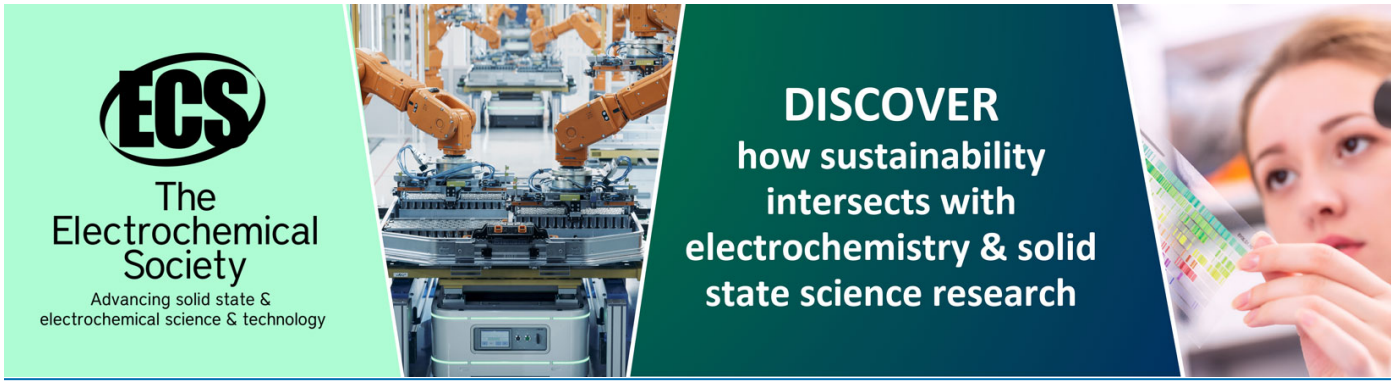
Design and development of rear under ride protection device (RUPD) with improved energy absorption using ANSYS



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Design and development of rear under ride protection device (RUPD) with improved energy absorption using ANSYS

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Abstract. Every year thousands of vehicle occupants are killed or injured due to road accidents. Out of which 8% are due to large truck accidents. Truck under ride accidents represents major part of the truck related accidents. Rear Under ride Protective Device(RUPD) of the truck is the main structure for absorbing the energy of collisions during rear impact. It is essential to improve the energy absorption characteristics of RUPD due to poor road conditions and primitive passenger safety systems in India. The current project is aimed at improving the energy absorption capacity of RUPD, for that two different designs are made and analyzed for improved deformation and strain energy storing capacity. The analysis was carried out in ANSYS and results are evaluated between two models for improvement in the deformation and strain energy storing capacity.

Keywords: RUPD, Impact energy, corrugated, collision, Ansys

1. Introduction

It is very common incident that during the accident a passenger vehicle going under the heavy commercial vehicle either from the rear, front or side. During collision, there is a risk for the passenger vehicle to penetrate under (run under) the front or rear part of the truck and thus there are great chances of fatal injuries to the occupants of the passenger car. According to the study supported by Natural science foundation of china and the Natural science foundation of Hunan, it is reported that total of 92 rear end crashes between trucks on expressways are occurred during the year 2010 to 2016 [1]. The Under ride protection device is an attachment fixed to the rear end chassis cross member in heavy commercial vehicle which will avoid the under running of the passenger vehicle at the rear side which further reduces the chances of severe fatal injuries to the passenger vehicle occupant. Most of the head injuries and consequent fatalities occur during a front ride of the passenger vehicle. The rear under run protection device prevents the vehicles from being wedged under the chassis during accidental crashes which significantly increases the safety of occupants. The significant factor in the rear under production device is that it has resistance to loading forces acting along or parallel to the vehicle longitudinal axis. This necessitates the requirement of a proper design with improved energy absorption. Based on the standard IS 14812-2005, the deformation in the RUPD bar and strain energy can be predicted for failure before the physical test using Finite element analysis using ANSYS. Based on the Indian Standard the physical test scenario is developed in the Finite element modeling to avoid product development for experimental test and to reduce cost involvement in design development [2].

