Optimization of the systems of the vehicle Peugeot 604 Buggy of the race of Engineering in Maintenance Automotive of the Technical North University.

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Abstract. *Nowadays there are major drawbacks in regard to safety in older vehicles which are causing several traffic accidents within and outside the city. Also causing human and material losses. With the advancement of technology it has been improved security systems active and passive with the implementation and equipment of electronic systems in vehicles. As students of the Engineering in Automotive Maintenance career, we made systems safety and comfort some improvements were performed to the vehicle Peugeot 604 type Buggy, optimizing brake systems, steering, suspension, chassis and body, for a vehicle in perfect condition. Buggy vehicle was freestanding, if it were to produce a crash, the vehicle tends to deform and damage other components which does not meet the requirements of a Buggy prototype, we proceed to the installation of a chassis for the vehicle to have independent body, in this way it helps to support the loads and vehicle components also it can suit the conditions of a sandpit prototype, the chassis of a Ford Explorer was used and after this the complete reconstruction of the same was done with the help of software called solidworks. Also the desing of mechanical parts is carried out with the simulation tool. With which the analysis of stress and safety factor can be obtained, further evidence of the suspension is performed in the matlab software, and an alignment and road test was also done. Leaving the vehicle in perfect conditions for safe and efficient driving. This project is a great contribution to students as part of work or learning material, so students can conduct their workshop practices in this Buggy vehicle, always taking care of their safety and being able to use their knowledge.*

Keywords

Reconstruction, Systems, Prototype, Buggy

Resumen. *En la actualidad existen grandes inconvenientes en el tema de seguridad de vehículos antiguos, ya que son los causantes de varios accidentes de tránsito dentro y fuera de la ciudad, además ocasionan pérdidas humanas y materiales. Con el avance de la tecnología se ha mejorado los sistemas de seguridad activa y pasiva, con la implementación y el equipamiento de sistemas electrónicos en los vehículos. Como estudiantes de la Carrera de Ingeniería en Mantenimiento Automotriz, se realiza mejoras de los sistemas de seguridad y confort en el vehículo Peugeot 604 tipo Buggy, optimizando los sistemas de frenos, dirección, suspensión, chasis y carrocería, para obtener un vehículo en prefectas condiciones. El vehículo Buggy era de tipo monocasco, al llegar a producir un accidente, el vehículo tiende a deformase y dañar los demás componentes, a su vez no cumple los requerimientos de un prototipo Buggy, es por ello que se procede a la instalación de un chasis para que el vehículo pueda tener carrocería independiente, de esta manera le ayuda a soportar las cargas y componentes del vehículo, además adaptarse a las condiciones de un prototipo arenero, se utiliza el chasis de una Ford Explorer, y luego de esto se realiza la reconstrucción completa del mismo, con la ayuda del software Solidworks se realiza el diseño de piezas mecánicas ,con la herramienta de simulación se puede obtener el análisis de tensiones y factor de seguridad, además se realiza pruebas de la suspensión en el software Matlab, una prueba de alineación y de carretera del vehículo dejando en perfecto estado para una conducción segura y eficiente. Este proyecto es de gran aporte para los estudiantes como elemento de trabajo o material de aprendizaje, de esta manera podrán realizar sus prácticas de taller en este vehículo Buggy precautelando siempre su seguridad y puedan emplear sus conocimientos.*

Palabras Claves

Reconstrucción, Sistemas, Prototipo, Buggy.

1. Introduction.

This work has as main objective the optimization of the systems of safety and comfort of the vehicle, as well as to realize the design using the software Solidworks, soon to proceed to the reconstruction of the vehicle to improve the systems of brakes, suspension, direction and body, In addition serves as didactic material for the students of the Race of Engineering in Automotive Maintenance.

The research problem is that the vehicle was with the main systems of safety and comfort obsolete which needed an efficient maintenance, at the same time an update of its parts and that this vehicle passed the tests of all systems That make it up.

The vehicle Peugeot 604 type Buggy was found to be deteriorated because it was made from an old car, its systems needed preventive and corrective maintenance so it was necessary to make several modifications and to be able to restore the prototype.

