Joint Integrity and Strength CAE Simulation Methodology for PHEV Vehicle Skid Plate Assembly

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ABSTRACT

Battery unit skid plate Joint integrity and Strength are key design attributes to ensure Functionality of vehicle. This paper provides an overview of simulation methodology to predict joint integrity and Strength of Battery unit skid plate. Bolt Joint integrity checked against the maximum vertical each wheel spindle loads, which captures maximum bending and twisting. This is the condition in which bolts can experience high load and bolt slippage should check against this load. Skid plate experiences different loading based on drivability and road profile. To simulate severe off road event condition, Maximum load which skid plate experience, applied, as Point load on skid plate at various critical locations to find the deflection and to make sure skid plate is strong enough to protect underneath battery unit.

Keywords: Joint integrity, Strength of skid plate, CAE

1 Introduction

PHEV (Plug-in hybrid electric vehicles) have both an internal combustion engine and electric motor as a driving source. These Electric motors are operated by rechargeable batteries. Hence protecting these batteries becomes key design parameter to ensure safe effective functionality of the vehicle. Skid plate of battery unit goes as bolted joint on vehicle chassis. The bolted joint (Figure 1) should be withstand against operation condition. This can be ensure selecting appropriate bolts resulting from CAE analysis.

2 Methods

Bolted joint Slippage condition will occur when there is insufficient frictional resistance in the joint to take service loads.

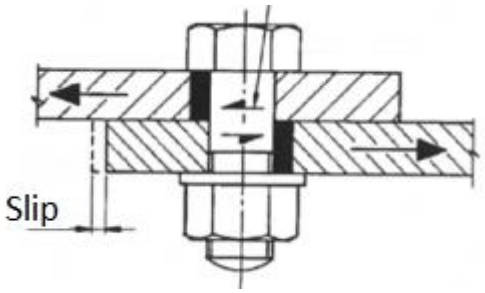

Figure: 1 (Bolted joint)

Strength of skid plate should be strong enough to withstand against the load experience due to ride on different road profiles. (Figure 3 and Figure 4 shows typical off rod torsion and bending of skid late conditions).

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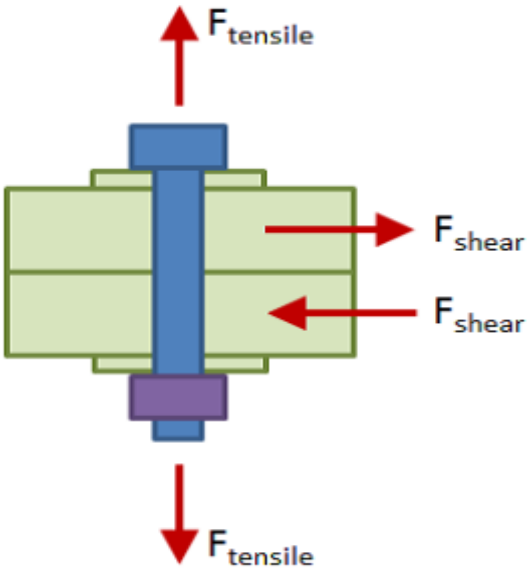

Figure: 2 (Shear force in bolted joint)

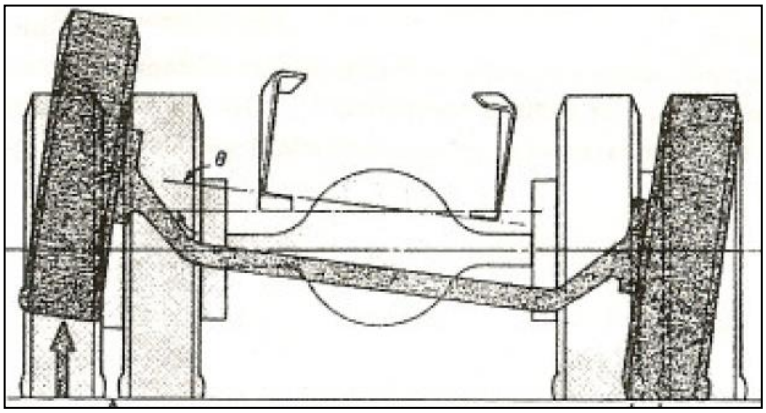

Figure: 3 (Off road riding torsion condition)