2. Finite Element Modeling

The model created and used for the Finite element analysis is corrugated steel plate instead the commercially used Solid RUPD in circular cross section. The Corrugated steel device designed in a manner to absorb more impact energy and to offer more deformation.

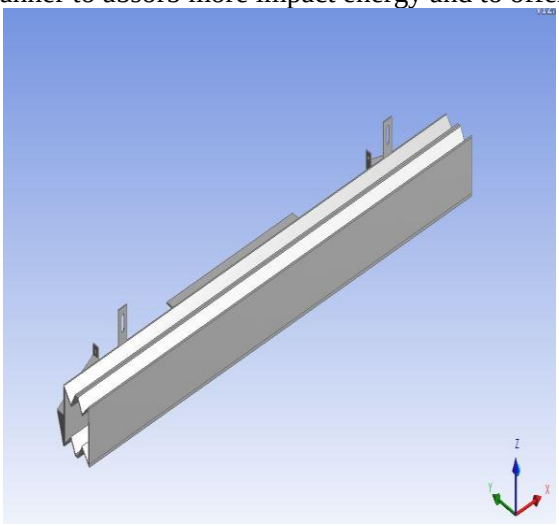

Figure 1. FE modelling of RUPD structure.

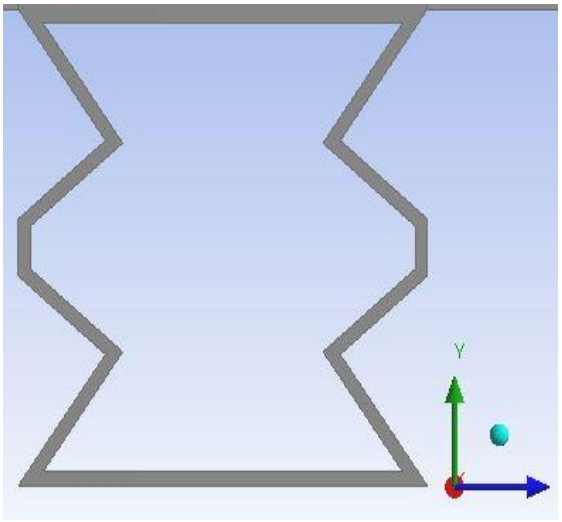

Figure 2. Cross-Section of the designed RUPD device.

3. Boundary and Loading Condition

The chassis member are constrained in all degrees of freedom. They are very critical member and subjected deformation under a severe case. The load conditions are applied as per the standard of IS 14812-2005 [6].

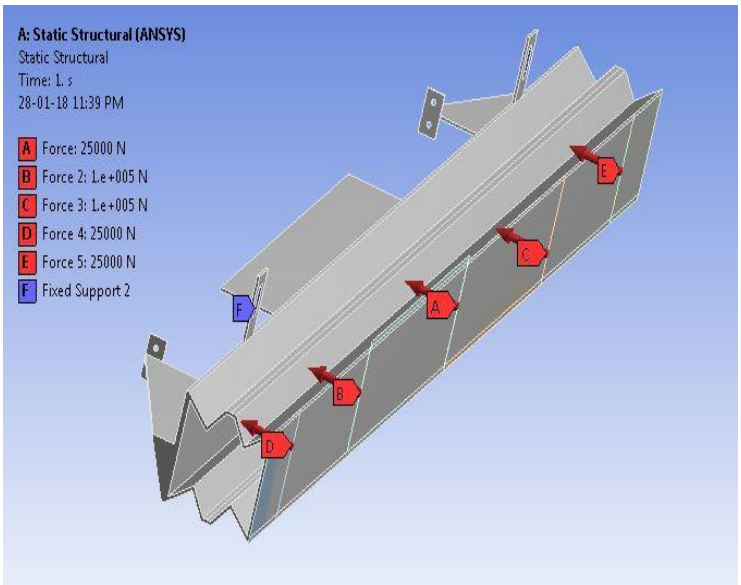

Figure 3. Model shows the Boundary and loading condition.