This project is developed at the Technical North University in the workshops of the city of Ibarra, resulting in a new Buggy in excellent condition and any test that is submitted.

2. Materials and Methods

The methodology applied is as follows:

Modeling.- Reconstruction of the Peugeot 604 type Buggy vehicle through Solidworks software for the design of all mechanical components of the steering, suspension, brake, chassis and body systems using material selection standards such as the American Society of Testing and Materials (AISI 4340 - AISI 1020 - AISI 1018), other materials such as: glass fiber, gray cast iron, magnesium-rubber, aluminum 6011, and ductil iron.

Optimization.- The systems that have been optimized are as follows; The brake system with the implementation of four-wheel brake discs, hydraulic steering system with zipper, independent front suspension (multi-link), rear suspension of rigid axle with system bar tie, chassis and body.

Adaptation.- Of new suspensions in both the front and rear to absorb the irregularities of the road and give comfort in the driving, a chassis and independent body, so that it fulfills the function of supporting loads and efforts that will be submitted the prototype Buggy.

Analytical - Synthetic.- It is necessary to collect data from the tests performed on each system of the vehicle and then proceed to perform the correct and efficient maintenance, also collect necessary information from different systems and parts of the vehicle to develop the project. The tests to be performed are simulation of the suspension using matlab software, alignment, static analysis of stresses to the suspension components, chassis and safety factor using Solidworks software.

The techniques and instruments applied are as follows:

Analysis of mechanisms.- Analysis of solid elements in suspension elements such as the top table, the bottom table, tension rods and the chassis using the software Solidworks, was also performed the study of the center of gravity, mass transfer In acceleration, braking and curve.

Drawing planes.- A3 (ISO) drawings of mechanical elements and parts were made using Solidworks software of the main components of vehicle safety, with the help of the plans to implement the reconstruction of the prototype Buggy.

Measurements.- Data collection using measuring instruments such as the flexometer, caliper and footplates, the measurements are used to make the respective plans and designs in Solidworks software and to put them into practice when making mechanical parts to implement in the prototype Buggy.

Simulation.- With the use of the simulation tool Solidworks allows greater control, in addition to verify the performance of the designed elements, this can identify the effort that is submitted each mechanical part with real data and observe if it meets the required conditions Applying the distribution of loads on the components, thus knowing if it is suitable for construction, in addition to the software Matlab is performed the simulation of the suspension using the coefficient of damping and the coefficient of elasticity of the spring to see if it is fit for this Type of Buggy vehicle.

2.1. Design and optimization of the BUGGY prototype.

We worked on the vehicle Peugeot 604 type Buggy year 1986 with a V6 engine, weight of 1450 kg. Modifications and adaptations are made with elements of a 1997 Ford Explorer vehicle.

Figure. 1. Vehicle Peugeot 604 type Buggy and Ford Explorer.

2*.1.1 Chassis design.*

The software solidworks 2016 is used, in turn the design of the chassis with all its components such as crossbeams, beams, bases and supports where the body is housed, to observe if it meets the conditions necessary for the new prototype Buggy sandbox.

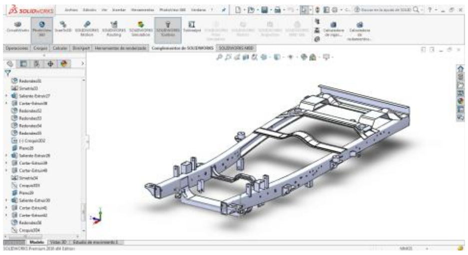


Figure. 2. Chassis design.

It is chosen the material of which it is made (AISI 1020 Cold Rolled Steel), this material has very high strength and ductility and is also of great use in the automotive industry, to carry out the simulation takes into account the elastic limit of 350 N/mm^2

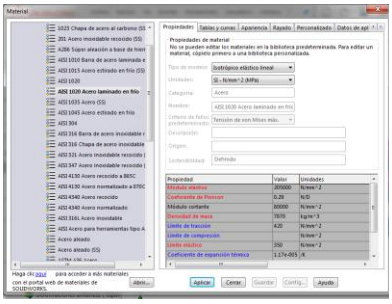


Figure. 3. Material Selection.

Analysis of stresses of the chassis.

