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A CEA APPROACH FOR NONLINEAR ANALYSIS OF CASING OF HANDLE BAR OF 2-WHEELER

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I. ABSTRACT

The steel pipe constituting a member of the handle bar of the two-wheeler is assembled with the thermo-plastic casing and secured in place with a cross pin and the two-halves of the case are in turn secured with two screws. This assembly is subjected to torsion loads while the rider holds the grip of the accelerator and uses it as a support. Besides, the same is also subjected to buckling loads while the rider accelerates or decelerates suddenly or even while braking. The scope of this dissertation work falls in this area where the design of the component or the sub-assembly needs to be reviewed for the sake of failure during use. In this case, the lower case of the handle bar is met with failure near the accelerator end of the handle. A study is being initiated by the sponsoring company for identifying the source of this failure and addressing the same with modified or improved design feature/s for reducing the incidence of failure. The material in this case is Nylon-6 (30% glass-filled).

Index Terms- handle bar, thermo-plastic casing, Nylon-6

II. INTRODUCTION

In recent years there has been an increased sale in the two wheeler segments in various parts of the world. Not only gents but ladies also give preference to the two wheelers as compare to cars. Driving a two wheeler is quite convenient in the crowded places and narrow roads of the cities. Also fuel economy of 2-wheeler is much better than 4-wheelers. So they are becoming very popular in all age-group peopleThe two wheeler and the four-wheeler industry is normally faced with challenges related to safety. The compliance of vehicle in this regard is of utmost importance while the same could be approved by the concerned regulatory authorities for being used on the public roads. Besides, all other parts and components that support and/or form an integral part of the assembly of the sub-system could be required to comply with the norms.The other areas attracting compliance are the warranty claims received from the customer during usage over the field or the report filed by the concerned field Engineer observing the field test for the vehicle. The breakage and/or damage to the component could be highlighted during the time the vehicle is put to actual use. The scope of this dissertation work falls in this area where the design of the component or the sub-assembly needs to be reviewed for the sake of failure during use.For this paper case, the lower case of the handle bar is met with failure near the accelerator end of the handle. A study is being initiated by the sponsoring company for identifying the source of this failure and addressing the same with modified or improved design feature/s for reducing the incidence of failure. The material in this case is Nylon-6 (30% glass-filled).

