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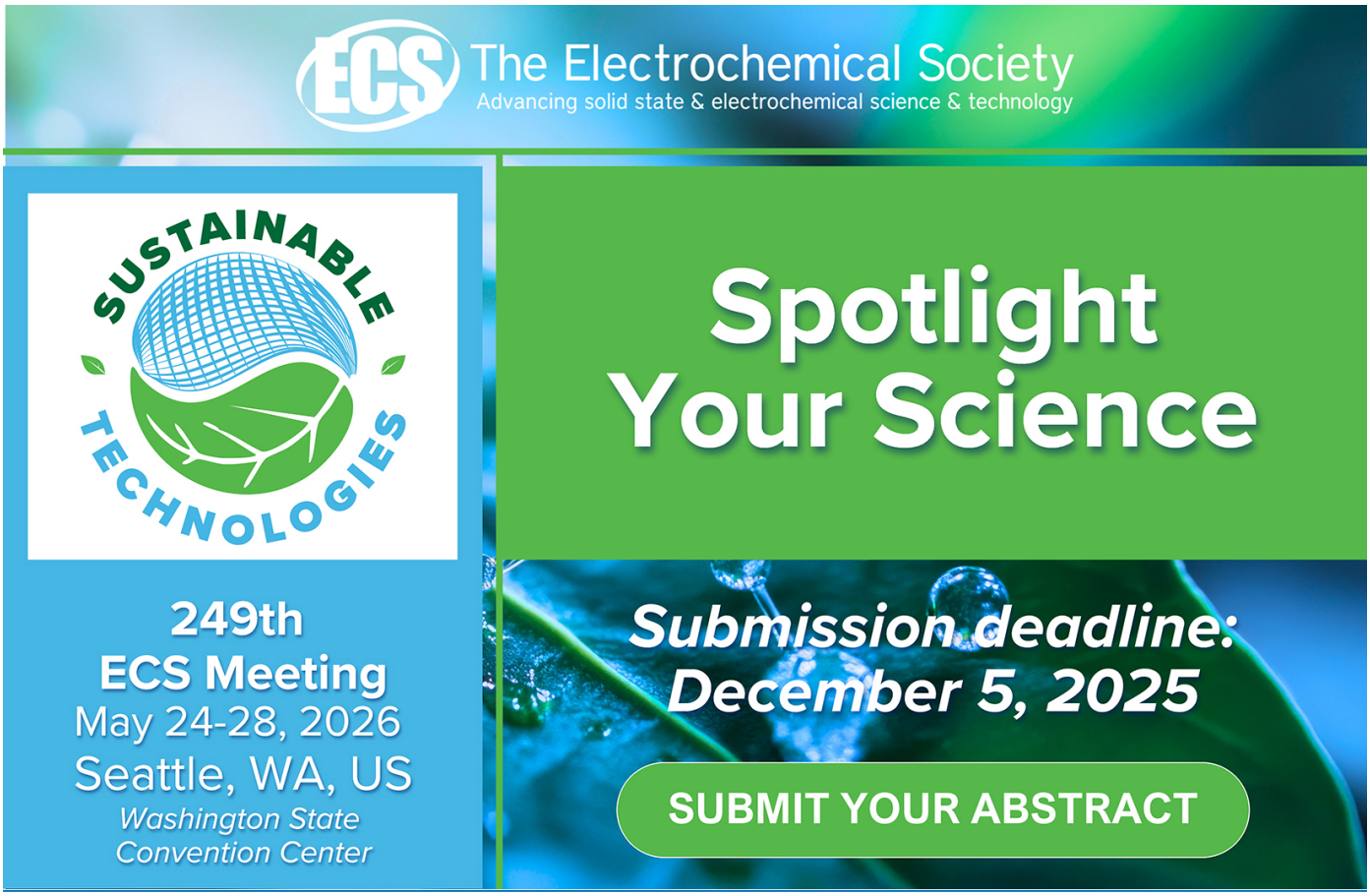
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Failure study as a physical component in mechanical suspensions of two automobile models of an automotive company

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Abstract. Car suspensions are a key element for the good behavior of cars. There are many types with their advantages and disadvantages, but among them, the most used and known today is the MacPherson strut suspension. The MacPherson strut is a system devised by Earle S. MacPherson in the 40s and patented by Ford in 1953, which today is used for the front axle of most cars. This type of suspension is very versatile because it can be used on the rear as well as front axles, and because of its low cost. These types of vehicles present many breakdowns on these pieces in the municipality of "Ocaña, Norte de Santander, Colombia" since the type of terrain is very complex (steep slopes, poor condition of the roads, among others), which leads to breakdowns on the pieces due to shear stresses, which could cause a traffic accident and high repair costs. This work seeks to show the identification of the vehicles that use the MacPherson strut and its possible failures. Subsequently, the analysis of the stresses on the lower arm system of the MacPherson strut is carried out in compact cars using simulation software. to perform the physical analysis behavior.

