Modal Analysis and Stiffness Optimization of Glass Fibre Reinforced Mudguard Using FFT & FEA Analysis

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Abstract— Mudguards of two wheelers are subjected to harmonic and random vibration due to various road conditions. They are made up of Plastic or sheet metal structures which undergo failure at joints or cantilever ends. Reinforcement of these existing structures with epoxy and glass fiber will strengthen it in its dynamic characteristics. Modal analysis will be carried out to investigate stiffness of existing and reinforced structure. Modes shapes and resonant frequencies will be checked for both models. FFT analyzer and Impact hammer will be used to perform experimental modal analysis. Validation will be done by comparing both experimental and FEA results. Suitable conclusions will be drawn and future scope will be suggested.

Keywords: Glass fiber Reinforcement, FFT analyzer, FEA, Mudguard

I. INTRODUCTION

The automotive industry is poised to make the lightweight designs to get the cost and weight benefit along with customer delight. So main emphasis is given on the thickness reduction of frame/body panels and use of alterative materials.

The use of simulation software in metal forming process has increased significantly in recent years as the benefit of trouble shooting and optimizing process on the computer rather than through extensive shop floor trials have been realized. The rapid development of software technology, together with faster and lower cost computer hardware, have recently enabled many manufacturing operations to be modeled cost-effectively that only a few years ago would have been considered impractical. Many of these advances have been made possible by tailoring and optimizing programs for specific applications, which has resulted in the general terms of “sheet forming” and “bulk forming” applied to different types of process modeling software. However, the choice of software for an uninitiated company is not always as simple as this classification. For examples, sheet metal forming is currently developing much interest in the globe as a means of reducing both the development cost of stamping a new part and the production lead-time. These costs are accumulated over the entire development process from initial part design to the final production tool. The correct software tool will depend on both the application and the stage of product development.

Design of sheet metal forming is traditionally relying on the experience accumulated by tool design engineers through long and costly trial and error experiments. Simple empirical methods provide some guidelines for cases similar to those on which these methods were developed. In increasing number of cases with complex geometry's and thinner stronger materials, experiments are used extensively consuming time and money before providing a workable solution. These experiments usually lead to one severity conclusion (the pressed part fails or not) with little if any information on the safety margin.

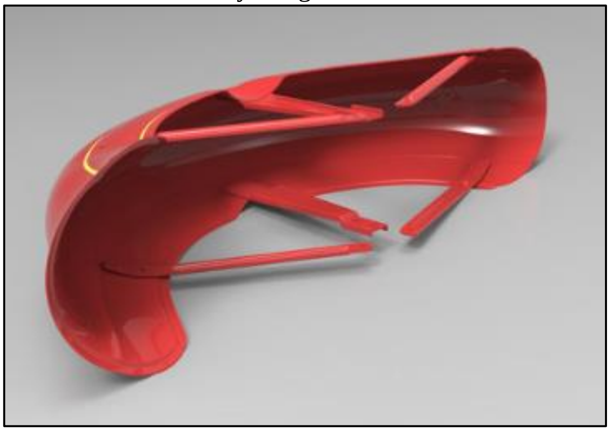


Fig. 1: Actual Mudguard

II. LITERATURE REVIEW

S.M.Chavan 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 to thinner 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 of the dent resistance against static and dynamic concentrated loads. This paper describes an investigation of the suitability of explicit dynamic FE analysis as a mean to determine the dynamic dent properties of the panel. This investigation is carried out on the body panel of utility vehicle and covers two parts, in first experimental analysis is carried out on developed test rig, 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 the second part. Simulation is carried with non-linear transient dynamic explicit analysis using Ansys -LSDyna software. The experimental results show great accuracy with simulation results. The effect of change in thickness and geometry of the existing fender is then studied with help of simulation technique. By considering the best possible option overall weight offender is reduced by 7.07 % by keeping the dent resistance of the panel constant.[1]

Pankaj K. Bhoyar et al. Super plastic forming (SPF) is a near net-shape forming process which offers many advantages over conventional forming operations including low forming pressure under low flow stress, low die cost, more design flexibility, and the ability to shape hard metals to form complex shapes. However, low production rate due to slow forming process and limited predictive capabilities provides lack of accurate constitutive models for super plastic deformation, treated as an obstacle to the widespread use of

SPF. Recent advancements in finite element tools have shown while analyzing the complex super plastic forming operations. These tools can be utilized successfully in order to develop optimized super plastic forming techniques to develop the future materials. To present the discussion mentioned above an analysis of super plastically formed front Fender car panel using HYPERFORM 9.0 software is elaborated here. Present work consist of a finite element simulations of super plastic forming of aluminum 5182 & 8090 alloy sheet in to the front fender panel of car is carried out at 4600C-5000C temperature to estimate the pressure tonnage, % thinning & major & minor strain in terms of FLD curve. Further analysis is carried out by increasing the blank holder pressure & compares the results from different pressure levels (low, medium & high), by considering better pressure level comparison of Al alloy 5182 sheet to the Al-Li alloy 8090 sheet has been explained. The major objective of present paper is to introduce the future material as a substitute in automobile industries [2].

