Simulation Analysis Of Dynamic Dent Resistance On Auto Body Panel

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Abstract

In automotive industry there is increasing demand for higher quality exterior panels. Better functional properties and lower weight. The demand for weight reduction has led tothinner sheets, greater use of high strength steels and a change from steel to aluminum grades.This thickness reduction, which causes decrease in the dent resistance, promoted examination ofthe dent resistance against static and dynamic concentratedloads. This paper describes aninvestigation of the suitability of explicit dynamic FE analysis as a mean to determine thedynamic dent properties of the panel. This investigation is carried out on the body panel ofutility vehicle and covers two parts, in first experimental analysis is carried out on developed testrig, which is interfaced with the computer. This test rig measures deflection with accuracy of.001mm. The experimental results are then compared with the simulation results, which is thesecond part. Simulation is carried with non-linear transient dynamic explicit analysis usingAnsys -LSDyna software. The experimental results show great accuracy with simulation results. Theeffect of change in thickness and geometry of the existing fender is then studied with help ofsimulation technique. By considering the best possible option overall weight offender is reducedby 7.07 % by keeping the dent resistance of the panel constant.

Keywords: Dent resistance, Explicit Dynamic, Test rig. Automotive.

1. INTRODUCTION

A localized plastic deformation caused by an impact on a sheet metal is describedas dent. Quantitatively a dent is in the terms of physical features such as depth,diameter, and width. Dent resistance is defined as minimum force or load required toinitiate a dent and hence is measure of suitability of a particular sheet metal in a givenapplication like automotive panels. Denting in the real world is random. Dent inautomotive panels can be produced by in plant handling or in service. Impacting apanel on another or dropping a panel onto a holder or conveyor can occur infabrication. In service, dents caused by flying stones, door or shopping cart impact inparking lots, palm printing, hail force etc. are also normal. The cost for repairing thedamage is relatively high. Thus minimizing this kind of damage has become a goal ofthe automotive manufacture particularly when thin sheet steel is used. Improvementcan also enhance perceived product value. In automotive industry there is increasingdemand for higher quality exterior panels, better functional properties and lowerweight. The demand for weight reduction has led to thinner sheets, greater use of highstrength steels and a change from steel to aluminum grades. These demand have meant that the stiffness and dent resistance of panels has become more focused, and the needfor accurate methods, both experimental and numerical, for pre detecting the stiffnessand dent resistance has been emphasized. In present work dynamic dent resistance ofauto body panel is estimated both by experimental and numerical methods and theresults are validated.Dent resistance can be measured by static as well as dynamic methods, as perrequirements. For static dent testing, data are typically compared by analyzing dentdepths caused by a fixed load or by comparing the load necessary to cause a fixed dentdepth. Dynamic Dent test of laboratory specimen are run on test systems referred to asDrop-weight-tester. In the drop weight test typically a specimen and an indenter isused, the indenter is dropped from the height and typical load deflection curve isplottedMany studies regarding the dent and stiffness of automotive panels have beencarried out, some with contradictory results. Dicello and George [1] came to theconclusion that the lower stiffness of the panel, the better the dent resistance. Yutori etal [2] found that the higher the stiffness, higher is the dent resistance, there seems tobe no simple relation between the stiffness and dent resistance. Werner [3] concludedthat for a panel with low stiffness it is beneficial to reduce the stiffness, whereas for apanel with high stiffness it is beneficial to increase the stiffness in order to improve thedent resistance. In [4] it was found that the static dent resistance is directlyproportional to the final yield stress of the material (i.e. work-hardening duringstamping and bake-hardening during painting). In [5] it was found that bake hardenedsteels show batter dent resistance than non bake-hardenable steels, even though thematerials had a similar thickness and yield stress after forming. A comparison betweenthe dent properties for steel and aluminum was made in [6], it was concluded thatthere is a principal difference between the appearance of these curves for steel andaluminum. The curves for aluminum shows a local maximum in dent resistance at thepanel curvature, where as the curves for steel shows a local minimum.Dent resistance is complex in nature and governed by various factors such as thepanel geometry and curvature, the support conditions, the sheet thickness, the materialproperties of the sheet material, the load level and load type. In addition, the effect ofthe stamping process resulting in thickness reduction, work hardening of the sheetmaterial, residual stress and springback also directly or indirectly affecting the dentresistance. In general conclusion that can be drawn from different investigation carriedout is that the dent behavior is complex phenomenon depending on several differentparameters and that is hard to intuitively assess the dent properties. Anotherconclusion that can be drawn is that there, in general, is a large scatter in theexperimental results reported in the literature, which increases the complexity of thedent behavior of the auto body panel. Today, stiffness and dent resistance of outerpanels, such as doors, hoods and lids are normally determined by physical testing.However zsthis testing procedure has several drawbacks. It is both costly and timeconsuming but most importantly it cannot be carried out until rather late in the carproject, in general towards the end of the design process. By then most of the factorsgoverning the stiffness and dent properties are already specified. Thus prediction ofpanel's strength properties at an early stage in the design process is required, which ispossible by simulation technique.

