International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Vibration response and Optimization of Swing arm through Hardening

Vidyadhar Sudarshan Dixit[†*], Masnaji Rajaram Nukulwar[†], Sunil Tukaram Shinde[†] and S. S. Pimpale[‡]

[†]Mechanical (Design Engineering) Department, SPPU, JSPMs Rajarshi Shahu College of Engineering Tathawade. Pune. India
[‡]Mechanical (Design Engineering) Department, SPPU, JSPMs RSCOE Tathawade Pune. India

Accepted 01 April 2016, Available online 05 April 2016, **Vol.6, No.2 (April 2016)**

Abstract

All machines, vehicles and buildings are subjected to dynamic forces that cause vibration. Most practical noise and vibration problems are related to resonance phenomena where the operational forces excite one or more modes of vibration. Modes of vibration that lie within the frequency range of the operational dynamic forces always represent potential problems. Mode shapes are the dominant motion of a structure at each of its natural or resonant frequencies. Modes are an inherent property of a structure and do not depend on the forces acting on it. On the other hand, operational deflection shapes do show the effects of forces or loads, and may contain contributions due to several modes of vibration. This Paper deals with optimization and modal analysis of the rear suspension arm used in motorbikes. Suspension arm has been modeled using CATIAV5, meshing will be done in HYPERMESH12.0, and ANSYS 15.0 will be used for post processing. Modal analysis will be performed. Optimization will be done by changing the material from MS to Al. Once we get desired results, model will be fabricated and tested with FFT analyzer to check for response of the Swing arm.

Keywords: *Swing Arm, Rear suspension frame, Optimization of Swing arm, Structural Analysis of Swing arm, Modal Analysis of two wheeler Rear suspension frame.*

Introduction

A swing arm or Swinging Arm originally known as a swing fork or pivoted fork, is the main component of the rear suspension of most modern two wheelers and ATVs. It is used to hold the rear axle firmly, while pivoting vertically, to allow the suspension to absorb bumps in the road. Originally two wheelers had no rear suspension, as their frames were little more than stronger versions of the classic diamond frame of a bicycle. Many types of suspension were tried, including Indians leaf spring suspended swing arm, and Matchless cantilevered coiled-spring swing arm. The swing arm has also been used for the front suspension of Scooter. In this case it aids in simplifying maintenance.

Swing arms have come in several forms:

Swinging fork - The original version consisting of a pair of parallel pipes holding the rear axle at one end and pivoting at the other. A pair of shock absorbers are mounted just before the rear axle and attached to the frame, below the seat rail.

Cantilever - An extension of the swinging fork where a triangulated frame transfer's swing arm movement to compress shock absorber/s generally mounted in front of the swing arm.

*Corresponding author: **Vidyadhar Sudarshan Dixit**

Parallelogram Suspension was first introduced commercially in 1985 on the Magni Le Mans. Magni called the system Parallelogrammo. Various parallelogram systems have been developed by other manufacturers.

A single-sided swing arm is a type of swing arm which lies along only one side of the rear wheel, allowing the rear wheel to be mounted like a car wheel (unlike the conventional motorcycle double-sided swing arm). Single-sided swing arms are traditionally found on small motorcycles or scooters, where a robust chain case doubles as the swing arm linking the engine and rear wheel. Single-sided swing arms need to be much stiffer than the double-sided versions, to accommodate the extra torsional forces, and as a result, they are usually heavier than double-sided arms. Having a single mounting point guarantees proper wheel alignment.

Induction hardening

Induction hardening is a form of heat treatment in which a metal part is heated by induction heating and then quenched. The quenched metal undergoes a martensitic transformation, increasing the hardness and brittleness of the part. Induction hardening is used to selectively harden areas of a part or assembly without affecting the properties of the part as a whole. Induction heating is a non-contact heating process which utilizes the principle of electromagnetic induction to produce heat inside the surface layer of a work-piece. By placing a conductive material into a strong alternating magnetic field, electric current can be made to flow in the material thereby creating heat due to the I2R losses in the material. In magnetic materials, further heat is generated below the Curie point due to hysteresis losses. The current generated flows predominantly in the surface layer, the depth of this layer being dictated by the frequency of the alternating field, the surface power density, the permeability of the material, the heat time and the diameter of the bar or material thickness. By quenching this heated layer in water, oil, or a polymer based quench, the surface layer is altered to form a martensitic structure which is harder than the base metal. Induction hardening is used to increase the mechanical properties of ferrous components in a specific area. Typical applications are powertrain, suspension, engine components and stampings. Induction hardening is excellent at repairing warranty claims / field failures. The primary benefits are improvements in strength, fatigue and wear resistance in a localized area without having to redesign the component.