1. Introduction

The acquisition of four-wheeled vehicles for more than 50 years has increased exponentially, which has helped the development of society, but this has also generated a very considerable number of accidents either by reckless driving or mechanical problems. Therefore, the development and innovation of components to improve the performance and comfort of vehicles is essential [1,2].

The conditions of the environment, terrain, and maintenance of the vehicle are some of the parameters that must be taken into account when owning a motor vehicle since responsibility can prevent car accidents. The world's leading cause of human death is caused by road traffic accidents, a figure that is around 1.3 million human lives lost as a result of such accidents [3,4]. Every commercial vehicle has a suspension system, which varies according to the model, range, and purpose for which it is built. In the case of low range vehicles, which are very common on the streets, these possess, in most cases, a type of suspension called MacPherson. Due to its simplicity and low cost, it is the most used for this type of vehicle, but this does not mean that it is the best [5,6].

MacPherson strut is a type of suspension widely used in modern automobiles. The strut takes its name from Earl S. MacPherson [7], an engineer who developed it for use in 1951, on the Ford Consul model, and later on the Zephyr. It can be used on both the front and rear axles, although it is usually

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used on the front, where it provides a point of support for the steering and acts as a turning axle for the wheel [8].

This work seeks to design and simulate the stresses on the lower arm system of a MacPherson strut suspension in order to avoid possible failures and cost overruns caused by the stresses to which the part will be subjected in a suspension [9,10]. This type of suspension is very versatile because it can be used on front and rear axles and is widely used in modern compact cars for its low cost. In the municipality of "Ocaña, Norte de Santander, Colombia", these types of vehicles have many breakdowns in this piece since the road type is very complex (steep slopes). [11,12]. While driving a motor vehicle, the user will experience vibration effects caused by different sources of excitation such as bumps, holes in the ground, or other conditions that alter the stability of the car. Thanks to the suspension of the vehicle, these vibrations will be considerably reduced to the chassis of the car. Thus, passengers will have greater comfort while driving the vehicle [13].

Similarly, this work is focused on simulating the conditions to which the lower arm of a MacPherson suspension can be subjected [14], as well as designing some type of reinforcement or redesigning the lower arm to mitigate the problems that currently affect the automotive industry and Norte de Santander region.

2. Methodology

This project is based on a research with computer-aided design (CAD) technologies, which looks for alternatives and improvement of the lower arm of a McPherson strut suspension. Also, the working conditions of the piece are considered and recreated using computer simulations of a prototype created from an original part of a car suspension, with the purpose of redesigning or reinforcing it to increase the useful life of the piece without reducing its efficiency established by technical standards.

The first objective of this work was to identify the current situation regarding the failures of MacPherson suspension of compact cars in the municipality of "Ocaña, Norte de Santander, Colombia". These results were obtained by visiting the different motor vehicle inspection stations and automobile repair shops endorsed by the "Cámara de Comercio, Ocaña, Colombia". For this reason, a survey was carried out in the different recognized automobile repair shops in the city. As a result, a sample was obtained in which it was determined that one of the most used brands in the region is the Chevrolet with its Aveo and Optra models. Therefore, the preliminary research focused on these two types of vehicles.

The working conditions and functions of a vehicle suspension were also taken into account. The main function of the suspension is to control the movements originated by vibrations; these are originated by periodic oscillations of different amplitudes and frequencies. The conditions of the suspension parts are also affected by the temperature, ventilation, and meteorological conditions such as rain, which can cause corrosion, among others. ISO 2631 [15] standard defines and specifies people tolerance to vibrations that may occur in a vehicle [13].



Figure 1. Vehicle suspension of a Chevrolet Optra.

Passive independent suspensions systems such as Macpherson, as a show the Figure 1, are modeled using a system with two degrees of freedom since it is a conventional model. Figure 2 shows a physical representation of the model which uses two masses joined by a spring, a shock absorber, and an actuator. The Figure 3 show a schematic of the prototype. The suspended mass or m1 represents the mass of the chassis, and the unsuspended mass or m2 represents the mass of the wheel [3]. The third objective was to reinforce the previous prototype in order to minimize breakdowns due to stresses. The Table 1 show the volumetric properties of the piece.

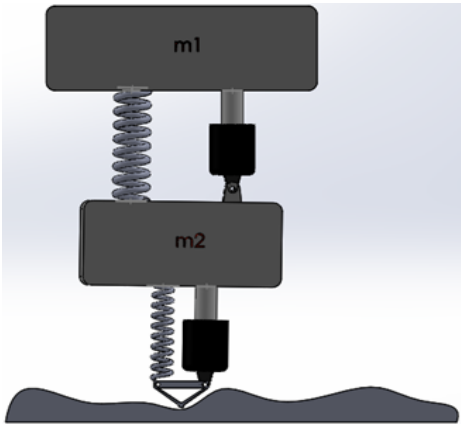


Figure 2. Semi-active suspension schematic for a wheel, physical behavior of the spring.

