TO SIMULATE AND STUDY THE BEHAVIOUR OF VEHICLE FRONT STRUCTURE THROUGH TOX JOINTS IN FRONTAL COLLISIONS.

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Abstract - *A frontal crash is the most normal type of crash resultant in mortalities. Crash simulations are used to investigate the safety of the car occupants during impacts on the front end structure of the car in a "head-on collision" or "frontal impact". The aim of this project is to improve the crashworthiness of the vehicle for front impact analysis by replacing the spot welds in the BIW structure with TOX joints. The crash tests were performed for a frontal impact of 56 km/hr; during the impact the energy graphs of various parts of vehicle was observed. The model of the vehicle was meshed in Hypermesh 11 and LS-DYNA solver was used for simulation of both the baseline model and modified model. It was observed that replacing spot welds with TOX joints in BIW of vehicle yields better results.*

Keywords: Frontal crash, Spot welds, TOX joints, Crashworthiness, Hypermesh, LS-DYNA.

1. INTRODUCTION

Vehicle accidents are bang updated every day. Nevertheless the info indicates that ten thousand useless and enormous quantities of 1000s to million injured every year. Principal strides have been made in frontal security. A crash simulation is a simulated regeneration of a significant crash experiment of a vehicle using a pc simulation with a purpose to check out the level of safety of the automobile and its occupants. Crash simulations are used by automakers throughout computer-aided engineering (CAE) analysis for crashworthiness within the computer-aided design (CAD) approach of modelling new cars. In the course of a crash simulation, the kinetic power, or power of motion, that a car has earlier than the influence is transformed into deformation energy, more commonly with the aid of plastic deformation (plasticity) of the auto physique material (body in White), on the end of the influence. Car accidents are a regular incidents happening in this generation, and the Frontal impact has the maximum number of incidents causing and the maximum number of fatal accidents. Therefore, occupant safety is very important and it is the first priority compared to other impact accidents. Fatalities are caused due to incorrect energy absorption during collision or impact and this is due to improper connection between the components like spot welds. These improper connections are developed into Scatter and Bifurcations and the energy is transferred to the occupant.

1.1 Objective of the Project

Car accidents are a regular incidents happening in this generation, and the Frontal impact has the maximum number of incidents causing and the maximum number of fatal accidents. Therefore, occupant safety is very important and it is the first priority compared to other impact accidents. Fatalities are caused due to incorrect energy absorption during collision or impact and this is due to improper connection between the components like spot welds. These improper connections are developed into Scatter and Bifurcations and the energy is transferred to the occupant. Following are the details how Frontal Impact crashworthiness can be increased.

- To simulate and study the behaviour of Vehicle front Structure in Frontal collisions to increase the Crashworthiness and this can be done as follows
- By Improving the Crashworthiness or robustness of vehicle front structure by reducing Scatters and suppressing Bifurcations caused due to improper connections in between the Components.
- This can be done by Replacing Spot welds due to major failure issues with Tox Joints and study their behaviour in Dynamic Non-linear simulations as well as to reduce the cost of the Joining process.
- To suggest a design change or to improve the design Crash Box to absorb or to increase the Energy absorption during frontal impact.
- Overall improvements are to be done with respect to decreasing the human injuries in Frontal impact collisions.

2. Geometric Modelling

Toyota Camry is a car manufactured by the Toyota Motor Corporation it is a four door sedan. Camry is powered by 4 cylinders 1.5 liter petrol engine coupled with 4 speed automatic transmission. It is a front wheel drive car. The exterior dimensions are as follows length 4815mm, width 1825mm, height 1470mm.

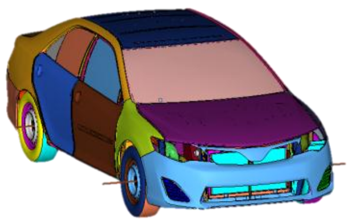

Fig. 1 Toyota Camry

2.1 Meshing

The geometric model in .iges format is taken in Hypermesh and the meshing was carried out. Shell mesh was done on the 2D components using 2D elements while tetra and hexa mesh was done on 3D components using 3D elements. The meshing was done as per the quality check. After meshing was completed the number of elements and nodes that were found are 2359917 and 1168721.