Mehmet C et al. The aim of this study is to increase power/weight ratio of a steel-alloyed vehicle body without any structural weakness and to use an integrated engineering solution of ‘‘computer-aided design, engineering and optimization (CADO)’’. In this optimization study, primarily the body’s ‘‘computer-aided design (CAD)’’ parametric model has been prepared for some static analyses are essential for the design study. In the following step, some critical dimensions of the structure’s parts have been defined as design parameters. The goal of the optimization study is a minimization of critical equivalent stress value is under the yield limit. In addition, a sensitivity study has been made on the body model with stress measures for an in-depth analysis. In various steps, Pro/Engineer CAD and Pro/MECHANICA computer aided engineering (CAE) software has been used. Finally, the obtained results have been presented as both visually and in diagrams or tables. In other words, this study can be defined as a computer-aided design and optimization application of a sophisticated three-dimensional (3D) sheet-metal structural model. Consequently, for the solution of a sophisticated structural design problem, it has been seen that integrated CAD/CAE programs supported optimization techniques are vital much more proper to provide the time, error and cost reduction compared to classical design processes, can be given as contributes of this study to previous literature.[3].

Jesús M. Blanco et al. Double-skin perforated sheet fac¸ ades, are enclosures composed of a perforated metallic sheet, air chamber and glass, is showing an increasing tendency in modern building design. In a previous research, their thermal behaviour was addressed, taking into account several physical parameters such as, perforation rates, colours and materials, as well as the influence of wind penetration through a Matlab®model, validated through a fully experimental test campaign, monitoring metallic sheets during 1 year, for different configurations, within a range of 0–35% (perforation rates), black-white (colours) and galvanized steel-aluminium (materials). Here, following this research, first of all, the behaviour of such configurations is also fully addressed, through a complete Energyplus®model (design builder), which was validated through the above mentioned Matlab®model and experimental outputs. The relevant contribution shows a new parametric energy assessment taking into account additional variables such as the air-gap and location (according to the different climate zones defined for Spain). Finally, the influence of different enclosures on the cooling, heating and lighting loads (energy consumptions) of the building as a whole was obtained, demonstrating the suitability of the previously optimized configurations in terms of relative energy savings. This leads to set up a new methodology aiming to the optimization of design sustainability based on minimum energy consumption.[4].

Baskaran et al. In the current scenario automobile industries focuses on enhancing the strength and reducing the weight of body parts. In two wheelers mudguard is provided to prevent the dirt’s and sand particles in tire from entering and damaging other parts. Presently most of which are made from ABS/Polypropylene plastics. They are of high cost and not completely degradable. In my work an attempt has been made to use strong and abundantly available sisal plant fibers as reinforcement in epoxy resin to make low cost, high strength and less weight substitute for mudguards. [5].

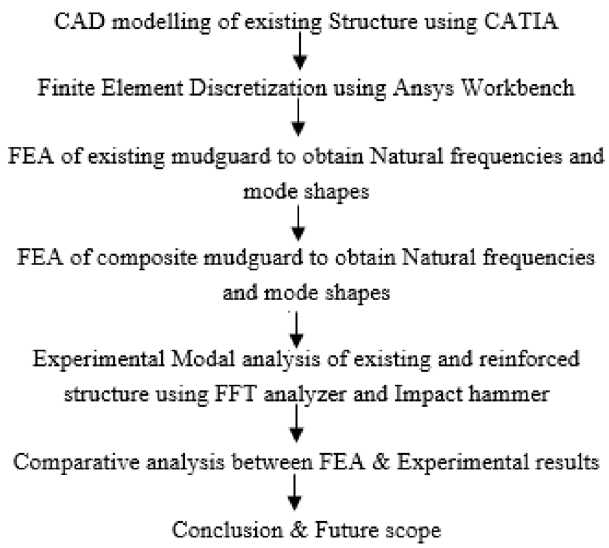
III. PROBLEM STATEMENT

Two-wheeler mudguards are subjected to harmonic and random vibration due to various road conditions. They undergo structural failures due to vibration excitations.