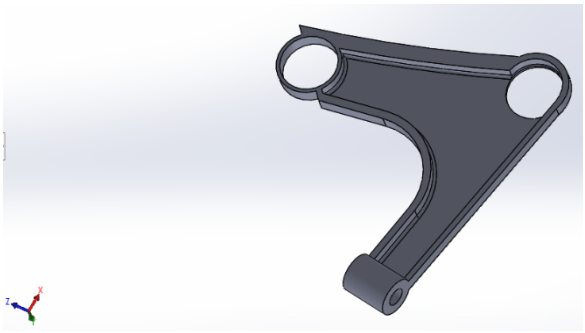


Figure 3. Schematic of the prototype.

Table 1. Volumetric properties of the piece.

Parameter	Value
Mass	4.88854 kg
Volume	0.000618802 m^3
Density	7900 kg/m^3

3. Results

The respective reference part of the MacPherson suspension of a 2007 Chevrolet Optra model showed an excessive fatigue point with a load corresponding to the front load exerted by the vehicle, as show in the Figure 4, which presented a small deformity and even crack in the joint between the lower arm and the chassis, as a show in the Figure 5, where the Figure 5(a) show the couplings between the lower arm-wheel and the Figure 5(b) show the chassis-lower arm. Also, it can be noted that it could cause a deformation in the center of the piece, which will take it out of service.

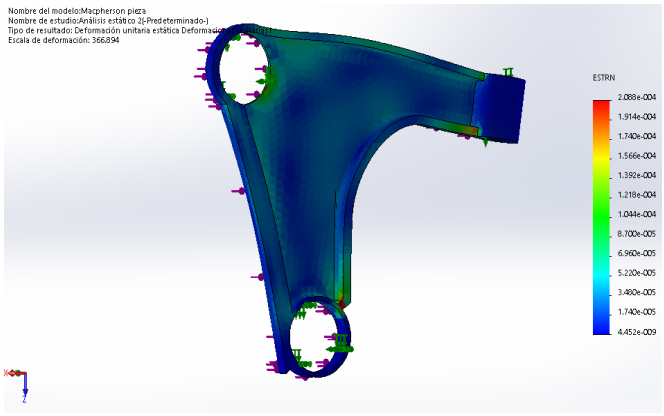
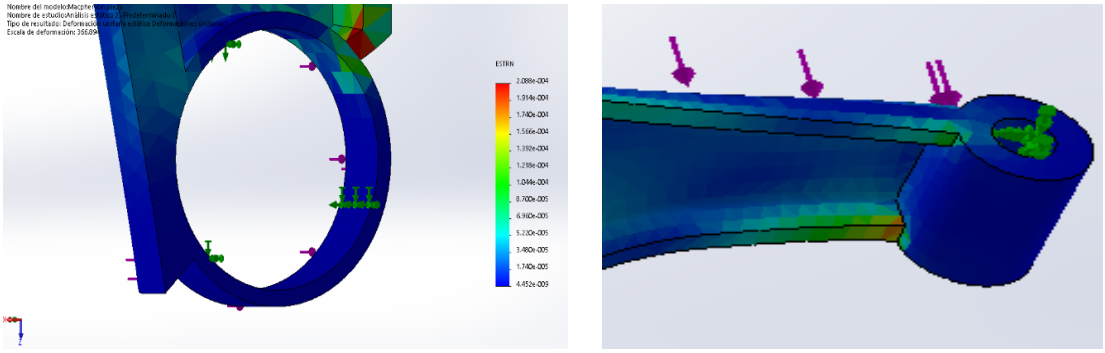


Figure 4. Simulation of static deformation.



(a) (b)

Figure 5. Magnification of the area most prone to deformation or fracture: (a) Couplings between the lower arm-wheel and (b) the chassis-lower arm.

These fatigue failure results obtained from simulation using computer-aided design software are very similar to those presented by the real part, as seen in Figure 6, after being subjected to certain unknown conditions. These results are approximate, as there are many parameters that can affect the piece.



Figure 6. Lower arm failure (chassis-lower arm coupling).

4. Conclusions

The work resulted in a preliminary study of the elements that contain a suspension and which of them fails the most, which is why the lower part of the device was selected, as well as the Chevrolet and its Aveo and Optra models. A CAD tool was used to design and simulate the selected element. Furthermore, the applied stresses were observed at the points where the allowable stresses of the piece are exceeded. As a result, this is the point where the part fails, according to the physical analysis. This is a good physical analysis where it is demonstrated both in simulation and real processes the present faults MacPherson support.

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