According to the result of the static stress analysis a maximum limit of 108 N/mm^2 is obtained, that is, according to the table the chassis meets its structural characteristics to perform an excellent work without tending to deform, as It can be seen in figure 38 below the elasticity limit of350 N/mm^2.

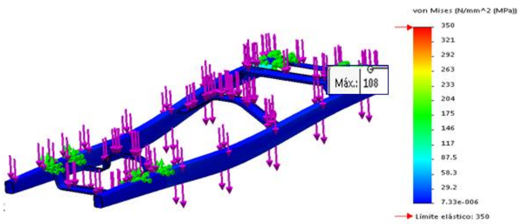


Figure. 4. Analysis of tensions.

Chassis safety factor.

As can be seen in figure 5, the safety factor is a coefficient that calculates the maximum resistance of an element in turn the exact value to which it is subjected, in this case gives a minimum of 3.24 in green, a maximum of 10 in blue color guaranteeing that this chassis has a great resistance to withstand higher loads, if it is less than 1 a fracture in the structure can occur or present a deformation and not fulfill its service.

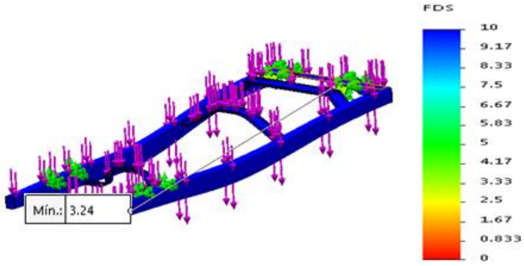


Figura. 5. Factor de seguridad.

2.1.2. Suspension design.

Front suspensión

With the help of Solidworks software, the elements and mechanical parts that form part of the independent front suspension are designed, such as the top table, bottom table, spindle and other components, with exact measurements and then the respective assembly in the chassis.

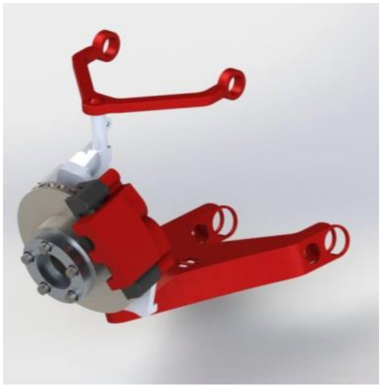


Figure. 6. Front suspension.

Later suspensión.

The suspension of rigid bars with bases of all-terrain vehicles or Buggy type vehicles is designed for the design of templers, shock absorbers, spirals, stabilizer bar, upper tension rod, all of these components must perform their respective Function to support weights, efforts and adapt to road irregularities.

Figure. 7. Subsequent suspension.

General parameters required for the design:

Specific characteristics of a vehicle type Buggy sandpit and data for mass transfer calculations such as:

- Wheelbase: 2430 mm
- Track width: 1720 mm
- Mass of the vehicle: 1455Kg

• Total mass: 1605 kg (considering two passengers)

• Distance to floor: 300mm

• Center of gravity height: 528mm (with the help of Solidworks software)

2.1.3 Transfer of masses.

The transfer of masses are the moments acting in the center of gravity of the vehicle and are transferred from one wheel to another when there is direct contact of the tires with the ground due to acceleration, braking or changing direction as a curve, This phenomenon can be identified by the driver of the vehicle.

Aerodynamic loads are considered despicable, as their tubular structure and the speeds attained do not generate great influences on the vehicle. For this reason, the structure will be subjected to the following loads:

• Permanent loads (G), which refer to the weight of the vehicle and the occupants.

• Variable loads (Q), which refer to loads generated by inertia when accelerating, braking or bending.

These loads are multiplied by a recommended load factor in order to guarantee the design and durability of the components to be evaluated:

• The permanent loads will have a factor of $\boldsymbol{\gamma_G} = 1.33$

• Variable loads will have a factor of $\boldsymbol{\gamma_Q} = 1.50$

This is also the analysis of mass transfer in the most extreme conditions, such as acceleration, sudden braking and vehicle in a curve with a high speed of 60km / h in a turning radius of 50m, where the vehicle is forced to check Strength, durability of its components for safe and efficient driving.

a. Mass transfer during acceleration.