Case hardening

It is process used to increase wear resistance, surface hardness and fatigue life through creation of a hardened surface layer while maintaining an unaffected core microstructure. Case or surface hardening is the process of hardening the surface of a metal object while allowing the metal deeper underneath to remain soft, thus forming a thin layer of harder metal (called the case) at the surface. For iron or steel with low carbon content, which has poor to no hardenability of its own, the case-hardening process involves infusing additional carbon into the case. Case-hardening is usually done after the part has been formed into its final shape, but can also be done to increase the hardening element content of bars to be used in a pattern welding or similar process.

Both carbon and alloy steels are suitable for case-hardening providing their carbon content is low, usually less than 0.2%. Case hardened steel is usually formed by diffusing carbon and/or nitrogen into the outer layer of the steel at high temperature. The depth of hardening is ultimately limited by the inability of carbon to diffuse deeply into solid steel and depth of surface hardening with this method is up to 1.5mm.

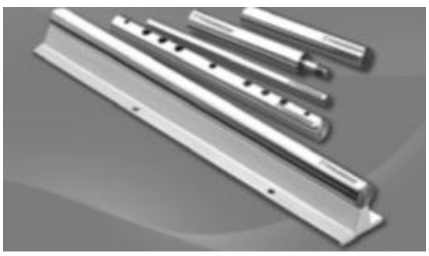

Fig. 1 Case hardened steel

The process of casehardening, however, increases the carbon content at the surface of mild-steel and, on quenching this layer, hardens in the same way as a carbon steel, though the core of the mild-steel remains soft. The depth of hard casing depends largely on the period during which the mild-steel is at red heat and in contact with the case-hardening compound.

Literature Review

Prof. M.Sc. Božič S, Prof. Gombač E, Prof. Harmel A. School Center Postojna, The Faculty of Maritime Studies and Transport Slovenia Redesign of motorcycle rear suspension with cad technology The automotive industry is constantly looking for new ways to reduce fuel consumption. This is not only an individual concern for the car and motorcycle customer but also an environmental question on a more global level. When it comes to meeting these environmental requirements, the contribution from body design and manufacturing engineers lies in the field of weight savings.

Giacomo Sarti James Sarti supervisor Prof. Roberto LOT correlator, Prof. Ugo Galvanetto Design of a motorcycle swing arm innovative for competition motorcycles The purpose of this thesis is to analyze the behavior vibration of a carbon swing arm similar to that used in the category Moto2 World Championship. After the creation geometric, the engine the CAD will come to imported PATRAN and subjected to appropriate load conditions to evaluate the stiffness. Verran not evaluated the vibration modes and the principal directions of stiffness exural and torsional. Later this experimental model will come to use to study a single arm focellone commercial Al and for enabling fontanel experimental results. Upon completion of these evaluations will be linked to the peculiarities of the two different models to create the basis of design an unprecedented swing.

A. Shyam, R. Pachaiyappan, Sa. Paveethrun, M. Srinath Design of Govern Arm Suspension System The GOVERN ARM suspension system was analyzed, designed and then fabricated. Due to the implementation of govern arm suspension system in vehicles cushioning effect will be enhanced. It too gives stylish look and comfort. Thus the improvement of load bearing capacity will be analyzed at future. Thus this paper has proposed a newly designed suspension system as govern arm suspension system.

Gaurav Vasantrao Bhunte and Dr. Tushar R. Deshmukh A Review on Design and Analysis of Two Wheeler Chassis In this paper an effort is made to review the investigations that have been made on the different analysis techniques of automobile frames. That analysis may be, static analysis or dynamic analysis. A number of analytical and experimental techniques are available for the analysis of the automobile frames. Determination of the different analysis around different conditions in an automobile frames has been reported in literature. An attempt has been made in the article to present an overview of various techniques developed for the analysis of automobile frames and results of that analysis due to which further study on the chassis will become easy.

