives the good correlation with the physical test but also saves huge time and cost.

REFERENCES

[1] "Study on Road Safety" By Government of India in 2011.
[2] "Relation of GDP to Road Safety" planning commission of India in 2000.
[3] "Road traffic injury" Report by WHO and World Bank in 2008.
[4] 11th5 year plan 2007~2012 from government of India-budgetary allocation on road safety measurement
[5] "Causes of Road Injury" Report No.CR 19337-425480 by national highway Safety administration
[6] Eggleman 1987 "Causes of road accidents due to cab interior".
[7] Seiff"Analysis Methods to reduce injury" .
[8] "Laboratory on wheels "by VOLVO Team.
[9] Sukegawa"Guide Lines for frontal crash test of Heavy duty trucks"
[10] Clark 2005 "Effect of steering wheel movement during frontal crash".
[11] Merger 2005 "Physical study of frontal crash behavior" .
[12] CMVR Regulation AIS-029
[13] "Root causes of road accidents" by US department of Transportation.
[14] David C Viano "SAE Publication "Seat in Rear crash safety "in 2001.
[15] "SAE CORPORATE RESEARCH PROGRAMME" by SAE publications.
[16] Farrel Krall "A Compiled Historical Chronology" in 2006.
[17] Survey results of high safety council in Williamsburg in 1972.
[18] Report by safety advisory council of India in 2011
[19] "Truck Occupant Protection a report by NHTSA S217".
[20] Sujan M. 1998 "cab crashworthiness.
[21] Yu-Cheng L. 2006 "Structural Design Optimization of the body section using the finite element method" SAE Paper 2006-01-0954.
[22] Krishnaswami V. and Blower D. 2003"Feasibility of Heavy truck occupant protection measures" The University of Michigan Transport Research Institute.
[23] Kubaik 1997"Analysis of three point seat belt".
[24] Bayarri M. 2009 "Predicting crashworthiness".
[25] Patil G. 2011"Optimization of front door hinge for crashworthiness".
[26] Silvana M. 2003"Structural Adhesives" SAE paper number2003-01-0332.
[27] Broker V. 2003"Practical analysis methodology for low speed vehicles collisions involving vehicles with modern bumper system" SAE paper 2003-1-0492
[28] Rawlinson R. 2010 "A Study of energy absorbing bumpers in low speed crashes".
[29] David C. 2009 "High Retention Seat performance in quasistatic seat tests"
[30] Seto Y. Nissan Motor 2011 "Research on a Braking system for reducing Collision Speed"

[31] Andrew J Hopper "Low Speed Vehicle Collision Practical Analysis methodology for low speed vehicle collisions involving vehicles with modern bumper systems."
[32] Kodaka K. "Rear End Collision Velocity Reduction system" (Honda R and D)
[33] Deshpande V. "Crashworthiness and Numerical analysis of Composite inserts in Vehicle Structure" SAE Paper no 2012-01-0049, in Apr'2012.
[34] Nirmal Narayanasamy of Delphi, Paper no 2005-01-0705 on Systems Approach in Development of Adaptive Energy Absorbing Steering Columns by Virtual Engineering
[35] Qiao P.2008 "Impact Mechanics and High Energy absorbing materials".
[36] Mr. Uwe Schramm, Harold Thomas, Detlef Schneider of Altair Engineering GmbH, Germany presented a paper on structural optimization for crash analysis using non liner software (Paper no 374).

CITE AN ARTICLE

Deshpande, A., Tiwari, V., & Saini, J. (2018). TRUCK CABIN OPTIMIZATION DUE TO INCREASED AXLE LOAD REGULATION, USING VIRTUAL ANALYSIS TOOL. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY, 7*(9), 174-178.