2. AUTO BODY PANEL AND ITS MATERIAL

The material used for fender is steel with Young's Modulus of 210 GPa and Nux (Poisson's ratio) value of 0.3. The material characteristics of the fender are given in table 1 . In the table t denotes the initial sheet thickness

Table 1 – Material properties of body panel

Material	t	σ_y	S_{ut}	r_0	r_{45}	r_{90}	n	E	v
	mm	Mpa	Mpa					GPa	
MS	1	143	290	1.96	2.6	2.11	0.22	120	0.3

σ_y is the yield strength, S_{ut} is the ultimate tensile strength r_0, r_{45}, r_{90} are the anisotropy coefficient in terms of ratio of width strain to thickness strain, n is the strain-hardening exponent, E is Young's modulus and v is Poisson's ratio.

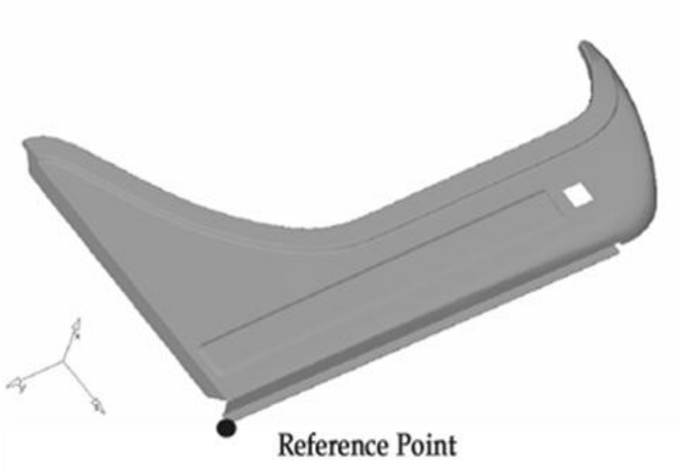


Figure 1 Front fender of auto body panel

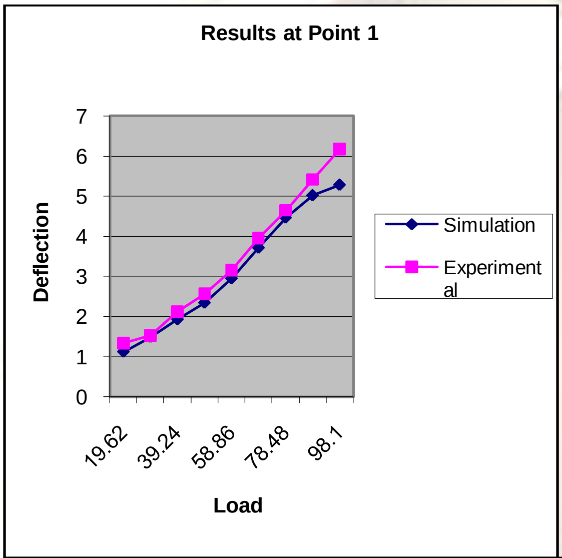
3.EXPERIMENTAL AND SIMULATION PROCEDURE

For experimental determination of dynamic dent resistance of auto body panel testrig is developed this test rig consist of two mainparts viz. body of test rig andinterfacing unit. The body of the test rig is designed so as to test the door, fender,hoods etc. of automobile. Interfacing unit is used for converting analog signals comingfrom the transducer to digital one for getting data on computer for load deflectioncurve.In experimental procedure the dent resistance of fender is calculated at threedifferent points, denter is allowed to fall from the height of 101.2 mm this drop heightproduces initial drop velocity of 1.38 m/s [7] For denting different loads varying from19.62 N to 98.10 N were used. The fender is kept on the two supports, the distance oftwo supports from the dent point is 100 mm from both side. Distance of threedifferent dent points on the fender from the reference point (as shown in figure 1) in xand z direction is given in the table 2. Initially the denter is vertically aligned with thefirst point, the denter plate is so adjusted that the distance between the tip of the denterand the upper surface of the fender is 101.2 mm, at this point denter plate is fixed onthe vertical studs by tightening the screws. The tip of the transducer is kept exactlybelow the first point touching the bottom side of the fender. The denter is allowed tofall on the fender from the said height, this impact causes plastic deformation of thefender, which gives the value of the dent by calculating the difference between theinitial reading and the final reading of the transducer. This procedure is repeated forthe different loads and the different points.Simulation is carried out with AnsysLs-Dyna, which combines the Ls-Dynaexplicit finite element program with the powerful pre and post processing capabilitiesof the Ansys program. Shell 163, a 4-noded element with both bending and membranecapabilities is used. The element has 12 degrees of freedom at each node: translations,accelerations, and velocities in the nodal x, y, and z directions and rotations about thenodal x, y, and z-axes. For getting accurate results fine meshing is done with theHypermesh and then model is imported to the Ansys for analysis.