Figure: 4 (Bending effect on Skid plate)

3 CAE Methodology to Predicting Joint integrity of Battery unit skid plate

As battery unit is bolted with PHEV Chassis cross members (Figure: 5 Line diagram), The approach discussed here is to create a Proving ground Time slice load based each wheel max. Vertical load as a CAE input (Figure: 6 shows wheel spindle load), which represents approximate max. Bending/twisting behavior of the frame. Induced forces in each bolted joint monitored and check against property of bolt for slippage condition.

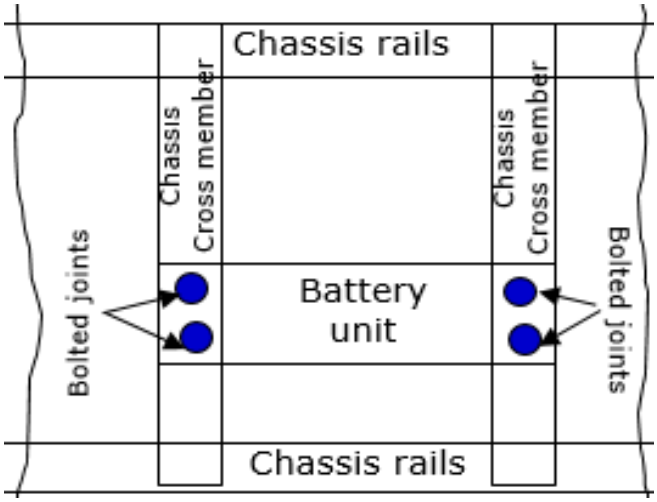

Figure: 5 (Battery unit bolted to chassis cross members)

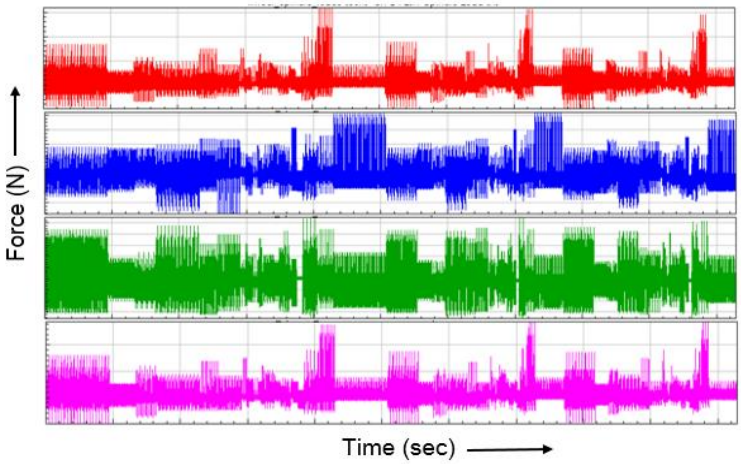

Figure: 6 (Wheel Spindle load)

Figure 7 and Figure 8 shows typical twisting and bending of Frame rail along with cross members in the same scenario battery assembly skid plate bolted joint experience worst forces. Tabulated induced forces and shear capacity of bolts.