The Load P1=25000 N, P2 =100000 N, and P3 =25000 N are considered as steady load because the analysis is carried under static structural condition.

4. Material properties of RUPD Bar

The RUPD device is assigned with the following material properties for design validation.

Table 1. RUPD bar material properties.

Material	Tensile strength (MPa)	Yield strength (MPa)	Poison Ratio	Young's Modulus (GPa)
Mild Steel	440	370	0.29	205
Copper	220	70	0.36	130
BSK 46	640	500	0.31	210

It is clear from the properties of materials mentioned in table1, that BSK 46 has more tensile, yield and modulus value than the other materials in the list

5. Result and Discussion

5.1. Design Validation

The model shown in figure 1, is compared with RUPD with Copper stiffener shown in figure 4. The result shows that the change in the design has significant effect on the deformation characteristics and strain energy. It is clear from the result shown in table 2, that the design of RUPD with Corrugated structure has more energy carrying capacity than the RUPD with copper stiffener. The same corrugated steel RUPD is checked for different material for any enhanced performance (i.e. deformation) or energy absorption capability.

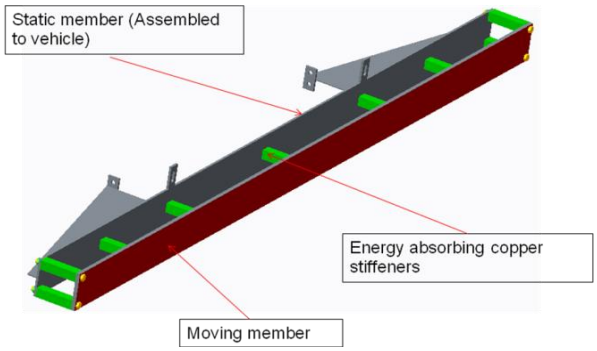

Figure 4. RUPD with Copper Stiffener.

Table 2. Comparison between RUPD with Copper Stiffener and RUPD with Corrugated Structure.

Model	Material	Total Deformation (mm)
RUPD with Copper	Mild steel	1.262

Stiffener		
RUPD with Corrugated structure	Mild Steel	5.272

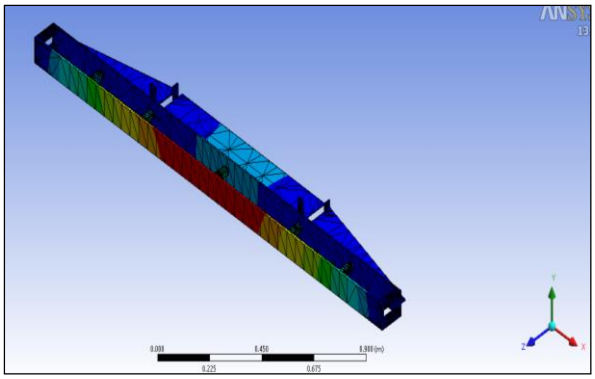

Figure 5. Deformation plot of RUPD with Copper Stiffener.

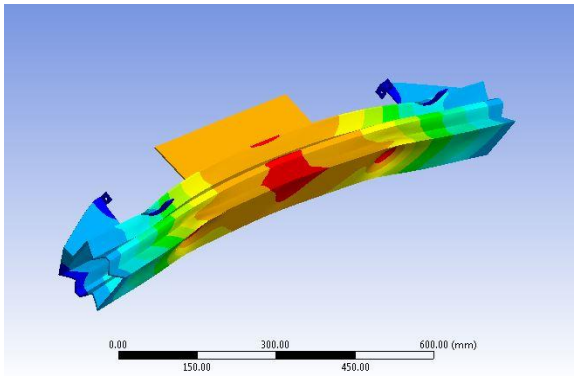

Figure 6. Deformation plot of RUPD with Corrugated structure.

