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Analysis of the resistive behavior of the chassis of an electric vehicle type e-trike

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Abstract: In the present article the resistive analysis and the simulation of its response to static load of the chassis of an electric vehicle type e-trike are realized by means of the use of the software SolidWorks 2015. The static analysis was realized with techniques of computer aided engineering, The SolidWorks Simulation finite element analysis package. As a result, it was found that the stresses supported by the structure do not exceed the mechanical limits of the material and that the components only undergo deformation and displacements in the margin of the elastic zone, and no plastic deformations or ruptures occur.

Keywords: Desing assisted by computer; MEF; Static analysis; Electric vehicle

I. Introduction

At present, efforts aimed at technological improvements and innovation in transport have intensified and the use of renewable sources in vehicle fleets is the new trend (Margaritis et al., 2016). Some authors (Chaparro, 2002, Figueroa, 2005, Alfaro, 2008; Díaz, 2015) consider that transport is the activity sector with the highest energy consumption, 25% of greenhouse emissions are due to transportation, Petroleum accounts for most of the energy sources used, as well as a high rate of contamination and risks to public health. The design of electric vehicles has become an energy solution to the needs of reducing pollutant emissions and the use of non-renewable energy sources. One of the trends of the automotive industry is that the resulting vehicles are able to compete with conventional vehicles in cost, weight, recharge range, reliability, efficiency, autonomy, maximum speed and acceleration, among other characteristics.

The electric vehicles, as established by several authors (Conae, 2002, Díaz, 2000, Rocha, 2017) have some advantages among which they stand out being more efficient than vehicles with internal combustion engine. They also do not produce polluting emissions at the place of operation, have lower maintenance costs, are more reliable than vehicles with internal combustion engine, the braking system has in turn regenerative power capacity and are easier to handle.

Several studies and research have been carried out in this field, including the design, sizing and simulation of an electric car powered by hydrogen fuel cells and lithium-ion batteries, proposed by Correa et al. (2014); In the same way, Rocha et al., (2017), Zhao et al., (2016) and Torrejón (2014) in their work make significant performance improvements for electric vehicle batteries. On the other hand Guajala et al., (2015) performs an analysis of the advantages of the Nissan Leaf vehicle to those of fossil fuels. Domínguez (2013) also analyzes the viability of the electric vehicle in a food distribution company at home; Pérez (2012) in his work highlights the economic technical potential of an electric vehicle.

In addition to these investigations, several designs of electric vehicles have been developed, among which the electric kart design (Flores, 2014); In the work of Bernal et al., (2016) the selection of the propulsion system of an urban vehicle with electric power is carried out, Mesa et al. (2014) performs the design and prototype of an electric vehicle and studies emerging technologies in batteries for these devices. Similarly, Ciano et al., (2013) carry out the development of an experimental vehicle with an electric power system. The objective of the present work is to perform the resistive analysis of the chassis of an E-trike electric vehicle prototype, lightweight and low cost, in order to evaluate its performance in an ideal environment within a product transport process and services.

II. Methodology

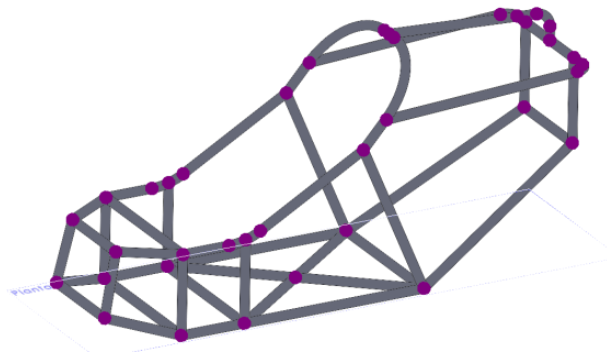
In this work we used Computer Assisted Design (CAD) tools, which allowed the modeling of the element under analysis, as well as the Finite Element Method (MEF). This last method, according to Pérez & Rodríguez (2014) and Luna et al. (2011), is a process that consists of a logical sequence of work, which can be divided into several stages. In order to develop this study, elements of the methodologies proposed in the work of several authors were taken into account (Gómez et al., 2005; Estrada et al., 2012, Estrada et al., 2013, Ocampo et al., 2014, Leslie & Águila, 2015, Areu et al., 2015, Llanes et al., 2015).

Tabla I. Mechanical Properties of AISI 1023 carbon steel.