III. LITERATURE REVIEW

By Seung-Bum Kwak, Nak- Sam Choi performed "Micro-damage formation of a rubber hose assembly for automotive hydraulic brakes under a durability test" on a rubber hose assembly for an automotive hydraulic brake in operation subjected to the combined stresses of cyclic pressure, cyclic bending and torsion as well as thermal load, which can occur during vehicle operation. A durability tester with loading rigs for applying the above cyclic stresses was run to investigate the failure mechanism in the rubber hose assembly. The test was performed in a thermal chamber that was maintained at 100°C. A pressure cycle of 0 to 9.8 MPa in brake oil was repeated at 42 cycles/min. The durability test was performed until the final rupture of the rubber layer.The failure mechanism of the rubber hose were examined at every 100,000 cycles of bending and torsion. The tested hose assembly specimens were analysed both at micro- and macro levels considering the required durability limit of 3,70,000 cycles.[1] By Honglei Zhang, Xuehui Lin Yanqun Wang have performed "Identification of Elastic Plastic Mechanical Properties for bimetallic sheets by hybrid inverse approach". They show that analysis, evaluation and interpretation of measured signals become important components in engineering research and practice, especially for material characteristic parameters which cannot be obtained directly by experimental measurements. This paper proposes a hybrid-inverse analysis method for the identification of the nonlinear material parameters of any individual component from the mechanical responses of a global composite. The method couples experimental approach, numerical simulation with inverse search method. The experimental approach is used to provide basic data. Then parameter identification and numerical simulation are utilized to identify elasto-plastic material properties by the experimental data obtained and inverse searching algorithm. A numerical example of a stainless steel clad copper sheet is considered to verify and show the applicability of the proposed hybrid-inverse method. [2] By Shenshen Chen, Yinghua Liu, Zhangzhi Cen have performed the "Lower bound shakedown analysis by using the element free Galerkin method and non-linear programming". They show that Shakedown analysis is a powerful tool for assessing the safety of structures under variable repeated loads. By using the element free Galerkin (EFG) method and non-linear programming, a novel numerical solution procedure is developed to perform lower bound shakedown analysis of structures made up of elasto-perfectly plastic material. These self-equilibrium stress basis vectors are generated by performing an equilibrium iteration procedure during elasto-plastic incremental analysis. The Complex method is used to solve the non-linear programming and determine the lower bound of shakedown load. The proposed numerical method is verified by using several numerical examples and the results show good agreement with other available solutions. [3]By Virginio Quaglini , Paolo Dubini, Daniela Ferroni, etc. studied "Influence of counterface roughness on friction properties of engineering plastics for bearing applications". It is studied that the effects of the roughness of the metal counter face (mirror finished or polished) on the coefficient of dry friction for some of the most common engineering plastics used in current bearing technology. The results show that an optimal roughness for minimum friction is likely to exist for any polymer, and it depends on the bulk properties of the polymer itself. ''Soft" plastics characterized by a low modulus of elasticity exhibit better sliding behavior on very smooth, mirror finished surfaces, whereas for high-modulus plastics lower friction is measured in combination with rougher, polished counterfaces. The influence of the contact pressure and sliding velocity are also investigated and found to depend on the layout of the tribological system. [4]By C. (Carola) D.J. Smulders, H. (Herm) Hofmeyer have performed "An automated stabilisation method for spatial to structural design transformations". They explain that a spatial–structural design process can be investigated via a so-called research engine, in which a spatial design is transformed into a structural design and vice versa. During the transformation from a spatial into a structural design, it is necessary to obtain a stable structural model, so that a structural analysis can be carried out. They present four methods to automate the stabilisation process, using data related to a structural design's geometry and its instability modes. The methods all use the null space and associated null vectors of the structural stiffness matrix. Then each null vector is resolved by either (a) rod addition, (b) plane addition, (c) hinge fixation by single rod substitution, or (d) hinge fixation by coupled rod substitution. The methods have been implemented in C++ and several test cases have been carried out.[5] By Hamid Ghaemia, K. Behdinan b, have performed "On the development of compressible pseudo-strain energy density for elastomers: Part 2 application to finite element". They show the results of a finite element procedure and analysis for pure gum rubber, based on a compressible strain energy function. The development of the proposed separable, one-term compressible constitutive equations is explained. An explanation of the isochoric part of the strain energy function based on constitutive relation proposed by the authors is also discussed. A brief review of material properties and the basic equations of the finite element procedure are given. Fortran 77 was used to code the user-subroutine.. The subroutine was then implemented into a commercial finite element package. The Updated Lagrangian (UL) procedure was used, based on the principal stretch ratios in which the material moduli are initially determined in the principal direction and then transformed to the local coordinate. [6]By Edson DennerLeonel n, Wilson Sergio Venturini have performed the "Non-linear boundary element formulation applied to contact analysis using tangent operator". This work presents a non-linear boundary element formulation applied to analysis of contact problems. The boundary element method (BEM) is known as a robust and accurate numerical technique to handle this type of problem, because the contact among the solids occurs along their boundaries. The boundary element method has been applied to solve non- linear contact problems in this paper. A BEM formulation based on the use of a tangent operator was proposed to solve this complex engineering problem. Each term of the tangent operator, considering the contact between crack surfaces and among bodies' inter- faces, was derived for the particular case of Coulomb's friction criterion. Four schemes to choice integral equations were used. The responses of the proposed formulation were compared with the results of equivalent models constructed using ANSYS (FEM). This comparison shows a good performance of the proposed BEM. It is important to emphasise that using tangent operator requires a low number of iterations to achieve the convergence.[7]By jean-Marc Battini, Quang-Huy Nguyen and Mohammed Hjiaj performed "Non linear finite element analysis of composit beams with interlayer slips". They showed a non linear finite element formulation for the analysis of two layer composite plane beams with interlayer slips. And a new finite element formulation for the non-linear analysis of two layer composit plane beam with interlayer slips is also presented. The element has two nodes and four degrees of freedom at each node. A corotational description has been used and a new corotational framework has been proposed. This means that the element is obtained using rather simple transformation matrices. The main advantage of this approach is that using the corotational framework, different geometrical linear elements can be easily transformed into nonlinear ones. [8]By T. Hong, J.G. Teng have performed "Non-linear analysis of shells of revolution under arbitrary loads". They presented a new finite element formulation for the non-linear analysis of elastic doubly curved segmented and branched shells of revolution subject to arbitrary loads. The circumferential variations of all quantities are described by truncated Fourier series with an appropriate number of harmonic terms. A coupled harmonics approach is employed, in which coupling between different harmonics is dealt with directly rather than by the use of pseudo-loads. A new finite element formulation has been presented for the non-linear analysis of doubly curved axisymmetric elastic thin shells under arbitrary loading and coded into a computer program called CHASH. The coupled harmonics method was adopted in this formulation so that coupling between different Fourier harmonics is dealt with directly. This allows an easy implementation of the arc length method. [9]By Seung-Eock Kim, Jaehong Lee, Joo-Soo Park have performed "3-D second-order plastic-hinge analysis accounting for local buckling". This analysis accounts for material and geometric non-linearities of the structural system and its component members. The problem associated with conventional second-order plastic-hinge analyses, which do not consider the degradation of the flexural strength caused by local buckling, is overcome. Efficient ways of assessing steel frame behavior including gradual yielding associated with residual stresses and flexure, second-order effect, and geometric imperfections are presented. In this study, a model containing the width–thickness ratio is used to account for local buckling. The proposed analysis is verified by the comparison with other analyses and Load Resistance Factor Design results. [10]