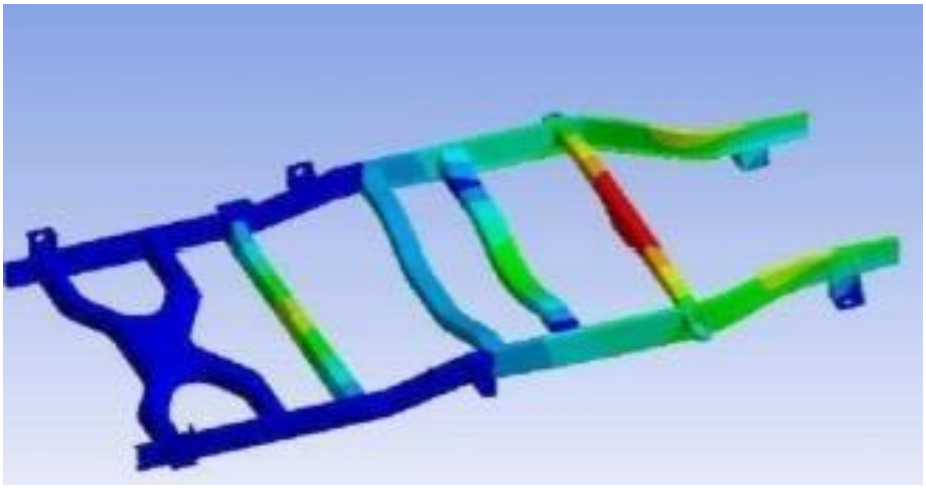

Figure: 7 (Twisting of Frame)

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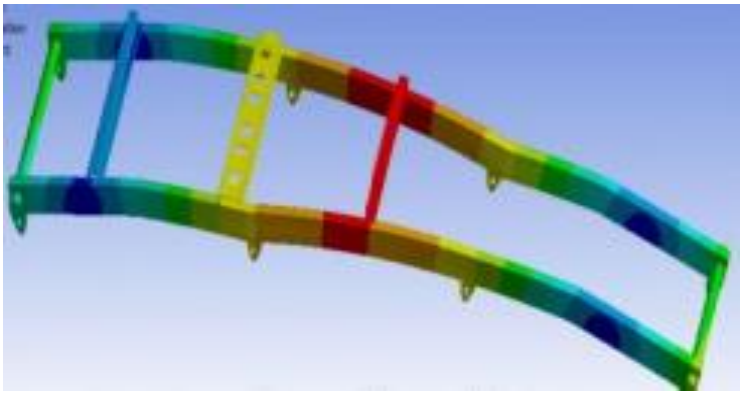

Figure: 8 (Bending of Frame)

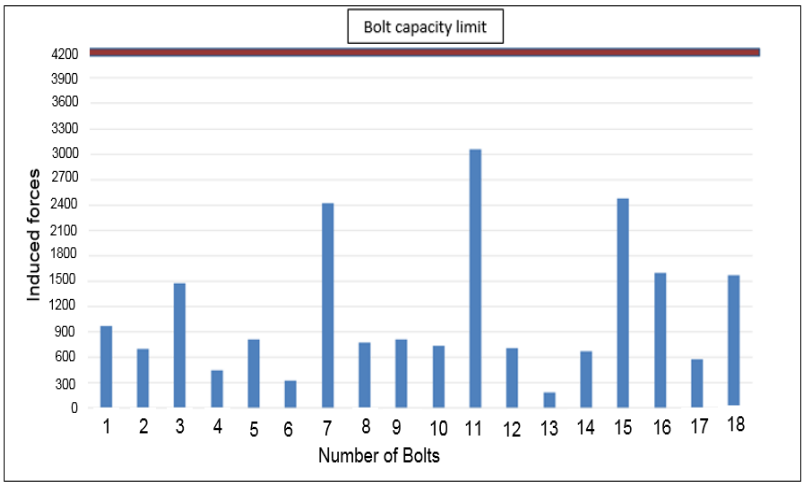

Figure: 9 (Induced Bolt forces and shear capacity limit)

Results shows in table 9, the Shear capacity of bolt more than induced shear forces in bolted joint. Which concludes none of the bolts ae slipping.

4 CAE Methodology to Predicting Strength of skid plate

The point load used in CAE to check the strength of skid plate depending upon the type of vehicle ride (on road/off road refer figure 10), which varies based on Vehicle trial rate.