Table 2. Location of analysis points from reference point

Point 1		Point 2		Point 3	
Z	Y	Z	Y	Z	Y
-160	-120	-70	-400	-120	-550

4.EXPERIMENTAL AND SIMULATION RESULTS OF THE FENDER



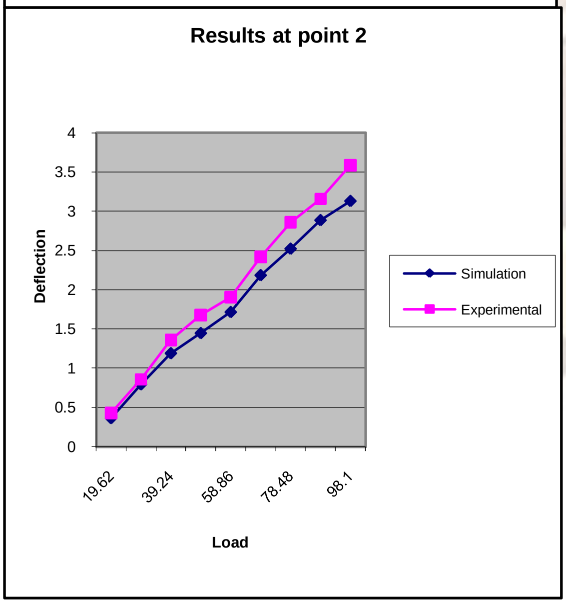


Figure 2 - Results at point 1 and 2

Figure 2 and figure 3 shows the comparison of load deflection curve at point 1, 2 and 3 calculated by the experimental and the simulation procedure. As can be seen from figure 2 and 3 experimental result shows close accuracy with simulation results. At indentation points 1, 2 and 3 it can be seen that the deformation is slightly more the experimental work., however the overall behavior is captured with variation of 5%. The three indentation points were selected from different parts of the geometry where there are different values of the strain levels

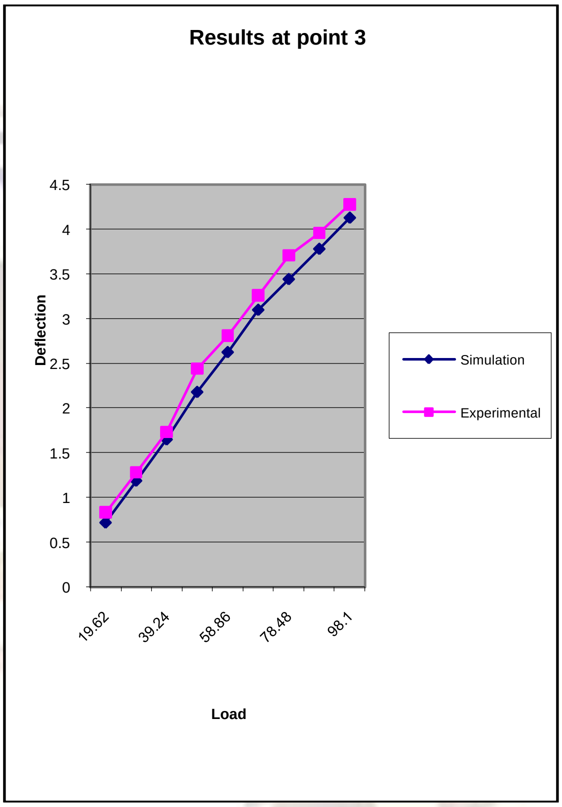


Figure 3- Results at point 3

5.SIMULATION RESULTS OF MODIFIED FENDER

The existing geometry of the fender is modified by sweeping the panel withcurvature of 7 mm as shown in the following figure 4. Numerical analysis is carriedout on modified fender for which same boundary conditions, same material propertiesand same denter with its material module is used. Simulation results of modifiedfender at different points and different loading conditions from 101.2 mm height iscalculatedIn numerical analysis offender while defining the real constant the thickness of the fender is assigned as 1 mm. In case modified fender denting

