Design and Analysis of Side Door Intrusion Beam for Automotive Safety

SWAPNIL GOSAVI[1], YOGESH BADGUJAR[2], MAYUR BEHARE[3], MAYUR CHAVAN[4], NIKHIL DHANWADE[5]

[1] *Assistant Professor, PES Modern College of Engineering, Pune.*

[2, 3, 4, 5] *Student, PES Modern College of Engineering, Pune.*

Abstract— Vehicle side impact is the condition of the two vehicles, in which the vehicles collide with each other at 90° or at some other angle. Space between the passenger and door is very less and there is no room for energy absorption during the side collision of vehicle therefore, side impact beam plays an important role in protecting the occupants. The intrusion of an opposing vehicle depends upon the stiffness of the door, door beam, sill region, b-pillar region, seat cross members. This study is based on the selection of proper cross-section of side intrusion beam for SUV. Side Door Intrusion Beam is one of the main energy absorbing part in event of side impact. This work focuses on comparative study of three cross-sectional profiles and three materials for side door intrusion beam. A detailed FEA & experimental study has been performed to analyze the static and dynamic behavior of different cross section profiles & materials of side door intrusion beam in the event of side impact. Comparative study of side door intrusion beams has been made to find out the force reaction and energy absorption capacity of the beam to protect the occupant from the side collision by using FEA software. Final side door intrusion beam will be testing on UTM for resistance force is validated on three point bending experimental test.

I. INTRODUCTION

Road safety is one of the major global concerns regarding the protection of human lives. Every year, 1.2 million people die in road related accidents, and 20-50 million suffer from non-fatal injuries. After frontal crash, side impact is the leading cause of road fatalities. Designing safety systems for preventing the accident, or controlling the damages it inflicts on the passengers once it occurs, is a global research subject in which the work developed in thesis is inserted. The side intrusion beam is a protective component installed in the vehicle door, designed to enhance passengers safety in the event of a side collision. This structure's role is to absorb the maximum amount of impact energy through an elasto-plastic deformation process. Thin-walled beams are frequently applied due to their high energy absorption capacity. Metals are commonly selected for the beam design, since they combine a high strength with an also high ductility, both crucial to energy absorption. The present work focuses on studying the impact of the cross-section geometry and material of a thin-walled beam in its bending performance.

II. LITERATURE SURVEY

This research paper focuses on comparative study of three cross-sectional profiles, three gauges and three materials for side door intrusion beam. A detailed numerical & experimental study has been performed to analyze the static and dynamic behavior of different cross section profiles, gauges & materials of side door intrusion beam in the event of side impact. Comparative study of side door intrusion beams has been made to find out the force reaction and energy absorption capacity of the beam to protect the occupant from the side collision by using FEA software. Taguchi method is used to determine the optimized design parameter by using static analysis of FEA model on three point bending simulations. Optimal design of side door intrusion beam with optimal energy absorbing capacity and resistance force is validated on three point bending experimental test. The Effectiveness of the optimal door beam design is verified on full vehicle side impact simulations. [1]

In this research paper FEA models have been developed with different cross-section to do three point bending test. Iterations are taken using LS-DYNA. Improved parameters are determined on the basis of maximum bending load capacity. The Bending force required for different sections are evaluated and compared. Optimum design of ‘side intrusion beam’ which is best performing for intrusion is determined. Research is started to change the current side impact beam with the better development and using a different cross-sections with same material as well as different material on the other hand in order to reduce the total weight of the vehicle without minimizing the safety of the passenger. In accordance with the basic principles of crashworthiness which states that the intrusion of the striking vehicle should be minimum and the deformation ability of the deforming structure should be low. [2]

In this research paper, full scale side impact test finite element model were presented. The test numerical models are based on FMVSS-214. The crash simulation utilized the LS-DYNA finite element code. The capacity of impact energy absorption of side door is discussed. Analyses on the performance of the beams in side crashes include displacement and intrusion measurement of door and injury analysis of dummy. This paper indicates that the side door beams have considerable potential for reducing occupant injuries. [3]

This paper presents a proprietary side impact protective door system within the space between the outer skin of a car door and the occupant, which will be as efficient as those already standard in frontal impact. [4]

III. METHODOLOGY

Modelling of side door intrusion beam of an SUV in CATIA V5R20 software. This work focuses on comparative study of three cross-sectional profiles. A detailed FEA & experimental study has been performed to analyze the static behavior of different cross section profiles & materials of side door intrusion beam in the event of side impact.

Final side door intrusion beam will be testing on UTM for resistance force is validated on three point bending experimental test.