Vehicle acceleration is required, and the time it takes to travel a distance, in this case a speed of 0 to 100 km / h in 9.9 seconds is used that comes from the Ford Explorer 4.0 L V6 (160 HP), therefore:

$$v = v_0 + a.t$$

$$a = \frac{v}{t}$$

$$a = \frac{27.78}{9.9}$$

$$a = 2.8\ {}^{m}/_{s^2}$$

This acceleration result 2.8 ${}^{m}/_{s^2}$, is subsequently used in the formula to calculate mass transfer during acceleration which is determined as follows:

$$w_a = \frac{a * m * h}{l}$$

Where:
w_a = Transfer of mass (N)
a = Acceleration (m/s2)
m = Total mass (kg)
h = Height of the center of mass (m)
l = Wheelbase (m)

$$w_a = \frac{2.8 * 1605 * 0.528}{2.430}$$

$$w_a = 976.5\ N$$

It is considered that the mass distribution of the vehicle type Buggy is 60% in the front and 40% in the back approximately, in acceleration is calculated in the posterior axis in turn uses mass transfer $w_a = 976.5\ N$ since the loads at the moment of acceleration tend to go backwards the load on the rear axle is:

$$w_t = (m * 40\% * Yg) + (\frac{Wa}{g} * Yq)$$

$$w_t = (1605 * 0.4 * 1.33) + (\frac{976.5}{9.81} * 1.5)$$

$$w_t = 1003.2\ Kg$$

In acceleration has a load on the rear axle of 1003.2 kg, dividing you get 501.6 kg on each wheel and on the front axle 1131. 45 kg giving 565.73 kg for each wheel, adding the loads should result in 2134.65 kg Is the total weight multiplied by the load factor, $\boldsymbol{\gamma_G} = 1.33$.

b. Mass transfer during sudden braking.

It is necessary to find the braking distance, ie the distance traveled by the vehicle from the activation of the brakes to their complete stop. This distance is obtained from the following expression:

$$df = \frac{v^2}{254e}$$

Where:

df = Braking distance (m)
v = Speed at braking (km/h)
e = Coefficient of friction pneumatic-soil.

$$df = \frac{100^2}{254 * 0.85}$$

$$df = 46.31m$$

The maximum deceleration caused by braking is:

$$a_f = \frac{v^2}{2 * df}$$

$$a_f = \frac{27.78^2}{2 * 46.31}$$

$$a_f = 8.33m/s^2$$

The mass transfer during braking is:

$$w_f = \frac{a * m * h}{l}$$

Where:

w_f = Transfer of mass (N)
a = Acceleration (m/s2)
m = Total mass (kg)
h = Height of the center of mass (m)
l = Wheelbase (m)

$$w_f = \frac{8.33 * 1605 * 0.528}{2.430}$$

$$w_f = 2905\ N$$

Mass transfer results in $w_f = 2905\ N$, this formula uses the braking acceleration and other known data, in the front there is greater weight by the location of its components in the front axle 60%, this result is applied in the formula of mass transfer over braking already that the loads go forward.

$$w_t = (m * 60\% * Yg) + (\frac{Wf}{g} * Yq)$$

$$w_t = (1605 * 0.6 * 1.33) + (\frac{2905}{9.81} * 1.5)$$

$$w_t = 1725\ Kg$$

When braking, a full load is obtained on the front axle $w_t = 1725\ Kg$, dividing 862.5 kg in each wheel, in the front axle and 409.65 kg as a result 204.83 for each wheel in the rear axle, summing the loads the result is 2134.65 kg which is the total weight multiplied by the load factor $\boldsymbol{\gamma_G} = 1.33$

c. Transfer of mass during a curve

When passing through a curve, forces are generated that produce the transfer of load from the internal wheels to the external ones. It is considered that the vehicle enters a 50m radius curve with a maximum speed of 60km / h, for which the normal acceleration generated is calculated:

$$a_n = \frac{v^2}{\rho}$$

Where:

a_n = Normal acceleration (m/s2)
v =Speed (m/s)
ρ = Radius of the curve (m)

$$a_n = \frac{16.66^2}{50}$$

$$a_n = 5.5\ m/s^2$$

The mass transfer during the curve is determined by:

$$w_l = \frac{a_n * m * h}{b}$$

Where:

w_l = Transfer of lateral mass (N)
a_n = Normal acceleration (m/s2)
m = Mass (kg)
h = Height of the center of mass (m)
b = track width (m)

$$w_l = \frac{5.5 * 1605 * 0.528}{1.720}$$

$$w_l = 2709.8\ N$$

In mass transfer during a curve is made a very clear example to take data that is needed as is the case of normal acceleration $a_n = 5.5\ m/s^2$ In turn the lateral mass transfer was obtained $w_l = 2709.8\ N$, which is used in the general formula applying both the front and rear axles 60% - 40%.

Front Axle:

$$w_d = (1605 * 0.3 * 1.33) \pm (\frac{2709.8}{9.81} * 1.5)$$

$$w_{d1} = 1054.7\ Kg$$

$$w_{d2} = 226\ Kg$$

In the front axle there is 60% due to the location of its components. In addition, the calculations are performed on each wheel where 30% is used for the distribution of loads at rest, the inner wheel receives greater side load transfer $w_{d1} = 1054.7\ Kg$, and in the external $w_{d2} = 226\ Kg$.

Rear Axle:

$$w_d = (1605 * 0.2 * 1.33) + (\frac{2709.8}{9.81} * 1.5)$$

$$w_{d3} = 841.3\ Kg$$

$$w_{d4} = 12.6\ Kg$$

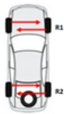
On the rear axle there is 40% since the weight of its components is less for calculations 20% is used for each wheel by the distribution of loads at rest, the inner wheel receives greater side load transfer $w_{d3} = 841.3\ Kg$, and in the external $w_{d4} = 12.6\ Kg$.

Analysis of load on each wheel

From the calculated values the following analysis is performed for each wheel under the different driving situations, consider that the total weight of the vehicle will be multiplied by the permanent load factor of 1.33, adding the loads on the four wheels of the vehicle in all positions The total weight is obtained.

Total weight =1605kg * 1.33= 2134.65 Kg

Table 1. Load analysis.

Transfer of masses.	Distribution of load on tires. 
RESTING Distribution 60-40 (%) (Forward-back)	L1 640.39 kg R1 640.39 kg L2 426.93 kg R2 426.93 kg
IN ACCELERATION	L1 565.73 kg R1 565.73 kg L2 501.6 kg R2 501.6 kg
BRUSH BRAKE	L1 862.5 kg R1 862.5 kg L2 204.83 kg R2 204.83 kg
CURVE	L1 1054.7 kg R1 226 kg L2 841.3 kg R2 12.6 kg

As can be seen in Table 1, where there is a greater load is when the vehicle takes a curve and all the weight is directed to the inner wheels obtaining as a result in **L1** 1054.7 kg and **L2** 841.3 kg, all this is given by the speed and The turning radius having a curve.

2.1.4 Analysis of the elements of the suspension system.

Analysis of suspension arms.

In curve. For the analysis, it is taken into account the greater load of those calculated in several driving conditions

Front top table.

Selection of material.

Before conducting the analysis of the front top table, the material in this case (ductile iron) with elastic limit of 551 N/m^2, is selected, as shown in Figure 8, to verify if the characteristics of this element support the Tensions to which they are subjected (Mott, 2006)

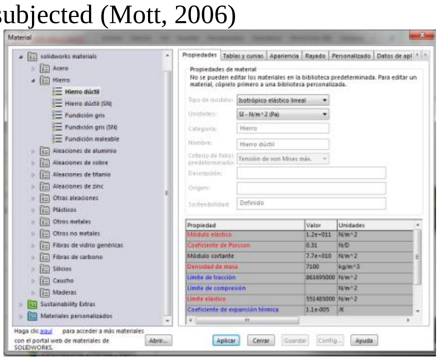


Figure 8. Application of material.
Source: (Solidworks, 2016)

Application of forces at fixed and moving points.

$$F = 1054.7kg * 9.81m/s^2$$

$$F = 10346.7N$$

Figure 9. Determination of points of attachment and application of forces.
Source: (Solidworks, 2016)

The highest force that is used is the one supported during a curve that is obtained from the analysis of loads in this case 1054.7 kg that is multiplied by gravity to obtain the total force since the weight is going to be directed to the rim depending the inclination of The road, in this step before performing the analysis should fix the moving and fixed points in addition the direction of the arrows as the force is applied.