Mechanical Properties	Units
Hardness, Brinell	121
Hardness, Rockwell B	68
Hardness, Vickers	126
Tensile Strength, Ultimate	426 MPa
Tensile Strength, Yield	360 MPa
Elongation at Break (in 50 mm)	15 %
Reduction of Area	40.0 %
Modulus of Elasticity	120-210 GPa
Bulk Modulus	140 GPa
Poissons Ratio	0.27-0.30
Shear Modulus	80 GPa

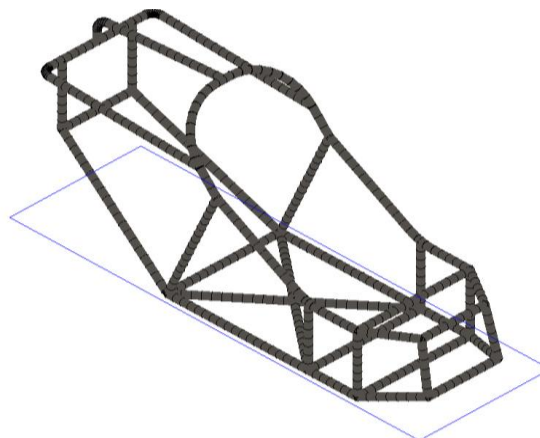
The 3D modelling was performed using CAD software SolidWorks 2015. The defined model comprises a detailed 3D representation of the vehicle chassis under study (Figure 1). In the same way, the properties of the materials that make up the structure of the same, the boundary conditions, the fixtures and loads are declared, and finally the meshing of the element to be analyzed is carried out. Static analysis was performed using computer-aided engineering techniques, using the SolidWorks Simulation finite element analysis palette. The structural elements of the device were constructed of AISI 1045 steel. This material has good machinability and fatigue strength, its mechanical properties can be seen in Table 1.

Figure 1. Chassis of the electric vehicle type e-trike.



Once the modelling of the structure is completed, the meshing of the prosthesis is performed. The chassis of the vehicle supports a dead load that includes the own weight of the elements and that are supported by the structure. In the case of this study, a load of 400 kg will be applied, constituting the estimated weight of the vehicle, including: suspension system, bodywork, powertrain (electric motor and batteries), seat, passenger, etc. The force of 3924 N which corresponds to these 400 kg will be applied, this force will be concentrated in the central part of the chassis and the tensions will be analyzed by the Von Mises criterion and the total deformation of the model.

Figure 2. Mounting the vehicle chassis.



The MEF converts a problem defined in terms of differential equations into a matrix problem that provides the correct result for a finite number of points, and then interpolates the solution to the rest of the domain; in this way,

it is only an approximate solution. The set of points where the solution is exact is called "set nodes". Said set of nodes forms a network, called "mesh formed by reticles". Each of the reticles contained in said mesh is a "finite element". The set of nodes is obtained by dividing or discretizing the structure into elements (Lee *et al.*, 2004). The mesh generated in selecting the finite elements, as can be seen in Figure 2, consists generally of thousands (and even hundreds of thousands) of points. The information on material properties and other characteristics of the problem is stored together with the information describing the mesh and can be found in Table II. Likewise, the restraints must be considered; For this case, they were taken as fixed geometry where they were located 4 points of support or ligatures where the suspension is united with the chassis of the vehicle.

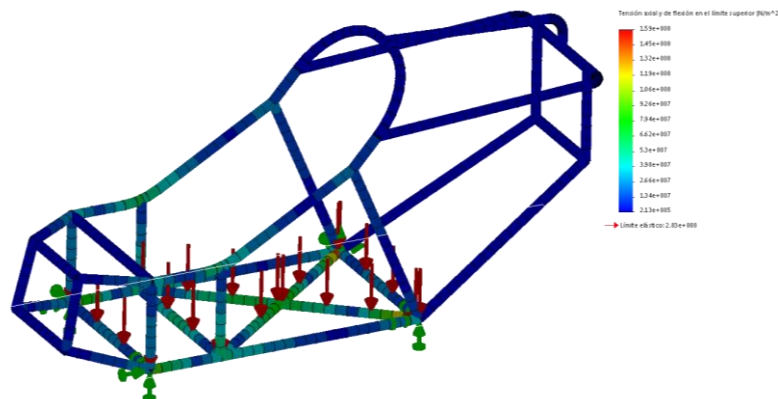
Table II. Characteristics of the mesh

Characteristics of the mesh	
Type of mesh	Beam mesh
Tolerance	0.3064 mm
Quality	Alta
Number of elements	523
Number of nodes	600