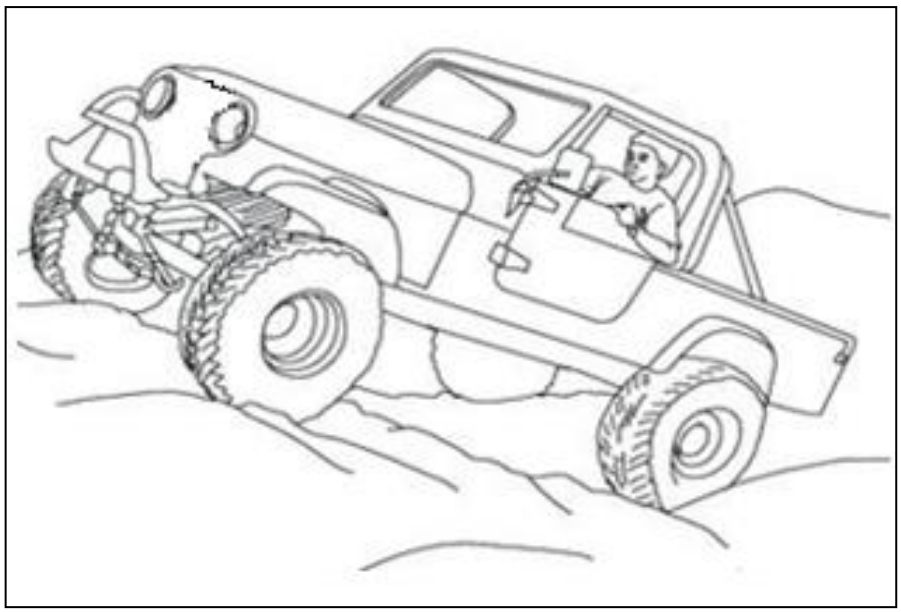

Figure: 10 (Off road ride)

The locations of applying load decided by the closest areas of skid plate to protecting part and weakest areas of skid plate. Couple of locations shows in Figure 11(line diagram).

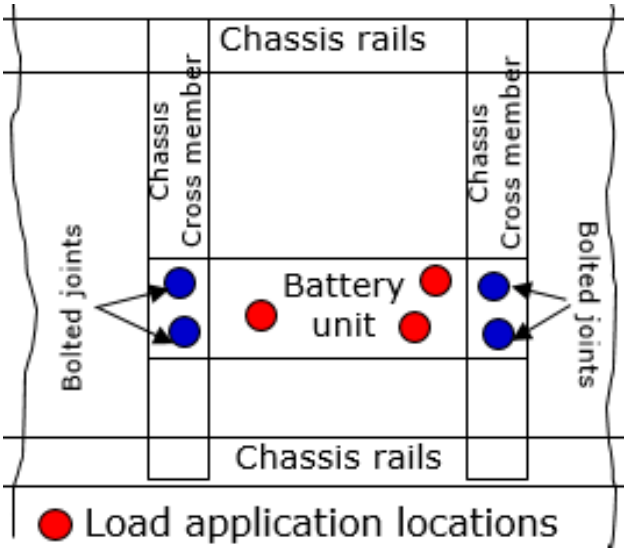

Figure: 11: Skid plate loading locations

The target of loaded skid pate should be not be touch to the protecting part. Induced plastic strain should be within the material elongation limits.

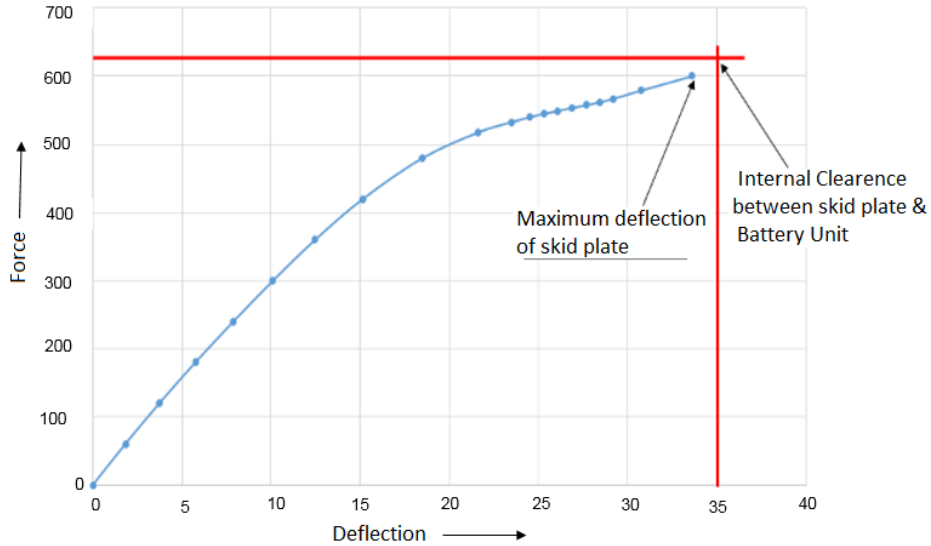

Figure: 12 (Skid Results from strength CAE analysis)