IV. OBJECTIVES

1) To enhance dynamic characteristics of existing mudguard by composite reinforcement
2) Composite reinforcement of epoxy resin and glass fibre will be done on existing structure
3) To measure natural frequencies and mode shapes using FEA and Experimental approach
4) To validate results and propose further future scope

V. METHODOLOGY



VI. STATIC ANALYSIS

A. Material Properties

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
5	Coefficient of Thermal Expansion	1.2E-05	C^-1
6	Isotropic Elasticity		
7	Derive from	Young's Modulu...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

B. Finite Element Analysis:

Design of existing suspension control Arm is done by using CAD package CATIA V5 as per following;

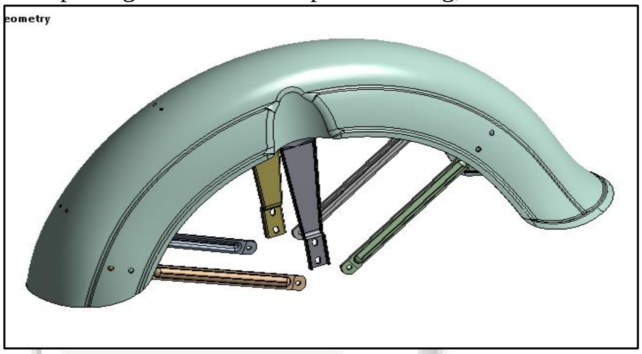
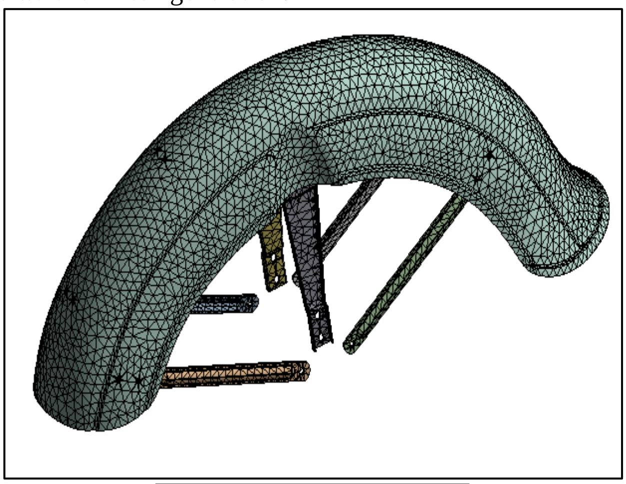


Fig. 2: CATIA model of Mudguard

C. Mesh

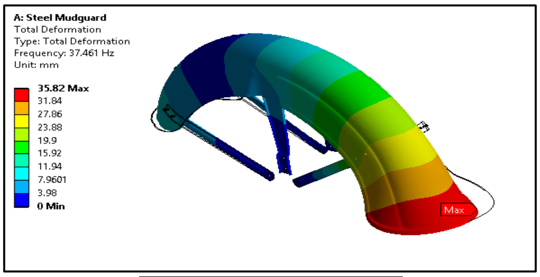
ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multiphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it. The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.



Statistics	
Nodes	74180
Elements	37117

Fig. 3: Solid Mesh

D. Results:



Tabular Data

	Mode	Frequency [Hz]
1	1.	37.461
2	2.	45.272
3	3.	89.738
4	4.	127.87
5	5.	152.17

Fig. 4: Modal Analysis

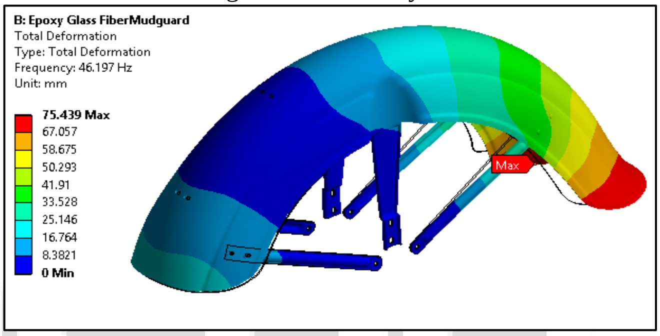
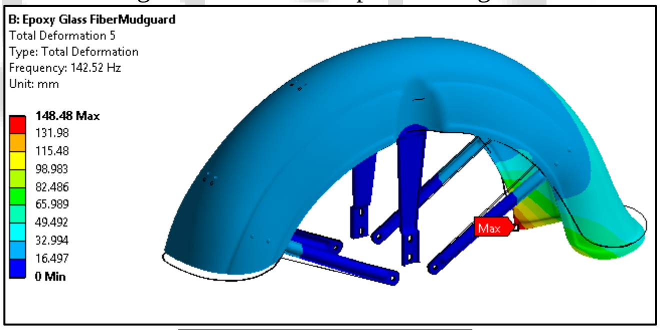