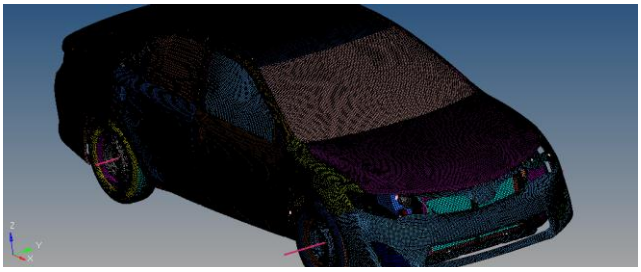

Fig 2: Meshed Model

3. Materials

Parts	Material	Young's Modulus (E) (Mpa)	Yield Strength (S) (Mpa)	Poisson's Ratio	Density Ton/mm³
BIW, Door Panels, Other Sheet Metal Parts	Low Carbon Steel	200000	271	0.3	7.890e-9
Intrusion Beam	Low Carbon Steel	200000	800	0.3	7.89e-9
	Docol 1000 Dp	200000	1100	0.3	7.89e-9
Engine Parts and Other Casting Parts	Cast Iron	200000	240	0.3	7.89e-9
Seats	Flexible Polymer Foam (LD)	3	0.3	.25	6.11e-11
Dash Board and Other Plastic Parts	Acrylonitrile Butadiene Stryrene	1000	20	0.3	4.0e-10

Table -1 Materials

4. Simulation

In this project we conducted two simulations

- The baseline model in which the BIW consists of spot weld connections.
- Model setup where the model in which the BIW consists of TOX joint connection

4.1 Frontal Impact Analysis with Spot-weld connection

In the model setup where the model in which the BIW consists of spot weld connection. This baseline model is made to run and colloid with a rigid wall. The model is impacted with a velocity of 55km/hr and most of the material in BIW structure is high strength low alloy steel with spot weld connections

4.2 Frontal Impact Analysis with TOX joint connection

In the model setup where the model in which the BIW consists of TOX joint connection. This modified model is made to run and colloid with a rigid wall. The model is impacted with a velocity of 55km/hr and most of the material in BIW structure is high strength low alloy steel with TOX joint connections.

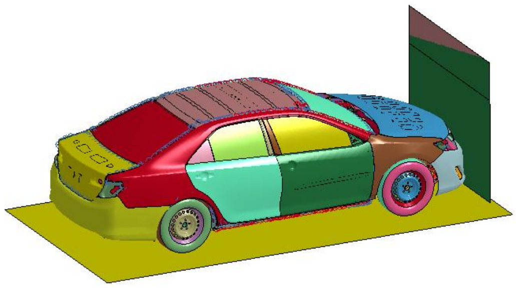

Fig. 3 Frontal impact with TOX and Spot weld

4.3 Results and Discussion

4.3.1 Velocity plots in Baseline model and Modified Model.

The velocity given to baseline model and modified model is unchanged. Both the model are run at same velocity which is 55km/hr or 15555 mm/sec.

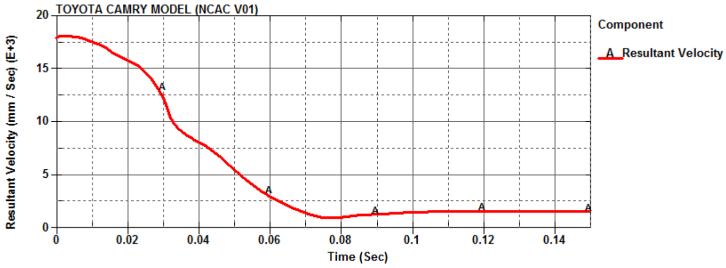

Fig: 4 Velocity plot of Model

4.3.2Internal energy absorbed by S-guard rail

Figure shows that the internal energy absorbed by the spot weld connection and TOX joint. S- Guard consists of 2 parts. The Energy absorbed in both the parts of Spot weld are as follows:

Part 1: 100KJ Part 2: 40KJ

The Energy absorbed in both the parts of TOX joint are as follows:

Part 1: 110KJ Part 2: 42KJ

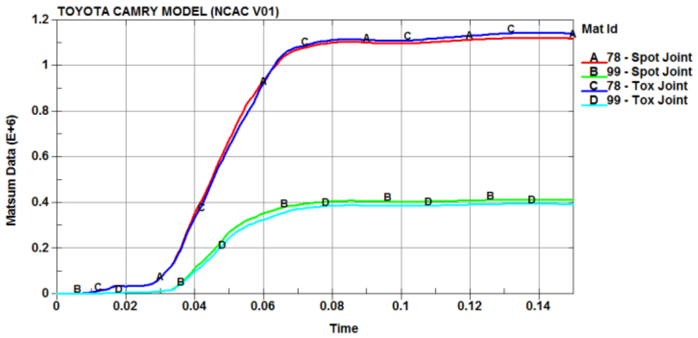

Fig 5: Energy absorbed by S- Guard Rail.