Basileios Mavroudakis, Peter Eberhard Analysis of Alternative Front Suspension Systems for Motorcycles The traditional choice in motorcycle front suspension systems is the telescopic fork. Although after many decades of development the performance of such systems is often already adequate, the design inherit disadvantages are still present. A number of manufacturers have devoted considerable effort in alternative solutions that might replace the obvious choice and deal with the aforementioned issue. Still, examples of production bikes featuring an alternative front suspension system are scarce and the domination of telescopic forks in production as well as in racing is prominent. Telescopic forks are mechanically prismatic joints, thus the static friction between the sliding parts cannot be eliminated. This can usually be experienced as poor response to small road excitations, especially under conditions that dim stiction critical. Furthermore, their intrinsic design necessitates high stiffness to avoid bending under extreme loads, and also transfers afore mentioned loads at a high point into the frame, resulting in further limitations regarding the frame design. Most riders have experienced phenomena as minor wobble oscillations that may be nothing more than an unpleasant shake of the handle bars but can possibly develop into a tank slapping. Necessitating a large and heavy frame, in order to be adequately stiff. The design layout does not allow for significant variations in suspension geometry parameters such as caster angle, trail and wheelbase.

Jaimon Dennis Quadros, Suhas, Vaishak N.L, Shilpa.B Study of vibration and its effects on health of a two wheeler rider The two wheeler riders are subjected to extreme vibrations due to the vibrations of its engine, improper structural design of the two wheeler and bad road conditions. These vibrations are most hazardous to the health, if it exceeds the permissible limit and may cause the illness of the spine, musculoskeletal symptom in the lower back as well as the neck and upper limbs. Experimental studies on the transmission and tolerance of vertical vibrations which are beyond the permissible limit according to the literatures confirms that, vibrations certainly affect the health of the two wheeler rider. Therefore it is necessary to evaluate the influence of vibration to the human body and to make up appropriate guidelines for the two wheeler design and selection parts. The intensity of these harmful vibrations is reduced by providing a standard type of Seat, front and rear suspension. The composite model is analyzed by a computer program (MAT lab) for vertical vibrations responses of the body parts to vertical vibrations inputs (sinusoidal) applied to wheels.

Kommalapati. Rameshbabu, Tippa Bhimasankara Rao Design Evaluation of a Two Wheeler Suspension System for Variable Load Conditions A suspension system or shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy. The shock absorbers duty is to absorb or dissipate energy. In a vehicle, it reduces the effect of travelling over rough ground, leading to improved ride quality, and increase in comfort due to substantially reduced amplitude of disturbances. The design of spring in suspension system is very important. In this paper a shock absorber is designed and a 3D model is created. The model is also changed by changing the thickness of the spring. Structural analysis and modal analysis are done on the shock absorber by varying material for spring, Spring Steel and Beryllium Copper. The analysis is done by considering loads, bike weight, single person and 2 persons. Structural analysis is done to validate the strength and modal analysis is done to determine the displacements for different frequencies for number of modes. Comparison is done for two materials to verify best material for spring in Shock absorber.

Modal analysis

Modal analysis is an efficient tool for describing, understanding, and modeling structural dynamics. The dynamic behavior of a structure in a given frequency range can be modelled as a set of individual modes of vibration. The modal parameters that describe each mode are: natural frequency or resonance frequency, (modal) damping, and mode shape. The modal parameters of all the modes, within the frequency range of interest, represent a complete dynamic description of the structure. By using the modal parameters for the component, the model can subsequently be used to come up with possible solutions to individual problems. Modal frequency response analysis is an alternative approach to determining the frequency response of a structure. Modal frequency response analysis uses the mode shapes of the structure to reduce the size, uncouple the equation of motion (when modal or no damping is used), and make the numerical solution more efficient. Due to the mode shapes are typically computed as part of characterization of the structure.

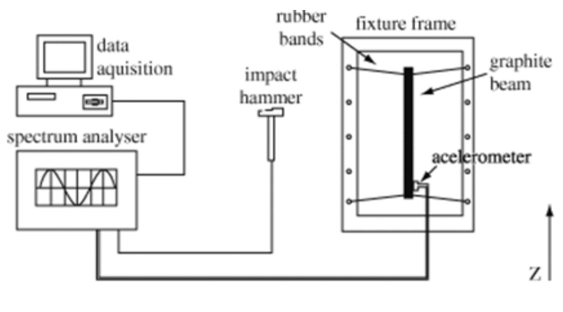

Fig 2 General View of test assembly

CAD Model

CADD software, or environments, provides the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CATIA V5 is mainly used for detailed engineering of 3D models and/or 2D drawings of physical components, but it is also used throughout the engineering process from conceptual design and layout of products.