Static stress analysis.

When static stress analysis is performed according to (-VonMises-), the mesh must be applied to the element, that is, a set of finite elements divided on the part.

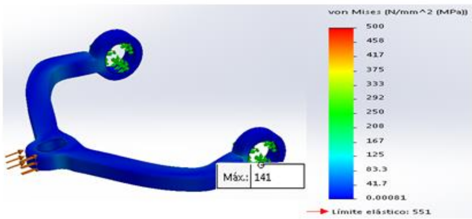


Figure 10. Tensions on the front upper suspension table.
Source: (Solidworks, 2016)

The elastic limit of the material is 551MPa, the analysis results in the maximum tensile strength of 141 MPa, when the maximum elastic limit is exceeded, the part will become deformed or a break point will occur. In this case, the part fulfills the function Required and its material is resistant to loads and stresses to be subjected.

Security factor.

The top table has an adequate safety factor of 3.92.

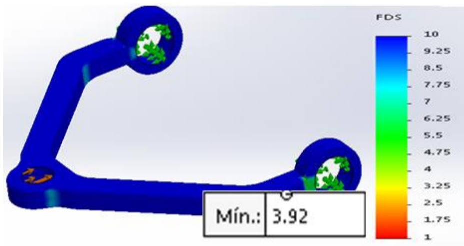


Figure 11. Safety factor on the front top suspension table
Source: (Solidworks, 2016)

This mechanical piece fulfills a good performance to support weight and to adapt to the irregularities of the way, knowing that the factor of safety always must be greater than 1 if it were smaller the material is deformed and rupture takes place.

This analysis is performed on each element of the suspension and then proceed to the assembly to the chassis.

2.1.5 General assembly of the suspensions to the chassis.

Once the Solidworks software has finished designing the suspensions and checking that all parts comply with the requirements, the front and rear suspensions and their brake system components are assembled to put them into practice.

Figure 12. General assembly of the chassis and its components.
Source: (Solidworks, 2016)

Design of the structure.

Once the installation of the braking, suspension and steering systems to the chassis has been completed, taking into account the necessary dimensions of the engine and box, the bodywork is modified using Solidworks software, taking as reference the bases of the chassis where it is located The body.
Figure 12 shows the body of the Peugeot 604 Buggy type vehicle, which had to be modified in its entirety because it was not in optimal structural conditions to avoid mechanical damage to the components and to ensure the safety of the occupants in the drive.

Figura13. Chassis and body of the vehicle Peugeot 604 type Buggy.

Selection of materials.

The selection of materials is made in a very professional manner, according to the design and the characteristics of the manufacturer, so that the body does not exceed the weight required for this type of sandpit vehicle.

Table 2. Materials used in the reconstruction of the body.

Plaques Noir TOL:	2mm. 3mm. 1/16.
Type de sangles C:	100 X 50 X 15 X 3.00 X 6000mm. 150 X 50 X 15 X 3.00 X 6000mm.
Tube rond:	2” X 2 X 6000mm
tube carré	40 X 40 X 1.50 X 6000 – 1 ½”
Coqueada maille obturateur.	
fibre of verre.	

Source: (Noboa, 2010.)

In Solidworks software, the design of the structure is made taking into account measurements at a scale of 1: 2, such as the track width that is taken from rim to rim 1720mm, The height of the main pair 1819mm and the length between axles of the vehicle 2430mm, for the construction of the structure on the bases of the chassis

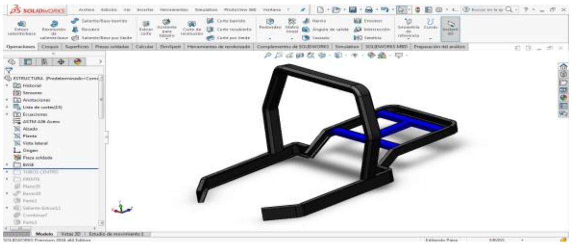


Figura 14. The basic structure.
Source: (Solidworks, 2016)

Once the structure has been formed, it is necessary to make the lateral mudguard of the body of the floor, the cushioned mesh of the front and rear blinds, and finally the design of the hood with air intake for greater ventilation and performance in the engine, To lighten the weight its construction was made in fiberglass, according to the vehicle type Buggy.