5.2. Effect of material properties on the RUPD bar

From the table 2, It is clear that RUPD with corrugated structure has more deformation than the RUPD with copper stiffener. In the next comparison, the ultimate tensile strength and yield strength of BSK-46 is higher than mild steel as it is depicted in the table 1. It clear explains that there will be improvement in the deformation and strain energy characteristics of RUPD bar. But the strain energy storing capacity of RUPD bar for BSK-46 material doesn't show a significant rise in the parameter with the Mild steel material as it is depicted in the table 3.

Table 3. Comparison of Mild steel and BSK-46 material property on the RUPD with Corrugated structure.

Model	**Material**	**Total deformation (mm)**	**Strain Energy (mJ)**
RUPD with Corrugated structure	Mild steel	5.2720	2410.7
	BSK 46	6.4013	2465.3

Percentage of variation between BSK 46 and mild steel in deformation and strain energy is 17% and 2.2% respectively. It is clear that the change in material property on the designed model for the same boundary and loading condition does not have any significant effect on the strain storing capacity but produces a significant effect on the deformation parameter.

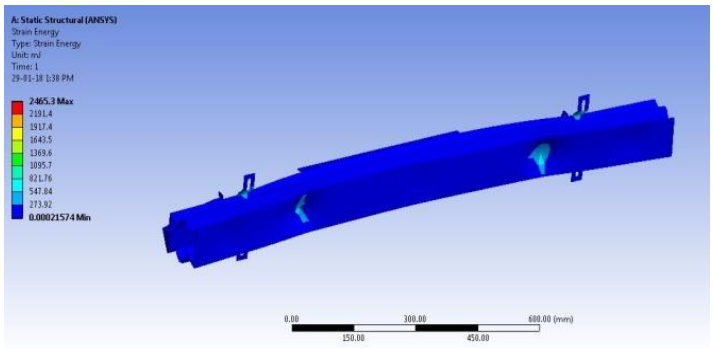

Figure7. Strain energy plot of RUPD with BSK-46 steel property

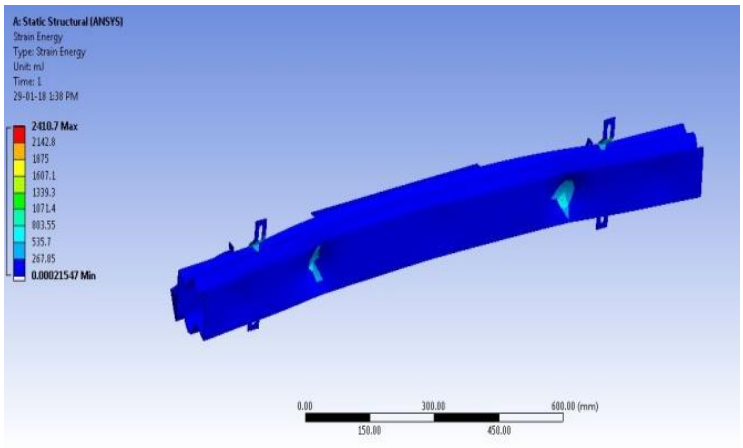

Figure 8. Strain energy plot of RUPD with Mild steel property

6. Conclusion

In this study, two different models of RUPD bar were analyzed for same boundary and loading conditions and two different material properties were assigned for the model to identify the effect of material property in the design. It is clear from the analyze the RUPD with corrugated structure has more deformation and energy carrying capacity than the RUPD with copper stiffeners. Next, the effect of material property on the designed model have a significant change in the deformation but not in strain energy parameter. It shows a variation of 17% and only 2.2% of variation in deformation and strain energy respectively between BSK-46 and mild steel. The change in the design of RUPD bar has most significant effect on the deformation parameter. It shows 76% of variation between the two proposed design. So, It is proven that the corrugated structure can be used as solution for improved energy absorption. It can be used for the practical heavy vehicles like Heavy duty trucks, Trailers, Agricultural tractor–trailers, Short haul trucks, Road trains etc.. When used in above vehicles, the improved RUPD will play a major role in reducing the transfer of impact forces to the occupants of smaller vehicles subjected to rear under ride crash thereby saving many invaluable lives.

7. References

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