4.3.3Strain Plots of S-guard beam.

Figure shows the Strain in the S-guard rail of TOX joint connection. From the Strain plot we can see that the strain percentage is 63.3 percent. It shows that the S- guard rail has strained to 63.3%. Two figures of Strain plots we can see that the connection with TOX joints has strained maximum and thus more energy is absorbed by introducing TOX joint.

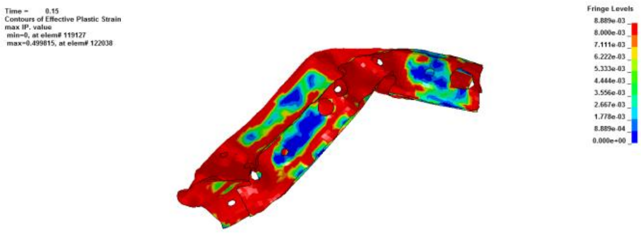

Figure 6 : Strain plot of S-Guard Spot weld Connection

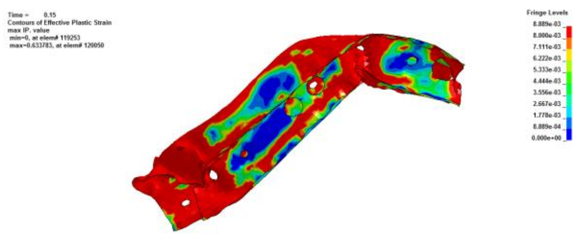

Figure 7 : Strain plot of TOX joint Connection

4.3.4Force Plot of S- guard rail.

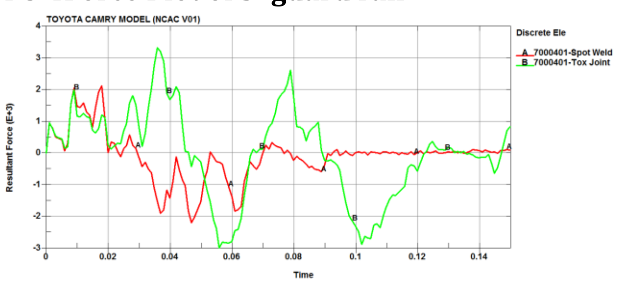

Fig 8: Force induced in S-guard rail

S Guard Rail (Spot Weld): 2100 KN

S Guard Rail (TOX Joint): 3200 KN

4.4 Strains and energy absorbed in Chassis Frame.

4.4.1 Strain Plots in Chassis Frame.

From plots we can see that the strain induced using spot weld connection is 28.62% and using spot weld connection is 113.35%. So the TOX joint induces more strain and the energy absorbed is more compared to spot weld.

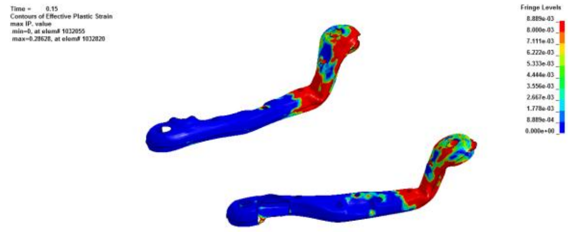

Fig 9: Chassis frame using Spot weld.

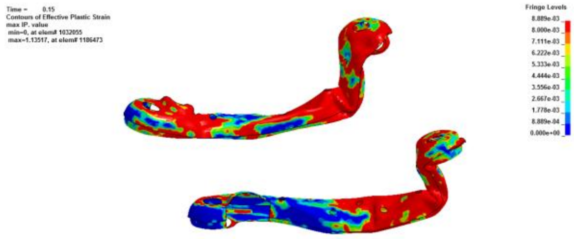

Fig 10: Chassis frame using TOX joint.

