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FLEXIBILITY OF EXISTING SUPD DESIGNS FOR IMPACT LOAD TESTING OF MOTORBIKES

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ABSTRACT

This research work describes nature of under ride, the design and analysis of new guard or protection device for sides of heavy and medium goods vehicle .The newly designed guard is designed and tested according to the I.S.standards. The work describes the development of side protective device for goods vehicle and protection under run situation of bicyclists, pedestrians, two wheeler riders, which happen to be major part of road accidents in urban area. Different impact conditions were studied for different motorbikes. This case study would ensure quality assurance and also research and development work for manufacturers on real life scenario and feasibility for manufacturing. This work will ensure greater traffic safety.

KEYWORDS: SUPD, Under ride, bike impact, IS14682.

INTRODUCTION

As per research presented by J.P Research India Pvt. Ltd. 136834 people died in road accidents out of which 19% of the deaths were due to trucks and trailers. Truck accidents represent a significant factor in the overall road accident scene. Analysing the Indian problem (1997), trucks with a gross vehicle weight of more than 3.5 tones are involved in around 20 % of the fatal road accidents; and approximately 60 % of these are car to truck accidents. The injury risk of accidents involving heavy vehicles appears to be far greater for occupants of opponent vehicles, especially for cars. [9]. Side Underride Protection Devices are intended for,

- To protect pedestrians, cyclists and Two wheelers from falling under the side of vehicle
- To protect car running under long trailers from rear side of trailer or from side direction or at least deploy the air bag

To cover requirements of safety of unprotected road users like Pedestrians, Cyclists and Two Wheeler riders to protect them from falling under the side of vehicle and being caught under the wheels, regulation as per Indian Standards, IS14682-2004 was introduced. It is applicable to M2, M3, N2, N3, T3, T4 category types of vehicles. Its requirement is of application of static load of 1kN with restricted displacement values up to 150mm. There is a separate Provision of certification on the basis of calculation.

Basic Limitations of IS 14682 are

- Does not cover very long trailers built for special purposes
- Does not address any condition of impact loading of cars / bikes

This paper discuss about effect of impact loading on existing Side Underride Protection Devices (SUPD) and redesigned device to evaluate its very first functionality of providing safety to cyclists and motorbikes.

METHODOLOGY

TATA 407 was selected for testing the guard on the basis of their availability through local dealers. As described in flow chart, first virtual testing of existing design was conducted for simple static test as per IS standards. Based on results of first testing, design changes were made for better results. This final design was tested for static as well as impact loading in different possible directions as well as for couple of different motorcycles of different weights. Final design was physically tested for static conditions and its correlation with FE results have established.

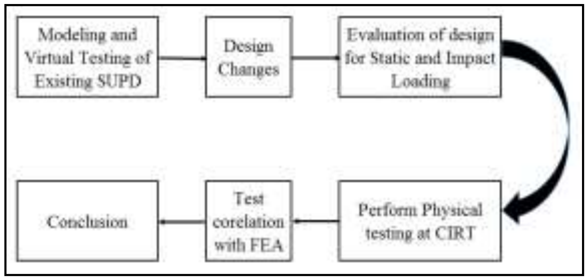

Figure 1 Methodology flow chart

FE modelling was done using Hypermesh as pre-processor. Model consisted of 21000 shell (Quad and Triangular) elements. Material model selected was MS material of astm E8. It is an elasto-plastic material. An arbitrary stress versus strain curve and arbitrary strain rate dependency can be defined. Also, failure based on a plastic strain or a minimum time step size can be defined. To define proper material stress-strain curve, UTM testing is done on coupon drawn from actual components as per ISO 6892 standard.

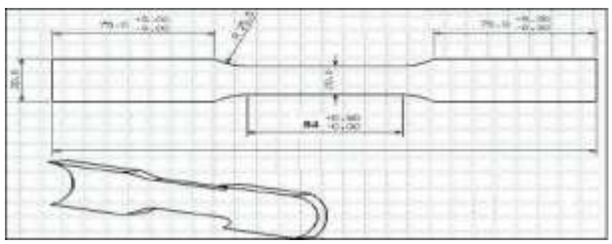

Figure 2 Material test coupon details as per ISO6892

As FEA solver needs Stress vs Plastic strain curve to be defined in case of impact simulations, Load vs Displacement curve is then converted to True Stress Vs Plastic strain curve and this curve is used for further FEA calculations.

Test Procedure:

Based on set objective of the study, we carried out FEA calculations in two stages

1. Linear Static Analysis of SUPD structure.
2. Non-linear Impact Analysis of SUPD structure.The material used was 1mm thick for initial load application and design considered . In order to analyse the structural integrity of the SUPD system, a non-linear finite element model is developed using the LS-Dyna soft ware, which is widely used in automotive industry. The component is implemented to chassis portion with fix for every DOFs. The bolts were modelled via beam elements. The boundary condition and constraints are assigned. The ram is modelled as rigid structure and plunger load is used for loading condition.

Stage -1: Evaluation of existing design

The exisisting design was of 1mm thickness.. It was attached directly to the body cross member section by means of welding appearing vertically suspended.By application of load of 1kn,it seemed to satisfy the I.S.standard. But when we tested for impact loading condition like direct perpendicular impact and oblique impact, it is observed that was failed to withstand the impact forces.

The guard did not possess of triangular support or enough strength to ensure reliability likewise of front and rear guard.