IV. RELEVANCE

Thermoplastics are perhaps the most important kind of polymer used in the manufacturing of components. They are easy to process, can be very ductile and resistant to corrosion. Typical applications include the automotive industry, piping, containers and packaging devices. Such a large number of applications require a more detailed structural analysis which, in turn, can only be reliably performed if the material behavior is well understood.There has been a substantial research effort during the last decades to understand polymers behavior, including its dynamic response. However, it is clear that thermoplastics models still require further improvements. In any event, constitutive models rely on material parameters that must be measured. Hence, any knowledge of the response of polymers to load, temperature, environment, etc. is important. In the case of structures undergoing large strains and dynamic loads, the material model should contemplate strain rate effects on its response, as it has been discussed for polymers.

V. OBJECTIVES

1. To prevent the breakage of casing of handle-bar of Two-Wheeler in the field.
2. Ensure adequate strength at par or better than the existing while simplifying the geometry of the casing.
3. Assimilate and help furtherance of the knowledge so obtained (through reference data compilation, application of software and physical experimentation) for the benefit of the Academicians and the Engineering Industry, in general.
4. Evaluate the design for strength while keeping in view the function of the casing.
5. Review the results of analysis.

The main Aim of project work is to "Prevent the breakage of Casing of Handle-
bar of Two-Wheeler in the field using CAE Techniques".

VI. APPROACHES, TECHNIQUES AND METHODOLOGY

1) Analytical approach using Empirical formulae and relations:-

This is typically a traditional method of addressing the given problem while considering the effects of unbalanced forces on the structural member whose construction is manifested or represented by any of the standard types of load carrying members for which the empirical formulae has been established. This forms the basis of `Machine Design' with principles of Applied Mechanics at the core of the subject matter.

2) Simulation using suitable software tools :-

This is a modern approach and is fast becoming the standard or de-facto method with the advent and penetration of software in the CAE domain. The assembly consisting of individual parts is modeled in the software environment and the requisite material properties, boundary conditions and constraints are applied. The software is then allowed to `solve' the structure for strength for the load test parameters of interest.

3) Experimentation :-

This refers to physical experimentation. This involves generating prototypes and testing the same after `setting up' the test conditions. The `in-process' parameters, variables are typically monitored using mechatronics interfaces. The data so collected is later interpreted and the problem diagnosed.

For the subject project work, the techniques would engage software tools like CATIA V5 (for Machine Design) – with output in IGES format & NASTRAN or ANSYS (For Structural Analysis)

VII. BENEFITS

The benefits of performing nonlinear FEA of elastomeric products are essentially the same as those for linear FEA. FEA should be an integral part of the design process, preferably from the CAD. The advantages of this enhanced design process include: improved performance and quality of the finished product; faster time to market; optimal use of materials; weight savings; verification of structural integrity before prototyping; and overall reduction of development and production costs. Furthermore, a good predictive capability can help to reduce the scrap rate in manufacturing stage; that is, "green" stage to the finally "molded" state, thereby ensuring a competitive edge.The structure so evolved could be setup with ease in the CAE (Nastran/ Ansys) interface that could further undergo the analysis after assigning the relevant properties, constraints, etc.