4.4.2 Internal Energy absorbed by Chassis frame.

From the below graph it can be seen that the energy absorbed by chassis frame in spot weld connection is 22KJ and energy absorbed using TOX joint in chassis frame is 48KJ. From this we can say that TOX joint absorbs more energy and reduce human injuries into the compartment.

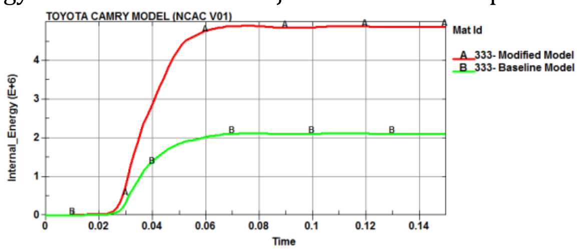

Fig 11: Internal Energy absorbed in both Joints

4.5 Results of Modified Crash Box.

4.5.1 Force Plots in Modified Crash Box.

Section force observed in crush box during frontal impact scenario with modified crush box are as follows.

- Force absorbed by crush box with spot weld connection is 3200KN
- Force absorbed by crush box with TOX joint is 5000N.

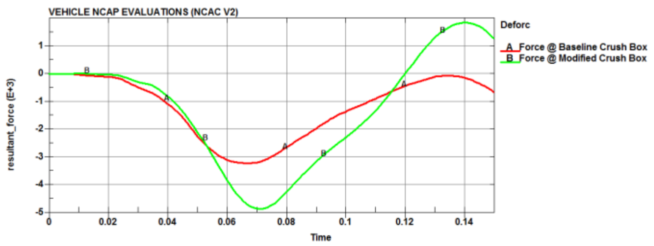

Fig 12: Force absorbed by Crush Box

It explains the section forces induced in the modified Crash box. From the above figure we can say that the modified is more than the baseline model. So we can say that the modified crash box yields better results.

4.5.2 Effective plastic strain plots in Crash Box.

The below figure explains the effective strain plots in Crash Box.

Strain percentage in Modified model is 103.95%.

Strain percentage in baseline model is 67.83%

Fig 13: Strain plot of baseline crash box

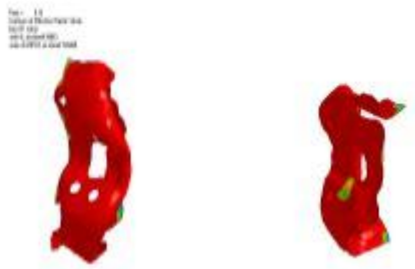

Fig 14: Strain Plot of Modified Crash Box

4.6 Force Plot in Bolt Joint.

From the below figures we can see that the force induced in modified model of bolt joints of frontal chassis assembly is more than the force absorbed in Baseline model. From this we can say that the energy absorbed is more in modified model and yields better results.

- Baseline Model- Maximum force induced in Bolt connection is 500N
- Modified Model- Maximum force induced in Bolt connection is 1000N

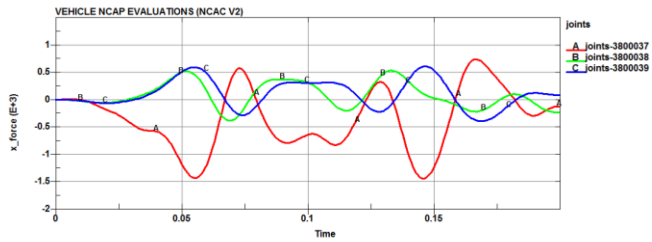

Figure 15: Force in Baseline Model.

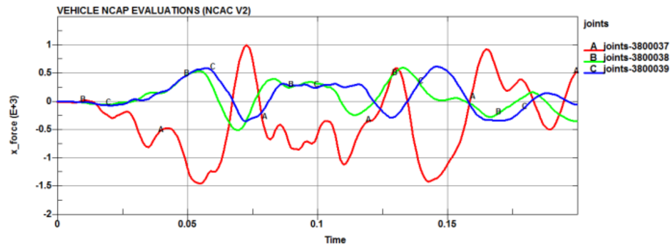

Figure 16: Force in Modified Model.

5. Summary of results.

In this section we will discuss and compare the results such of contour plots, section forces of individual parts, contact forces and displacements obtained from the simulation of baseline model and Modified model. The table shows the summary of contour plots of various parts involved in a Vehicle. The table shows the comparison between results of simulation of BIW using Spot weld connection and TOX joint connection. It also shows the comparison of the risk factor involved in both connections.