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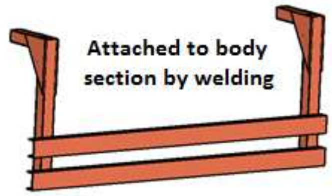

Figure 3Existing SUPD design

This fitment developed cracks in cross member in later stages, due to stress induced after impact in cross member. To overcome the issue of crack developments in the body sections and to transfer the load to more rigid parts, design modifications were done. Fig 4 shows modified design having its attachment directly to chassis with the help of Nuts and Bolts.

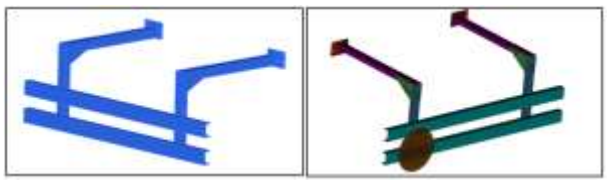

Figure 4 CAD and FEA model of SUPD

Basic aim for modification was to to move impact / static loads or dissipative force to more rigid structure i.e. on to chassis section. To check its performance in case of impact loading, two bike models with 95kg and 275kg masses were used for study purpose. Two conditions of direct perpendicular impact and oblique impact at 30^0 were considered.

Static Analysis of SUPD:

Load case of static loading of 1kN was set-up on modified design as per IS standard. Loads were ramped up to 6kN to test performance of SUPD under higher loading conditions. Load was applied through hydraulic plunger on centre of beam which was to be worst case condition.

Figure 5 Test setup for static testing

Test and FEA results showed close agreement for static condition loading. Modified structure with chassis mounting and 3mm thick channel sustained much higher loads compared to basic design. Table 1 shows test and FEA displacement for 6kN loading conditions on SUPD.

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Table 1Test-FEA results comparison

	Displacement in mm		
Load in kN	Actual Test	FEA	% Error
6	33	35	5.71%

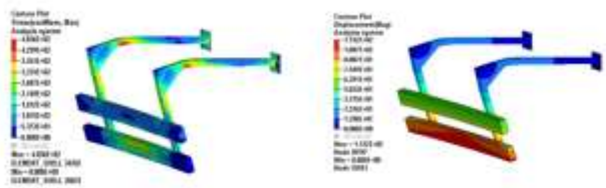

Figure 6 Stress and Displacement plot for 6kN load

Direct and Oblique Impact Load on modified design:
The impact loading condition is simulated using bike of mass 95 kg and 275 kg at a speed of 9 kmph. The set up for direct impact and oblique impact is as shown in fig-7. Non-deformable bike models were used for impact condition. Modified design sustains impact loading of both 95kg and 275 kg loading.

Figure 7 Load set up for Direct and Oblique impact

Case-1: 98kg bike
As shown in figures 8 and 9, structure sustains impact loading of 95kg bike at a speed of 9 kmph with very little deformation causing bike to decelerate fast which prevents its travel beneath vehicle.

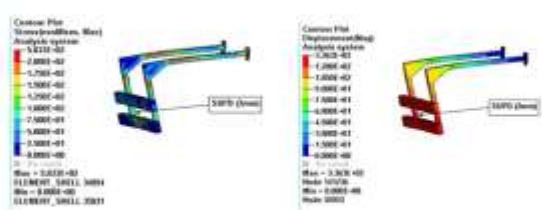

Figure 8 Stress and Displacement plot - 95kg Center impact

Developed stresses were observed in the region of bending and attachment locations.

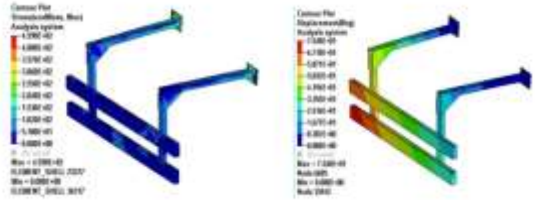

Figure 9 Stress and Displacement plot - 98kg Oblique impact

Case-2: 278 kg bike

To check second possibility of running a heavier bike under the vehicle tests for 275kg bike were carried out for modified structure. Deformations observed on structure for centre impact loading conditions were quite high compared to 95kg bike impacting at a speed of 9 kmph.

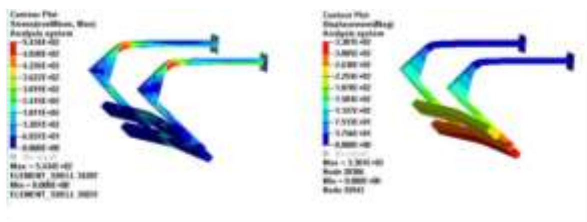

Figure 10 Stress and Displacement plot - 275 kg Centre impact

Deformation starts at the end of triangular gusset plates provided on both the vertical pillars which is next immediate weakest section on the structure in loading direction.

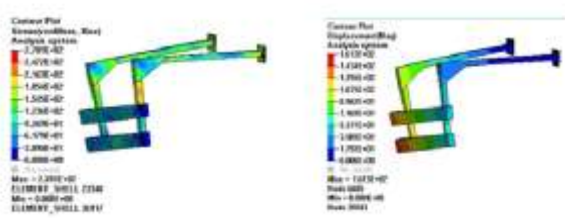

Figure 11 Stress and Displacement plot - 275kg Oblique impact

CONCLUSION

- Even though existing design meets the requirements laid down as per IS standards, it is unsafe for motorcycles in case of collision
- Being welded to vehicle cross member body, crack developed in the body was expected which is more costly repair for small longitudinal impacts
- Modified design with chassis mountings provides more rigidity to structure in turn increasing its strength.
- Modified design help reduce intrusion of motorbike underneath the vehicle in case of impact conditions

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