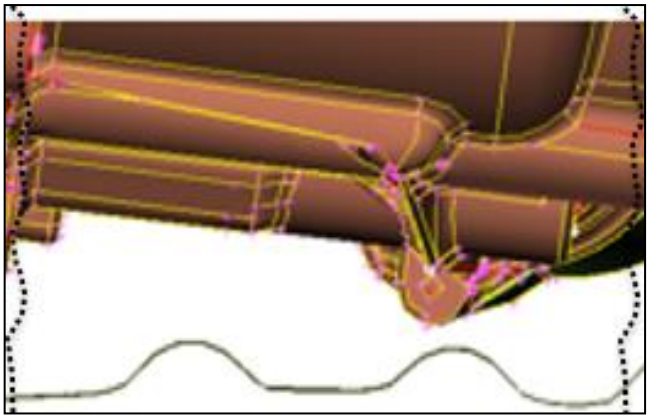

Figure: 13 (Clearance/penetration)

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Figure 12 shows force vs deflection curve for load location3, the maximum deflection of skid plate is within the design gap Figure 13) after full loading, same check repeated for all load locations and tabulated the results (Table 1). From results, skid plate is not touching with the PHEV Battery unit.

Table: 1 (CAE results showing skid plate not touching to Battery unit)

Sr No.	CAE Applied Load Locations	CAD Initial Gap	Baseline Results	
			CAE Deflection	Gap based on CAE predictions
1	Load Location 1	Design Gap	20.8	Clearance Observed After Applying Full Load
2	Load Location 2		29.4	
3	Load Location 3		33	
4	Load Location 4		26.7	
5	Load Location 5		21	
6	Load Location 6		22.9	
7	Load Location 7		20.4	

5 Practical Applications

- A Skid plate is a piece of metal that is designed to protect components of a vehicle by absorbing, deflecting and transferring impact energy away. On off road 4x4 vehicles skid plates often cover gas tanks, gear boxes, differentials, axles and oil pans. If you are driving over rock terrain a skid plate can protect your gas tank from being torn open and leaving you stranded out on the trails.
- The main use of a skid plate – and the reason they can be found on all of our TRD trim levels – is to protect everything that is normally exposed in your vehicle's undercarriage from the natural elements of driving off-road. All kinds of gravel, dirt, and other loose items can be drummed up when driving through off-road environments, and having the skid plate will prevent those things from irreparably damaging your vehicle's underbody.

6 Advantages

- Increased resistance against any impact or debris found on the road.
- It protects batteries from any danger dents from bottom side or from road profiles.
- On off road 4x4 vehicles skid plates often cover gas tanks, gear boxes, differentials, axles and oil pans.
- Skid plate also protects Engine assembly, fuel tank, etc.
- It covers the front compartment of the car, so the engine is more protected against dust and dirt.
- Skid plate mostly protect chassis underneath critical parts from outside impacts.

7 Conclusions

This paper presents a methodology to simulate the PHEV Battery unit skid plate joint integrity & Strength performances. Due to simulation methodology, it allows number of studies & helps to come up with robust concept in the early stage of design. Simulation outcome helps to reduce the product development time &

cost. Battery unit skid plate Strength simulation method is generic and employed to range of product from on road to off-road segments. Simulates battery unit skid plate strength performance against worst possible scenario arrives during operation. Hence, simulation input loading depends on trial rate of vehicles. Failure condition is Deflection of skid plate exceeds clearance of the protecting parts and induced plastic strains exceeds material elongation limit. For joint integrity comparing induced forces in the joints against the mechanical properties of bolts to finding slippage factor. Failure of joint decided based on the induced shear forced exceeding shear capacity of the bolt Acknowledgements

8 Acknowledgements

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