Table 2: Summary of contour plots

Part description	Yield strength Mpa	Simulation of Baseline Model				Simulation of Modified Model			
		Internal Energy absorbed(KJ) or Force (N)		Effective plastic strain (%)	Risk factor	Internal Energy absorbed(KJ) Or Force(N)		Effective plastic strain (%)	Risk factor
S-Guard Rail	350	100KJ	40KJ	49.9	Major risk	110KJ	42KJ	63.3	Low risk
Crash Box	350	3200N		67.83	Major risk	5000N		103.95	Low risk
Chassis Frame(Part)	350	22		0.57	Low risk	48		113.35	Low Risk

By introducing the TOX joints in the BIW structure of the vehicle body we can see many changes in the behavior of the different parts in the vehicle. The changes that took place after both the simulations are in force in the different parts and energy absorption and effective plastic strain. The changes are as follows:

1. The S-Guard rail which is an important part in vehicle crash scenario, the energy absorbed in the baseline model is less compared to the modified

model. To improve the Crashworthiness, the rail should absorb as much energy possible and only transfer less amount of energy. The energy absorbed in the modified where the TOX joints are introduced is more and thus reduces the risk factor and the effective strain is also more compared to baseline model.

2. The Crash box also plays an important role in the energy absorption criteria. The force absorbed with baseline model is less as compared to the modified model and the strain percentage in the modified model has increased by introduction of TOX joints.
3. Chassis frame part also plays a vital role in energy transfer. The energy absorbed in the baseline model is less and also the strain percentage is less compared to the modified model.

By these observations we can say that the introduction of TOX joints in the BIW structure brought about a change in the crashworthiness of the vehicle. The TOX or clinching technology which has been introduced in recent years in the vehicle joining process will bring about the change in Frontal impact and improve the Crashworthiness of the vehicle and reduce the human injuries.

6. CONCLUSION

On this project work, crash evaluation of frontal collision of automotive simulation is applied. Simulation is implemented in two instances which are with spot weld connections and TOX joint. Right here Altair Hypermesh v11 tool is used for meshing the whole model and passed the excellent standards's comparable to quality Index, Skewness, warpage, Jacobian etc. The FE model is successfully analyzed utilizing LS Dyna application and material; connections of the model are created as per current industry practices in an effort to co-relate it with realistic simulation. After finishing the analysis contour plots, global section force of entire model, energy absorbed of each the simulations are compared.

By introducing the TOX joints in the BIW structure of the vehicle body we can see many changes in the behavior of the different parts in the vehicle. The changes that took place after both the simulations is force induced in the different parts and energy absorption and effective plastic strain. The changes are as follows:

The S-Guard rail which is an important part in vehicle crash scenario, the energy absorbed is 100KJ for 1st part and 40KJ for 2nd part in the baseline model which is less compared to the modified model. To improve the Crashworthiness, the rail should absorb as much energy possible and only transfer less amount of energy. The energy absorbed in the modified where the TOX joints are introduced is more compared to baseline model and thus reduces the risk factor.

The effective strain of S-guard rail is 49.9% of Baseline model wherein the strain absorption percentage is 63.3% for Modified model.

The Crash box also plays an important role in the energy absorption criteria. The force absorbed with baseline model is 3200N which is less as compared to the modified model where the force induced is 5000N and the strain percentage in the modified model has increased by introduction of TOX joints i.e 67.83% for baseline model and 103.95% for modified model.

Chassis frame part also plays a vital role in energy transfer. The energy absorbed in the baseline model is 22KJ and for Modified model is 48KJ and also the strain percentage is less compared to the modified model. The strain in Chassis frame part is 28.62% using Spot weld connections and 113.5% using TOX joints.

The forces induced in Bolt joints of Front assembly chassis frame for baseline model is 523N and for modified model is 1032N.

By these conclusions we can say that the modified Model unit with TOX joints is safe and improves the Crashworthiness of the vehicle. The improvement in the Crashworthiness of the vehicle means less fatal human injuries, hence by introducing the TOX joints, energy absorbed by the parts of the vehicle is more compared to Spot welds. More the energy absorbed by the parts in Frontal structure less the energy transferred to the seating compartment. Thus we can conclude that TOX joints have more strength than Spot welds and thus reduces the scatters and bifurcations.

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