III. Results

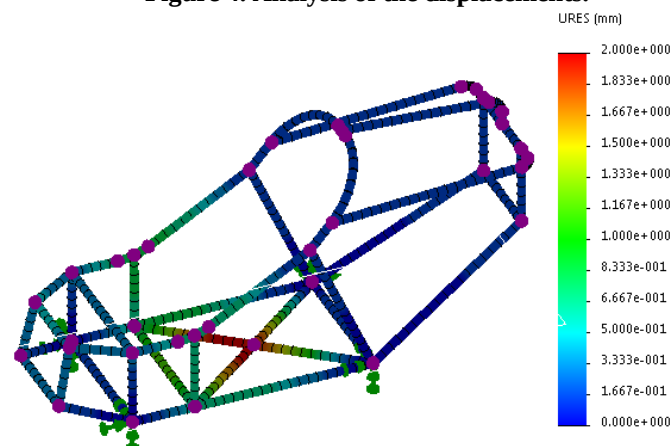
The 2D and 3D modelling of the mechanical element object of study allowed the geometric documentation of the chassis of the electric vehicle type e-trike. Derived from the analysis with SolidWorks Simulation, the graphical views of the distribution of voltages and deformations, as well as the numerical values of the calculated parameters are obtained, just as it is possible to visualize the drawing of voltages in other systems of units.

Figure 3. Analysis of Equivalent Stresses.



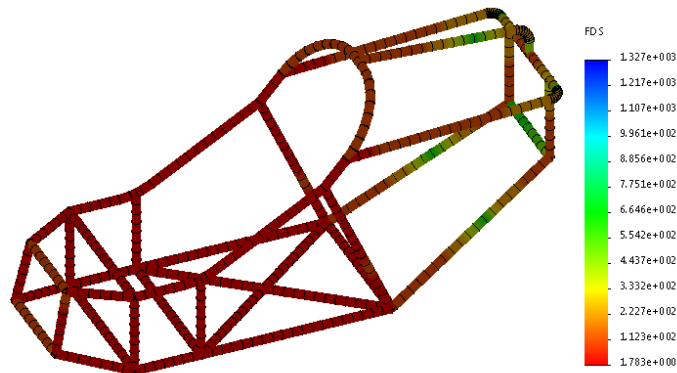
The static study of Von Mises was carried out, which determines the stresses and displacements of a deformable solid. From the analysis of the obtained extreme tensions it can be observed that the maximum tensions, (Figure 3) are of 159 MPa and it is compared with the elastic limit of the steel AISI 1045 that is 565 MPa. Therefore, since the maximum stresses were lower, it can be concluded that the chassis will withstand the loads to which it is subjected. In the case of static displacement, a maximum of 2 mm is obtained in the red area, as shown in Figure 4, which indicates the critical region of the same.

Figure 4. Analysis of the displacements.



The design check is made when the material, shape and dimensions have already been preset and it is necessary to know if they are adequate to withstand the state of the acting loads. This last step is conclusive to determine the accuracy of the previously performed results, as shown in Figure 5, obtaining a safety coefficient of 1.78 for the new design, which assures a reliable behavior of the same during the appearance of the extreme loads in conditions of operation of the machine. Finally derived from the results of the studies carried out on the vehicle chassis, it behaves properly, since the deformations and displacements are minimal, in relation to the characteristics of the material.

Figure 5. Safety factor.



IV. Conclusions

The geometric documentation of electric vehicle chassis under study was performed using the parametric SolidWorks software, in addition to the static analysis of it, thanks to the contest package Finite Element Analysis SolidWorks Simulation.

The structural elements of the device are capable of withstanding the maximum tensions of 159 MPa, which arise under the action of the load that supports the chassis.

The minimum safety factor calculated (1.78) from the maximum stresses proves that the device has reserves in terms of the mechanical resistance of its structure.

The material used in the construction of the device guarantees the resistance required for the work without failure of its component elements.

Finally, once analyzed the deformation and displacement to which the structure is subjected can be concluded that only components undergo deformation and displacement in the range of the elastic region of the material, and no plastic deformations or ruptures occur

V. References

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