Fig. 5: Results of Composite Mudguard



Tabular Data

	Mode	Frequency [Hz]
1	1.	46.197
2	2.	54.798
3	3.	84.545
4	4.	115.07
5	5.	142.52

Fig. 6: Modal Analysis of Composite Mudguard

VII. EXPERIMENTAL TESTING

The experimental validation operation is done by using FFT Operation testing (Fast Fourier Transform) analyzer. The FFT spectrum analyzer samples the input signal, computes the magnitude of its sine and cosine components, and displays the spectrum of these measured frequency components. The advantage of this technique is its speed. Because System operation FFT spectrum analyzers measure all frequency components at the same time, the technique offers the possibility of being hundreds of times faster than traditional analog spectrum analyzers.

Fourier analysis of a periodic function refers to the extraction of the series of sines and cosines which when superimposed will reproduce the function. This analysis can be expressed as a Fourier series operation. The fast Fourier transform is a method of operation mathematical method for transforming a function of time into a function of frequency. Sometimes it is described as system transforming from the time domain to the frequency domain. It is very useful for all method analysis of time-dependent phenomena.

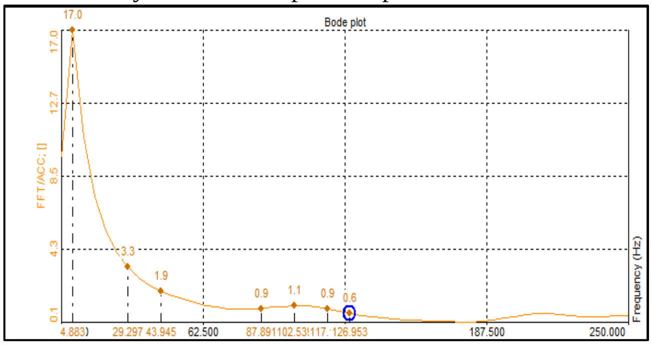


Fig. 7: Experimental Result of Steel Mudguard

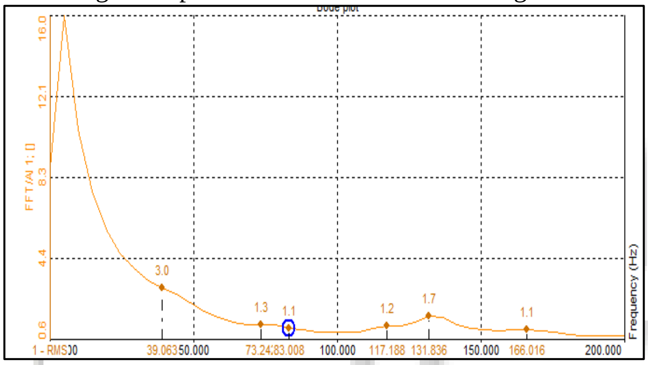
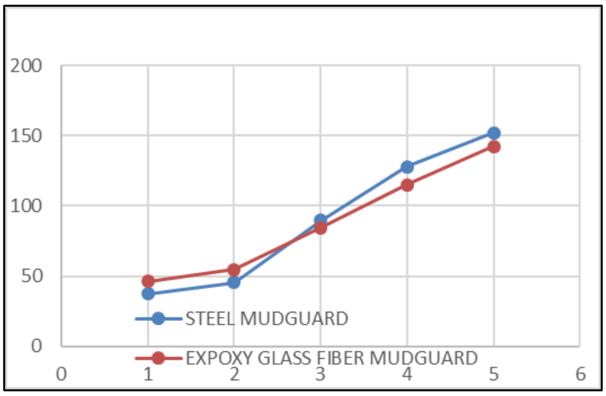


Fig. 8: Experimental Result of Composite Mudguard

VIII. RESULTS & CONCLUSION

MODE NO	STEEL MUDGUARD	EXPOXY GLASS FIBER MUDGUARD	STEEL MUDGUARD test	EXPOXY GLASS FIBER MUDGUARD TEST
1	37.461	46.197	29.29	39.03
2	45.272	54.798	43.94	73.24
3	89.738	84.545	87.89	83
4	127.87	115.07	102.23	117.18
5	152.17	142.52	126.95	131.83



From above graph it is clear that Natural frequency is higher at initial model for Epoxy mudguard and slightly less at higher order frequencies.

The Natural Frequencies obtained in the Analysis & Testing results are almost same so, the validation of the result is done.

Steel Mudguard has mass of 3.77kg and Epoxy glass fibre Mudguard mass is 1.58kg. Hence 58% reduction in mass is achieved which finally helps in increasing mechanical efficiency of vehicle as its controlled by mass of components.

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