Figure 15. Final Body.
Source: (Solidworks, 2016)

This is the overall design of the prototype after the general assembly is done with all its components, such as the chassis the front and rear suspensions, brake system, steering system, bodywork as well aesthetic components of a prototype Buggy, once ready The design plans are to be put into practice.

Figura 16. Ensamble general del prototipo Buggy. Fuente: (Solidworks, 2016)

3. Results

3.1 Construction..

For the construction of the vehicle, the aforementioned materials were used, see Table 3, in addition to the multiple machines and tools needed for the re-construction of the new Ford Buggy, all this was done in a mechanical workshop of modifications specialized in this type of vehicles .

Table 3. Machines and Tools.

MACHINES.	
Welds:	Gas arc welding (MIG). Electrical autogenous
Benders:	Tube. Tol.
Plasma cutter.	
Pedestal drill.	
Compressor.	
Lathe.	
Circular saw.	
TOOLS.	
Drill.	Game of cracks.
Polisher.	Iron saw
Set of keys.	Buril.
Hammer.	Support levers.
Screwdrivers.	Hydraulic jack.
Flat and round files.	Scissors for metal.
Manual press.	Flexometer
MATERIALS.	
Electrodes:	6011. 6013. Cebora.
Discs:	Cutting. Polish.
Wire for MIG.	

It uses the planes that were obtained from the design made in Solidworks software, proceed to build the body, used various machines such as welding (MIG), plasma cutter and tools necessary to carry out this process of reconstruction Of this vehicle.

Figure 17. Principle of construction of the body.

Finished the construction of the body of the fenders, side cans blind mesh front and rear, also made the bonnet in fiberglass, for mounting also fixing other components of the carrier leaving the vehicle ready for the process Of paint.

Figure 18. Finished body assembled to the chassis.

Buggy vehicle finished with all its components in perfect condition and ready to undergo any test, in addition this prototype should serve as study material for the students of the Race of Engineering in Automotive Maintenance, in the Technical North University.

Figure 19. Buggy Ford prototype.

CONCLUSIONS

- Solidworks software was designed in the chassis with all its components such as struts, crossbars, bases and supports where the body is housed, the material of construction is AISI 1020 Cold rolled steel with elastic limit of 350 N/mm^2, through the stress analysis it was possible to determine that the maximum limit is 108 N/mm^2, applying a distributed force of 16000 N, in turn the safety factor gives a minimum of 3.24, guaranteeing the application of this chassis in the prototype Buggy.

- It was determined that with the installation of systems such as: brakes, suspension and steering for the chassis must take into account the weight of the vehicle 1455kg, the force that will exist when producing the braking in the front 1725 kg and later 409, 66 kg by calculating mass transfer by adding the loads gives a result of 2134.65 kg which is equivalent to the weight of the vehicle multiplied by the load value Yg = 1.33, in this way it is determined that the materials applied in each system are efficient Giving safety, reliability and comfort when driving the prototype Buggy.
- Through the Matlab software, the simulation of the posterior suspension was performed, where the oscillations of the suspension can be seen and the time it takes to return to its initial position, for this simulation the coefficient of elasticity of the spring **Kw:** 6730109 [N/m] and the coefficient of damping **Ks:** 835054[N/m], It is determined that the choice of materials and modification of the rigid axle suspension with tie rods fulfill their support function.
- The solidworks software determines the maximum loads supported on the components of the vehicle, a structural modeling, a visualization of the Buggy vehicle with the assembly of all its systems in three dimensions, being able to determine the plans to carry out the construction of the same.
- The mechanical tests performed on the Buggy prototype revealed the efficient work of the same in the design and construction phase, achieving safety, reliability and comfort when driving.

Thanks

First we want to thank God for allowing us to be alive, healthy, and give us all his love to share this achievement with the people we love the most.

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