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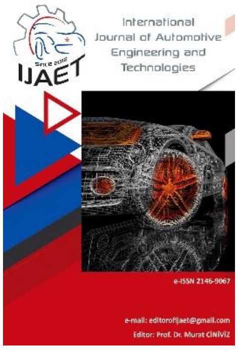

Original Research Article

Electric vehicle mechanical design, manufacturing and analysis application

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ABSTRACT

Today, energy is derived from a very large percentage of fossil-based sources, such as 80-85% worldwide. However, it is not sustainable that the use of fossil-based resources pollutes the environment, causes climate change, runs out of reserves and lacks price stability. The most important measure against climate change that poses a threat to the world is to reduce the share of fossil-based resources in energy supply.

In this context, in order to encourage universities in our country to design and manufacture electric vehicles and equipment, TUBITAK organizes competitions for universities and high schools under the name electromobile every year. In this study, TUBITAK Electromobile Battery was designed and manufactured by designing a unique electric vehicle to compete in the Electric Powered Vehicle category. After the mechanical designs of this vehicle we produced were made, the chassis and shell production was carried out by analyzing. After the mechanical designs of this vehicle we produced were made in the Solidworks program, the ANSYS 2019 R3 program was used for the analysis, and the chassis and shell were produced.

Keywords: Electric vehicle, mechanical design, chassis, analysis

1. Introduction

Electric cars are called vehicles with technology that generates all or part of their driving power with an electric engine and rotates the wheels. It feeds the electric engine the energy stored in the vehicle's batteries and these batteries are charged in various ways [1]. Electric vehicles can also produce their own energy. These are also divided into two as series hybrid and fuel cell. The internal combustion engine in series hybrid electric vehicles does not directly contribute to the vehicle propulsion. Fuel cell electric vehicles only have an electric engine. Electric vehicles with external energy supply, on the other hand, can receive the required energy with or without contact from the outside [2,3]. The location of electric cars is very valuable today. The world began to use new technology and gradually abandon diesel and gasoline vehicles [4]. In order to be a part of this technology in our country, he has taken new steps and embarked on a new journey under the name of TOGG.

The process of producing cars begins to be designed by arisen from the needs. According to the researches obtained, the cars begin the journey with the start of the designers [5,6]. The automotive sector, which has a wide field of study and technique, covers many areas. The interior design of the vehicle is based on the science of ergonomics, figurine in the making of clay modeling in certain dimensions of the vehicle, mathematics and physics calculations of the vehicle include many sectors such as engineering, the battery systems of the vehicle, chemistry and electricity, etc. It is a very long process until the research of these issues, the decisions made and the latest production [7,8,9]. Therefore, in this process, which requires continuous development and follow-up, the vehicles should be designed and modeled and then the necessary analyses should be done in a computer environment [10]. According to the results of these tests, the production of the vehicle is started in the continuation [11,12]. After the parts such as the engines and batteries to be used in the vehicle, electrical components and chassis are designed and manufactured, the prototype vehicle is placed in the necessary places. As a result of successfully passing many tests such as necessary driving tests and accident tests on this vehicle, the vehicle will now be ready for mass production with the preparation of the necessary infrastructure preparations [13]. In this study, an original vehicle with light weight and good strength was designed for daily use with Teknofest races in the Automotive Technologies Laboratory of the Faculty of Technology of Selcuk University. After the shell design, aluminum chassis design and analysis were made. After the design and analysis were completed, the production was carried out.

2. Chassis Design and Production

The chassis design can be considered as the skeleton of the vehicle, which should be light as a pain but also safe as strength. The manufacturing method to be used in the chassis should be considered as welding or bending, and principles such as material assignment profile geometry and thickness should be strictly taken into account [14].

Using the chassis design Solidworks program, the integrated points of the vehicle shell were also designed with the axle, distances in mind, "argon gas was attached to the under-gas welding and using ER 4043 aluminum welding wire, the 40x40x2 square 6063 T6 series profiles, which were cut in appropriate dimensions, were made from the inside out to avoid the dimmed punta, and after the process, the temperature distribution was made from the inside out so that there was no charge or pull on the profiles. The visual of the welding work done is given in Figure 1. After the welding work, studies were carried out on the position of the front arrangement and the connection places. It is visually indicated in Figure 2 regarding this study.