VIII. METHODOLOGY

- Identify the inputs (i.e. location of the part , physical properties of materials, etc)
- Check the existing physical sub-assembly on the field
- Conceptualizing and generating a geometry using CAD for the structure using existing design for reference data
- Exporting the geometry in the form of IGES or STEP file
- Evaluate the part design for fit and function
- Review the existing assembly for the given application
- Perform analysis using suitable CAE software
- Study the results of analysis
- Generate a revised layout for the component/s
- Review the Design for the Case/ Housing
- Finalize the specifications
- Conduct trials for experimentation
- Document the results for validation

IX. MATERIAL IDENTIFICATION AND SELECTION

Thermoplastics are perhaps the most important kind of polymer used in the manufacturing of components. They are easy to process, can be very ductile and resistant to corrosion. Typical applications include the automotive industry, piping, containers and packaging devices. Such a large number of applications require a more detailed structural analysis which, in turn, can only be reliably performed if the material behavior is well understood.There has been a substantial research effort during the last decades to understand polymers behavior, including its dynamic response. However, it is clear that thermoplastics models still require further improvements. In any event, constitutive models rely on material parameters that must be measured. Hence, any knowledge of the response of polymers to load, temperature, environment, etc. is important. In the case of structures undergoing large strains and dynamic loads, the material model should contemplate strain rate effects on its response, as it has been discussed for polymers.

There are total five different parts in assembly:

Part No.	Part Name	Material
0648-0191.1	Pin	Steel
0648-021C.1	Plastic interface Part	Nylon 6-30 GF
0648-049M_L	Plastic Mould part Upper	Nylon 6-30 GF
0648-049U	Plastic Mould part lower	Nylon 6-30 GF
Handle	Handle Bar	Steel

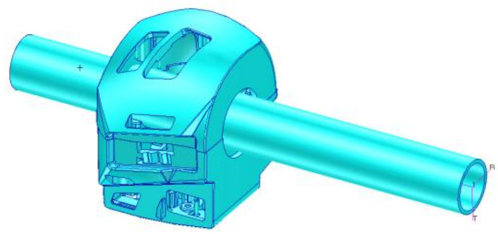
Table 1: Different parts in assembly

X. MATERIAL PROPERTIES

Material	Young's Modulus (MPa)	Bulk Modulus (MPa)	Shear Modulus (MPa)	Poisson's Ratio
Rubber (Typical Range)	0.76-7.6	3,000 - 3,5000	0.35 - 1.38	0.5
Lightly Vulcanised Rubber	1.40			
Mild Steel	207,348	158,967	79,483	0.29-0.3
Aluminium Alloy	69,116	67,733	23,499	0.31
Glass	55292	36.631	22,117	0.25
Concrete	27,646			0.18
Oak	10,021			
Polyurethene Foam	3.11			
Plastics:				
Polyethylene	138-380	89-255	55-152	0.25
Phenolic Laminate	8,501			0.25
Polycarbonate	2,384			0.35
Cast Acrylic	3,110			0.35
Cellulose Acetate	1,520			
Vinylchloride Acetate	3,179			

Table 2: Material properties

XI. STRUCTURE OF THE CASING OF HANDLE BAR



Top Stress values of different parts

Part No.	Part Name	Stress in Mpa at 365 Kgf	Stress in Mpa at 500 Kgf
0648-0191.1	Pin	125	163
0648-021C.1	Plastic interface Part	16	26.5
0648-049M_L	Plastic Mould part Upper	65.8	110
0648-049U	Plastic Mould part lower	1.75	3.99
Handle	Handle Bar	10.15	16.2

Table 3: Top Stress values of different parts

XII. POSSIBLE OUTCOMES FROM THE WORK

It will perform non-linear analysis of casing of handle bar of two wheeler. Stress analysis will carry out to evaluate structural integrity of the Assembly under given loading conditions. The model of this casing under review is now undergoing changes. The new design needs to be reviewed for structural strength while subjecting the components/ sub-assembly to Analysis using CAE. Techniques and thus the breakage of casing of the handle bar in the field will be prevented.

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