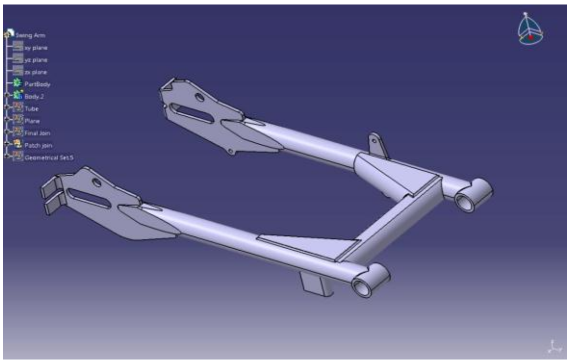

Fig. 3 Isomeric View of Swing Arm (CATIA V5)

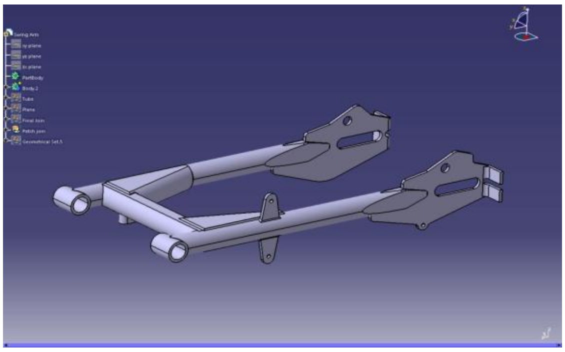

Fig. 4 Front View of Swing Arm (CATIA V5)

Meshing

A structure or component consists of infinite number of particles or points hence they must be divided in to some finite number of parts. In meshing we divide these components into finite numbers. Dividing helps us to carry out calculations on the meshed part. We divide the component by nodes and elements. We are going to mesh the components using 3D elements. As all dimension of suspension arm are in proportion we use the tetrahedral elements for meshing.

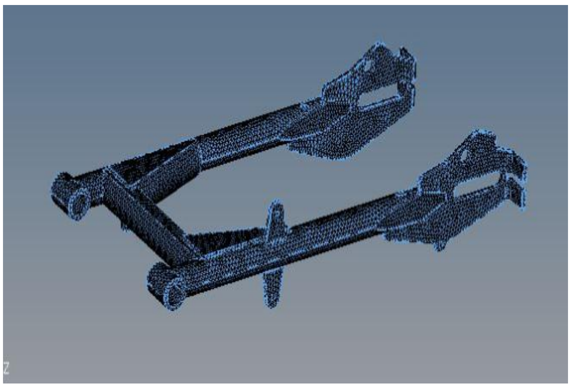

Fig 5 Tetra-hedral meshing on Swing arm

While meshing mesh size of an element is to be taken into consideration because all software's have some limits for the number of elements. Less the mesh size more will be the number of elements and coarse the mesh size less will be the number of elements. As the number of elements increases the run time increases. After meshing elements are to be checked for Quality i.e. elements have some definite quality criteria which should be met by all elements. A quality criterion consists of minimum and maximum angles of the elements, jacobian, warpage etc.

Number of nodes: 15443
Number of elements: 45956
Element size = 4 mm

After meshing is completed we apply boundary conditions. These boundary conditions are the reference points for calculating the results of analysis. Elements are defined by their properties. Material properties are assigned to the elements. Here proper arrangements are made so that we can run the analysis in solver software. After the completion of process model is exported to the solver.

Modal analysis of Swing Arm

Frame forms the structural backbone of a commercial vehicle, when the bike travels along the road, the frame is excited by dynamic forces caused by the road roughness, engine, transmission and more. Modal analysis using Finite Element Method (FEM) can be used to determine natural frequencies and mode shapes. After constructing finite element model of frame and appropriate meshing with shell elements, model has been analyzed and first 6 frequencies that play important role in dynamic behavior of chassis, have been expanded. It is clearly depicts that number of modes increases with natural frequency. Also modes (or resonance) are purely depends on properties of material. Resonance determined from stiffness, mass, damping ratio and boundary condition.