Figure 1: Chassis miter and welding work

Figure 2: Front layout and installation of tires

The roll bar and roll cage design, which is one of the main elements of the chassis, used a circular profile of 6082 T5 35x3 to be resistant and lightweight. The profile, which is cut with the appropriate bend diameters in mind, is bent in the pipe bending machine at appropriate diameters. The bent parts are first welded to the chassis, the support profiles are boiled with the under-gas welding to open the wolf's mouth and support the chassis and rollbar from four points. Before the roll bar and roll cage are produced, a CAD model has been created that will contribute to the creation of the production drawings. It was manufactured with the measurements taken on this model. The Cad model we created is shown in Figure 4.


Figure 3: Rollbar and Rollcage locations on the vehicle


Figure 4: Rollbar ve Rollcage CAD

3. Chassis and Roll Bar Roll Cage Analysis

3.1. Roll bar roll cage analysis

R3 version of ANSYS 2019 program was used for analysis. Only the Rollbar and Rollcage parts of the vehicle were modeled and assembled, preparing for the relevant analysis and then continuing by meshing. In terms of accuracy of the analysis, the maximum Skewness value is intended to be below 0.7. Since the geometry is too large, this quality was deemed sufficient not to get a large number of nodes. Various errors were corrected by cleaning geometry using Spaceclaim. After reaching the Ansys mechanical interface, material was assigned to the geometries. 6082 Aluminum alloys were used as materials in Rollbar and Rollcage. The properties of this material used are seen in Figure 5.

After the material assignment, the mesh throwing process was started. 0.63 Skewness Max using the Tetrahedron (Patch Independent) method after the settings are made. (Figure 6) and the analysis phase was started for the mesh structure, which was above the targeted quality.

As shown in Figure 7, rollbar and supports are boiled perpendicular to the chassis, so these surfaces are fixed. The main reason for fixing these points on the program is to indicate from which points the boiling process occurs in case the rollbar and roll cage, whose production phase is completed, are mounted on the vehicle chassis. By combining these points, more realistic results have been obtained.

After this process, nodal force was assigned to the top points as shown in Figure 8.

Figure 5: 6082 Mechanical properties of the material

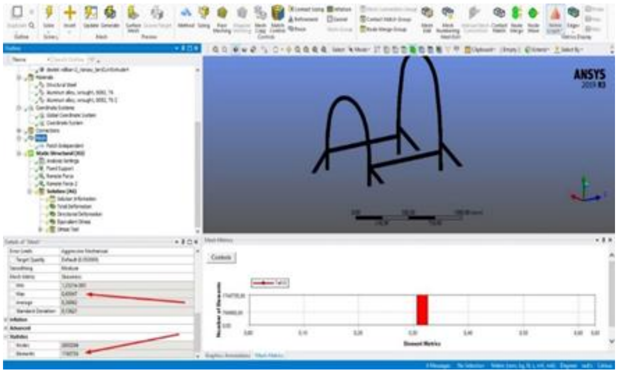

Figure 6: Mesh quality

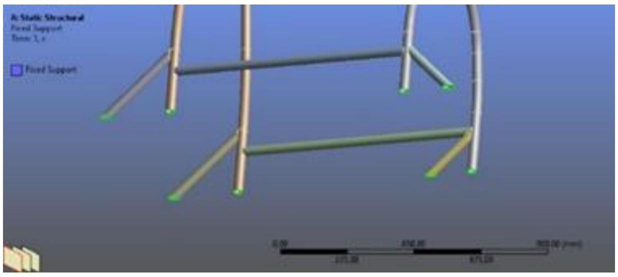
Figure 7: Fix points

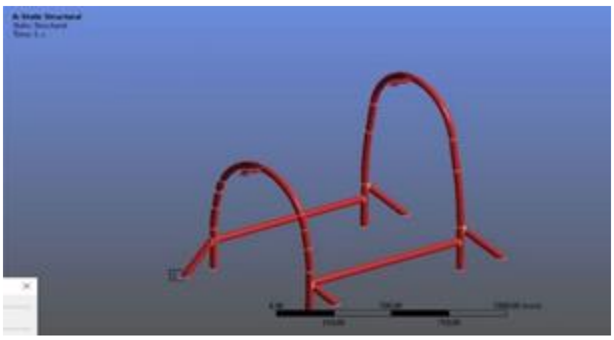
Figure 8: Force points

After this process, the Solution phase was started. The solution results are seen in Figure 9. If we look at the analysis in detail, a displacement of 32,459 mm was observed in the region where the total deformation would be maximum. As a result of the linear deformation analysis performed in the Z direction, the maximum possible displacement amount was measured as 0.08 mm.