IV. THEORY CALCULATIONS

Considering reference from research papers,
Length of beam: 450 mm
If mass of the car = 2000 Kg
Velocity of the vehicle= If the vehicle is running at 50 Kmph so the the velocity is 14 m/sec
Distance of crash= 0.5 m
Impact force can be calculated as
K.E. = F*d
1/2mv^2= F*d
F= 392 KN
Considering this Impact force as point load Lets study the behavior of different profiles selected namely:
1] C-section.
2] Round Cross section.
3] Square cross section.
For C-channel:
Ixx = 14801.83 mm4
P= 392 KN
Maximum bending moment:
Mb = Wl/4 = 392000x0.45/4= 44.1KNm
Mb = 44.1x10^6Nmm
Lets compare σb for all the profiles:
For C-section:
M = 44.1x10^6 Nmm
I = 14801.83 mm4
y = 12.5mm
σb = (M/I)*y = 37242.016 N/mm^2
For Round section:
M = 44.1x10^6 Nmm
I = 9623.31 Nmm
y = 12.5mm
σb = (M/I)*y = 57282.75 N/mm^2
Use For Square section:
M = 44.1 * 10^6 Nmm
I = 16345.33 mm4
y = 12.5mm
σb = (M/I)*y = 33725.22 N/mm^2

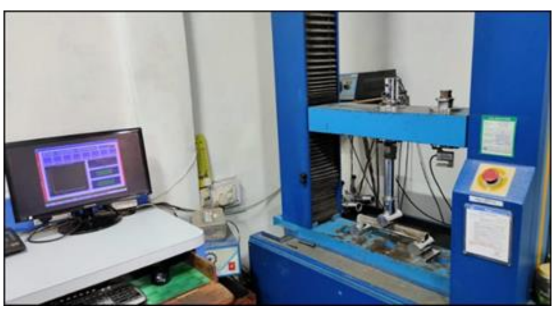
Since σb for square section is lower than rest of the profiles, we should select square pipe cross-section.

V. EXPLICIT DYNAMIC ANALYSIS

"Implicit" and "Explicit" refer to two types of time integration methods used to perform dynamic simulations. Explicit time integration is more accurate and efficient for simulations involving – Shock wave propagation – Large deformations and strains – Non-linear material behavior – Complex contact – Fragmentation – Non-linear buckling. Typical applications are drop tests and impact and penetration. ANSYS Explicit Dynamics analysis software provides simulation technology to help simulate structural performance long before manufacture. ANSYS explicit dynamics analysis software solutions are capable of solving short-duration, large-strain, large-deformation, fracture, complete material failure, and structural problems with complex contact interactions. We are going to perform three different iterations and find out which is better.

VI. EXPERIMENTAL TESTING

Component is placed in the position according to the analytical boundary condition.On UTM machine the deflection of beam is given as input as per the deflection the reaction force is plotted on the graph.The constraint for deflection of beam is set as 5 mm and the reaction forces are plotted.



CONCLUSION

Explicit analysis is performed on the different profiles of intrusion beam, from FEA results the square cross section is observed to have upper hand as compared with other two profiles. As the reaction force of the different profiles are observed , the reaction force of square cross section is better. As the reaction force better it will react to the forces applied on the beam more effectively than other profile. To increase the force reaction of square cross section reinforcement of E-glass fiber is done on the beam by hand lay-up method. This reinforced beam is validated on UTM machine.

PROFILE	REACTION FORCE	TOTAL DEFORMATION	EQUIVALENT STRESS
C-SECTION	20727	17.404 mm	2440.5 MPa
ROUND SECTION	9236.5	13.417 mm	1962.3 MPa
SQ. SECTION	39869 N	11.139 mm	2230.4 MPa

SR NO	TESTING FOR 5 mm DISPLACEMENT	REACTION FORCE(N)
1	FEA TESTING	7909 N
2	EXPERIMENTAL TESTING	7585 N

FROM THE ABOVE ANALYSIS IT HAS BEEN PROVED THAT THE SQUARE CROSS SECTION IS THE BEST PROFILE FOR SIDE DOOR INTRUSION BEAM.

REFERENCES

[1] "Design and analysis of side door intrusion beam for automotive safety" By Kiran C. More , Girish M. Patil, Akash A. Belkhede Volume 153, August 2020, 106788

[2] "Development of Side Door Intrusion Beam of Passenger Car For Maximum Bending Load" By Yogesh K. Nichit, Prof. Arun. K. Battu IJSART - Volume 3 Issue 8 –AUGUST 2017

[3] "Crashworthiness Evaluation of Side-door Beam of Vehicle." By T.L. Teng , K.C. Chang, T.H. Nguyen.

[4] MODULAR DOOR SYSTEM FOR SIDE IMPACT SAFETY OF MOTOR VEHICLES" By John Townsend, Michael Kaczmar, Mohamed El-Sayed

[5] "DEVELOPMENT AND ANALYSIS OF SIDE DOOR INTRUSION BEAM OF SUV" By Raghvendra Krishana, Shivangi Yadav, Rajeev Kumar and H. K. Paliwal Volume 9, Issue 9, September 2018, pp. 915–922, Article ID: IJMET_09_09_101

[6] "Impact of anti-intrusion beam effectiveness on reducing fatalities and injuries of vehicle occupants." By E. Černiauskas, A. Keršys, V. Lukoševičius, R. Skvireckas

[7] Design Study of a Side Intrusion Beam for Automotive Safety.” By Pedro Mota Rebelo