Structural analysis of suspension frame

Using Mild Steel
Material Properties: Young's Modulus (E): 205000 N/mm^2
Poisson's Ratio (PRXY): 0.29
Density: 0.00000785 kg/mm^3
STARTING OF ANSYS
Open>ansys software>file >change directory>select required folder>ok.
Units: command:/units, si,mm,kg,sec,k.
IMPORT MODEL FROM CATIA V5:
file>import>iges>ok>select from iges option>select required file>ok

Results for modal analysis

The natural frequency and displacements are calculated at different modes. Using Ansys 15.0 we calculated results for given material as shown in table 1.

Mode 1

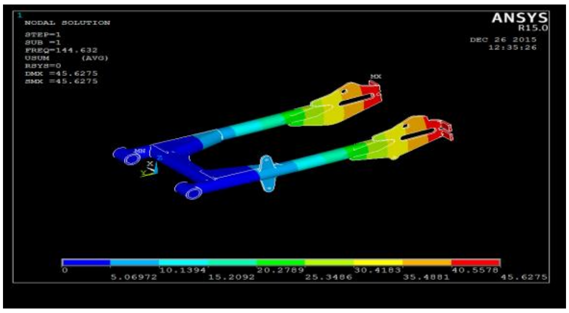

Fig 6 The frequency of 1st mode is 45.62 hz.

Mode 2

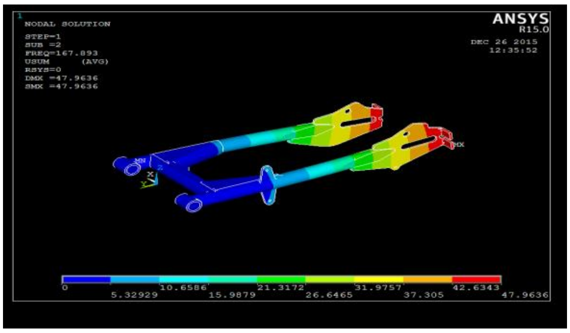

Fig 7 The frequency of 2nd mode is 47.96 hz.

Mode 3

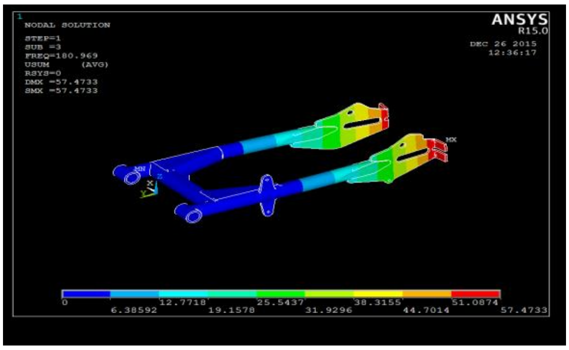

Fig 8 The frequency of 3rd mode is 57.47 hz.

Mode 4

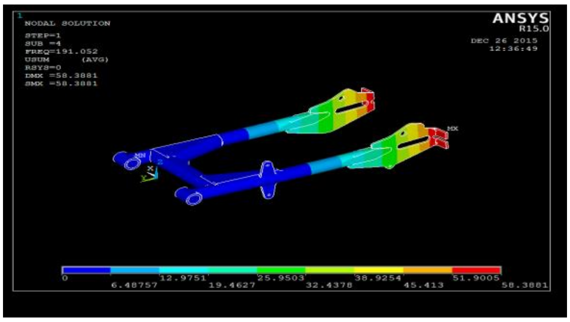

Fig 9 The frequency of 4th mode is 58.38 hz.

Mode 5

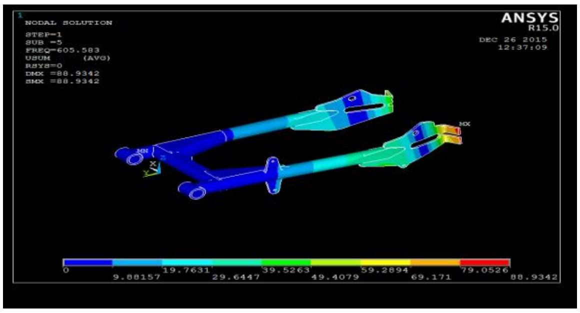

Fig 10 The frequency of 5th mode is 88.93 hz.