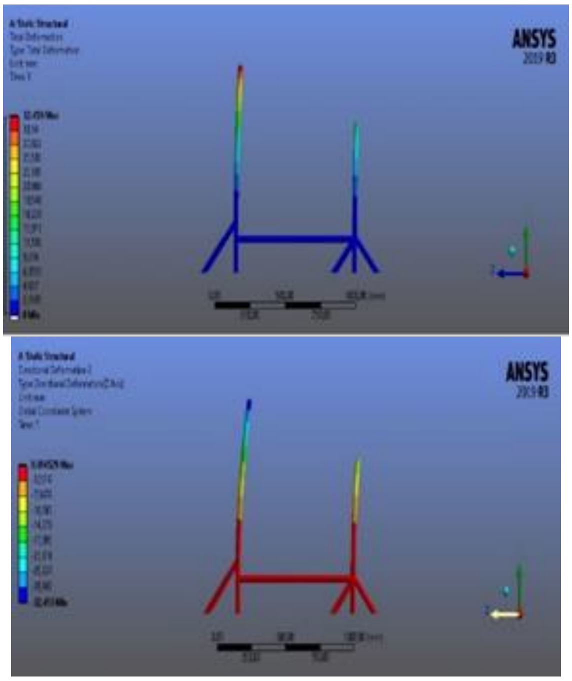

Figure 9: Results as a result of the specified force

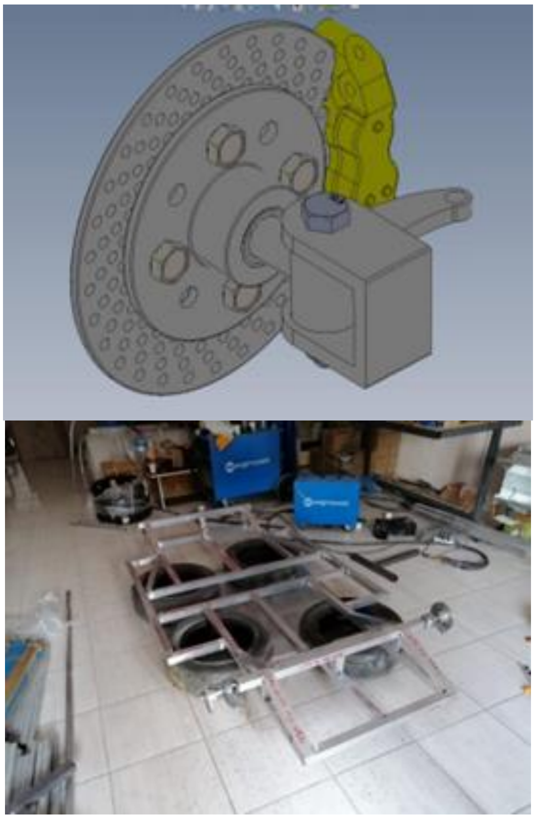

Figure 10: Hub CAD model and chassis appearance

3.2. Hub and wheel connection system and analysis

AISI 1040 steel material was preferred in accordance with the rim measurements that have been changed due to the inefficiency of the aluminum porcelains received, taking into account factors such as high strength and easy access as well as easy to process. Steel-filled material was supplied and chip removal was performed with universal lathes of the same size. Figure 10 shows the Hub CAD model and chassis.

Maximum stresses were determined by stress analysis of the direction of forces that can come on hubs. Maximum stress analysis of hub is seen in Figure 11.