Figure 4 - Modified fender

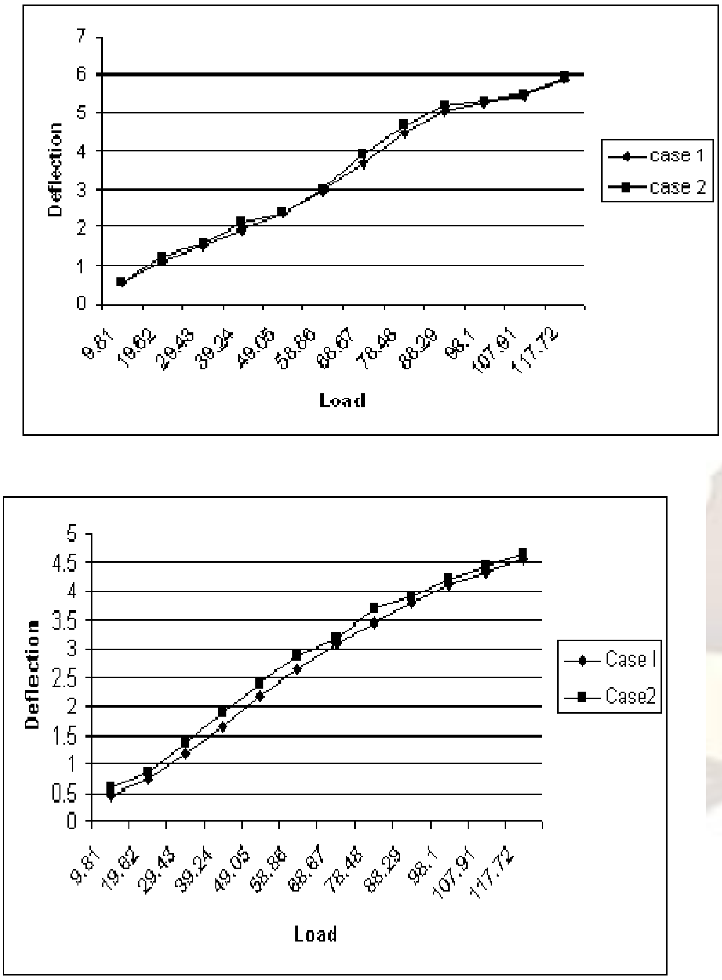


Figure 5 – Simulation results of Modified Fender at points 1 & 2

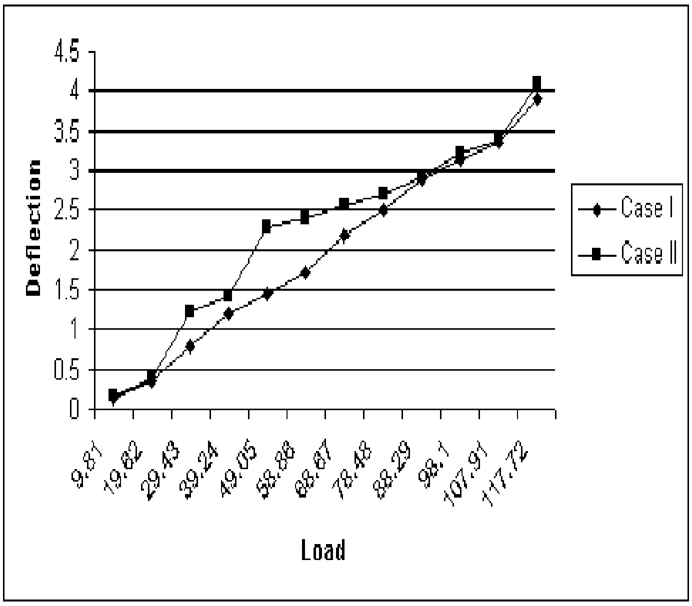


Figure 6 – Simulation results of Modified Fender at points 3

values are calculated by changing the thickness values, at thickness of 0.91mm dent values of modified fender are closely matching with the dent values of the fender as shown in figure 5and 6, this thickness reduction gives 7.07 %of weight reduction in modified fender.

CONCLUSION

An Experimental test method for determining dynamic dent resistance wasdeveloped. The results from the test carried out shows small scatter within ±5% ofaverage value.. Experimental results show greater accuracy with the simulation results.So AnsysLs-Dyna can be used to predict the dent behavior of auto body panel in earlystage of design process. Dent resistance of auto body panel can be improved bychanging the geometry of the panel. In present case dent resistance is improved bysweeping the panel geometry of the fender by 7mm. Weight reduction of 7.07% offender is also possible by changing the geometry of the panel with keeping dentresistance in the limit.

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