Mode 6

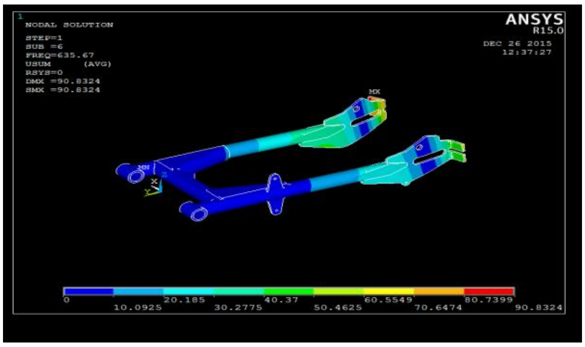

Fig 11 The frequency of 6th mode is 90.83 hz.

Table 1 Results for MS

Displacement	0.000297	
Von mises stress	2.383	325
	Frequency	Displacement
Mode 01	45.62	0.000922
Mode 02	47.96	0.001876
Mode 03	57.47	0.001991
Mode 04	58.38	0.000925
Mode 05	88.93	0.004175
Mode 06	90.83	0.003976

Conclusions

1) From this study we had study the vibration response of rear suspension arm of two wheeler bike.
2) By meshing of component we can define number of modes and elements of Swing arm.
3) By Ansys we can calculate modal frequency and failure area of suspension arm.
4) By case hardening we can increase the strength and improve life of suspension arm.
5) It is necessary to continue further study in the analysis and evaluation of the swing arm to provide the pathfinder a way.
6) To predict life of a swing arm there is need to have the results which are based on the load variation and impact in static as well as in dynamic.

References

R.S. Sharp, S. Evangelou and D.J.N. Limebeer (2004) Advances in the Modelling of Motorcycle Dynamics Multibody System Dynamics 12, Kluwer Academic Publishers Netherlands. pp 251–283.

Leijun, L. (2004) Failure analysis of aluminum alloy swing arm welded joints, Journal of Failure Analysis and Prevention, vol. 4, no.3, pp. 52-57

Basileios Mavroudakis, Peter Eberhard (2005) Analysis of Alternative Front Suspension Systems for Motorcycles Vehicle system dynamics, Vol 00, No. 00, pp 1-10.

C. Kendall Clarke, Don Halimunanda, (2008) Failure Analysis of Induction Hardened Automotive Axles, Springer, ASM International Journal of Failure Analysis and Prevention Volume 8, Issue 4, pp 386-396.

Prof. M.Sc. Božič S, Prof. Gombač E, Prof. Harmel A. The Faculty of Maritime Studies and Transport Slovenia (2009) Redesign of motorcycle rear suspension with cad technology pp 12-17.

Kommalapati. Rameshbabu, Tippa Bhimasankara Rao (2013) Design Evaluation of a Two Wheeler Suspension System for Variable Load Conditions International Journal of Computational Engineering Research, Vol, 03, Issue 4, pp 279-283.

Jaimon Dennis Quadros, Suhas, Vaishak N.L, Shilpa.B (2013) Study of vibration and its effects on health of a two wheeler rider International Journal of Research in Engineering and Technology eISSN: 2319-1163, Volume: 02 Issue: 08, pp 51-55.

Giacomo Sarti, James Sarti supervisor Prof. Roberto LOT correlator, Prof. Ugo Galvanetto (2013) Design of a motorcycle swing arm innovative for competition motorcycles University of Padua. pp 1-136.

Mohan K Misra, Bishakh Bhattacharya, Onkar Singh, A. Chatterjee (2013) Optimization of the induction hardening process of Tow Axle Spindle, International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 11, pp 2921-2929.

Pavan Kumar S., Dr. Maruthi B H, Aravind K.U., Bharatish A (2014) Modal and Static Analysis of Rear Crash Guard employed in SUV, International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 7, pp 550-554.

Gaurav Vasantrao Bhunte and Dr. Tushar R. Deshmukh (2015) A Review on Design and Analysis of Two Wheeler Chassis International Journal For Research In Emerging Science And Technology, Volume-2, Issue-1, pp 42-45.

Lalit Chettri, (2015) Annealing Induction Heating for Industrial Use, International Journal of Engineering Research & Technology (IJERT), Vol. 4 Issue 01, pp 784-788.