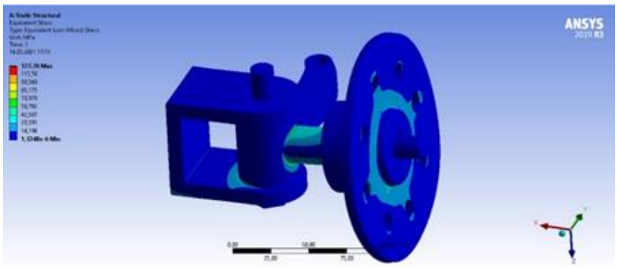

Figure 11: Hub Maximum Stress Analysis

3.3. Door connection system and analysis

After the installation of the chassis and shell, the chassis and door design were updated, taking into account the frame measuring 50x80 cm that must pass through the door. Our design was carried out in the dimensions that a frame with a size of 50x80 cm can enter. Piaggio Porter hinge was used in our door mechanism. The reason we chose this hinge was preferred because it made it easier to open the door outward. 3 profile connections placed inside the door have been added. The positions of the profiles are designed to minimize the strength of the vehicle door and the jolting during opening and closing. In Figure 12, the door gap is seen.

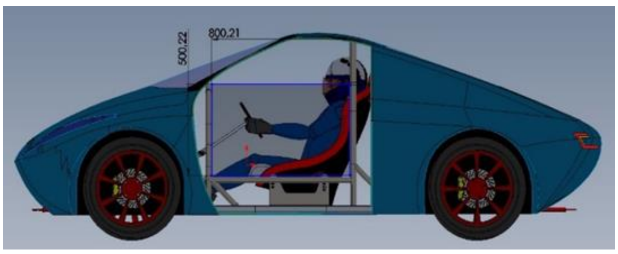

Figure 12: Door cavity

3.4. Door consolidation process

A rigid and non-moving door design had to be planned. Therefore, since the mold of the door will be prepared separately, the skeletal structure design was created by fixing it with aluminum profile (10x20) after production. The in-door skeletal system is seen in Figure 13.

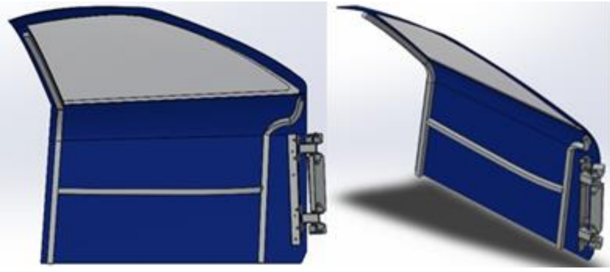

Figure 13: In-door skeleton

The foresground that might come from the top corner of the door is max. The 100 N force is transferred to the hinge edge with the moment calculation. The 91,617 N force coming to the edge of the hinge is shown in shapes. Our total deformation is 0.01 mm. The hinge design suitable for the door was determined to be as seen in Shape 14 in the analysis results. In Figure 15, the results of Total deformation and Maximum stress analysis taken from the ANSYS program of the hinge are shown.

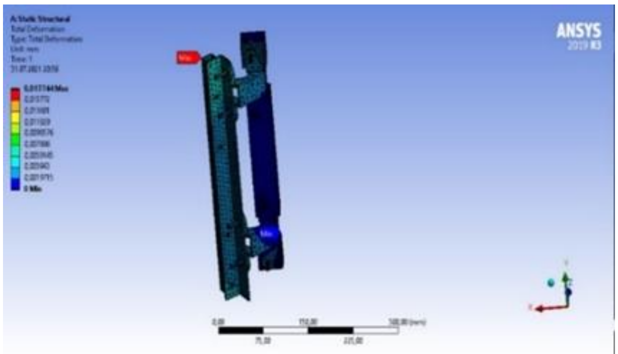

Figure 14: Hinge Total deformation analysis

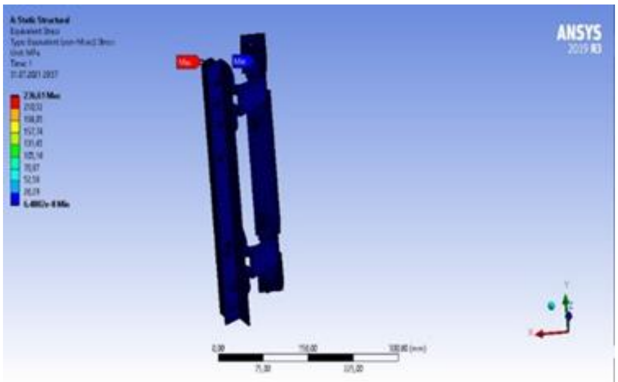

Figure 15. Hinge stress analysis

3.5. Vehicle CDF analysis

By looking at the iteration chart, our Cd result is determined as 0.19. The pressure distribution on the vehicle is seen in Figure 16 and the cd coefficient that is the result of this test is given in Figure 17.

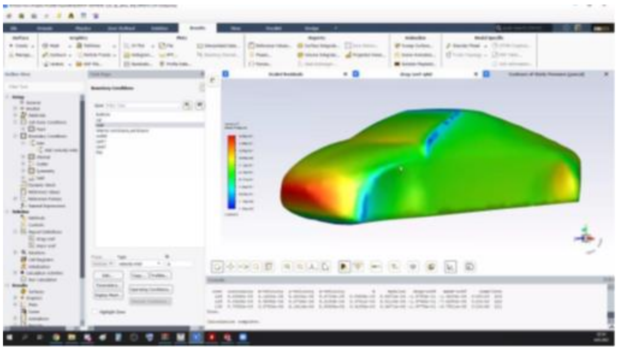

Figure 16:. Vehicle CFD analysis

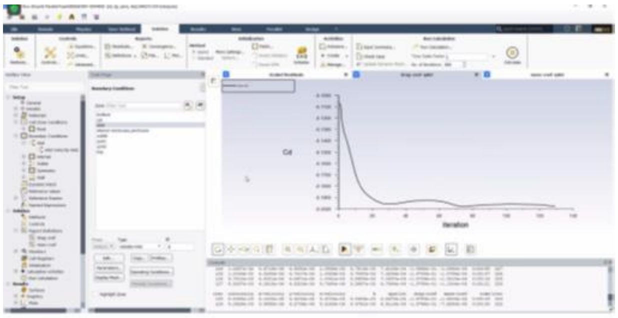

Figure 17: Itterization Chart

The Cd coefficient is the mathematical equivalent of the vehicle's resistance to the air flow in motion. The less this amount of resistance is, the less the amount of energy consumed by the vehicle while driving. It is one of the most important issues for efficiency [15]. This analysis was a computer aided analysis using the ANSYS program. Air resistance formula:

$$Air\ resistance = \frac{1}{2} \cdot d \cdot a \cdot Cd \cdot (v_t + v_r)^2$$

It can be calculated using the formula.

Figure 18. Manufactured electric vehicle

4. Conclusion

One of the most important problems of countries today is energy efficiency and energy cost. Countries that import nearly all of the oil it needs, such as our country, depend on oil exporting countries in terms of energy. Therefore, the issue of electric vehicles is of great importance for Turkey. The expansion of electric vehicles and the use of energy obtained from national power plants such as solar, wind, hydroelectric and thermal power plants to recharge the batteries of vehicles have the potential to reduce our country's oil needs. In addition, as a result of the use of electric vehicles, exhaust emissions that are highly harmful to the environment will be reduced by the use of fuels of petroleum origin. For these purposes, innovative studies on electric vehicles, which are popular today, will contribute to domestic and national production. With this work, an electric vehicle with a unique design is designed and manufactured. In particular, the mechanical design, production and control of the electric vehicle's drivetrains with domestic software within the scope of the project constituted the original aspect of the project. In this vehicle we have carried out, the system circuits and software embedded in the control software and the management system and telemetry application are also industrial structure and have created a unique structure. truck. In this study, students were also greatly contributed to the development of domestic electric vehicles, which are the subject of innovation.

CRediT authorship contribution statement

A.Engin Özçelik, Hakan Terzioğlu, İrem Sena Kök,: Writing - original draft, Investigation, Visualization, Supervision, Conceptualization, Methodology, Software, Formal analysis.
Ömer Cem Gökdoğan, Cüneyd Yavaşoğlu, Özgün Kurt, Ayberk Halıcı, Janset Altan, Muhammet Kayhaoğlu, Serhat Çetin: Investigation, Supervision, Writing - review & editing. Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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