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Research Article

Design and Production of a Unique Hand-Made Energy-Efficient 4 x 4 – Four Wheel Drive (4wd – 4 Matic) Traction System Electric Automobile

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Abstract

This article is related with the design and production period and also concerning about the main technical specifications of a hand-made energy-efficient Electric Automobile, designed and manufactured as a unique Project.

The most important feature of this hand-made energy-efficient Electric Automobile is as follows: This vehicle has a very unique 4 x 4 – Four Wheel Drive (4wd – 4 matic) Traction System and moreover, it is also the first 4x4 traction system Electric Automobile manufactured in Turkey. It can also be driven as 4x2 traction system, optionally either by front-wheel-drive (fwd) or by rear-wheel-drive. That is, this Electric Automobile has mainly both the capabilities of 4 x 4 – Four Wheel Drive (4wd) and also 4x 2 – Two Wheel Drive (2wd). In addition, it has a gear system having both the high-speed option in order to be able to drive it on the highway road and also the low speed option in order to be able to drive it for off-road. This unique 4 x 4 – Four Wheel Drive traction system enables the electric automobile a great energy transfer ability resulting in a high energy efficiency rate and at the same time this 4x4 system also provides a great and better road-holding and traction ability compared with 4x 2 – Two Wheel Drive system.

Keywords: Automotive, Electric Automobile, Electric Vehicle, Energy, Energy Transfer, Energy Efficiency, Energy Storage, Energy Density, Four Wheel Drive Traction System, Two Wheel Drive Traction System, Battery Package, Battery Charging Unit, Electric Motor, Motor Drive Unit, Vehicle Control Unit (VCU), Battery Management System (BMS).

INTRODUCTION

As an automotive technical and scientific application, this article is related with the design and production period and also concerning about the main technical specifications of a hand-made energy-efficient Electric Automobile, designed and manufactured as a unique automotive project.

The Electric Automobile has passed 100% of all the standard technical inspections. This vehicle has been manufactured fully in accordance with the required technical specifications and it is totally compatible with the category standards of racing cars. After having passed all the technical inspections and approved the vehicle accomplished to complete 55 km distance of track by cruising during 65 minutes continuously without any interruption. It has achieved to complete this track 2 (two) times, each of 55 km during 65 minutes. This means, 110 km - distance and 130 minutes -

time in total. The vehicle was 100% succesful and had delivered a complete full performance on the track and never lived any failure or breakdown.

The beginning stage of this electric automobile project has been started by doing research activities and then has been developed and followed by technical design studies, project drawings, engineering calculations, procurement, production periods, tests, inspections and lasted nearly one year and concluded succesfully.

The electric automobile project has been finalized with a 100% full and complete success. The automobile has a very unique, vintage style exterior physical appearance as well as it has an excellent interior design with a great useful control panel.

Method, Findings and Discussion

The most important feature of this hand-made energy-efficient Electric Automobile is as follows: This vehicle has a very unique 4 x 4 – Four Wheel Drive (4wd – 4 matic) Traction System and moreover, it is also the first 4x4 traction system Electric Automobile manufactured in Turkey. It can also be driven as 4x2 traction system optionally either by front-wheel-drive (fwd) or by rear-wheel-drive. That is, this Electric Automobile has mainly both the capabilities of 4 x 4 – Four Wheel Drive (4wd) and also 4x 2 – Two Wheel Drive (2wd). In addition, it has a gear system having both the high-speed option in order to be able to drive it on the highway road and also the low speed option in order to be able to drive it for off-road. This unique 4 x 4 – Four Wheel Drive traction system enables the electric automobile a great energy transfer ability resulting in a high energy efficiency rate and at the same time this 4x4 system also provides a great and better road-holding and traction ability compared with 4x 2 – Two Wheel Drive system.

The chassis frame of the vehicle and all the roll-bar and roll-cage systems have been made of aluminium material. Box-type profile bars having 3 mm of wall thicknes have been used for the carrying chassis frame and aluminium tubes having also 3 mm of wall thicknes have been used for the roll-bar and roll-cage systems. All the vehicle body shell has also been made of completely aluminium plates which has a wall thickness of 1.5 mm. It is possible to say that the automobile has a very robust structure and has a great mechanical strength and resistance. All the raw materials and also the consumables used for the production process of the automobile are certified materials. There are 4 (four) shock-absorbers in order to provide a cruise balance by a stable suspension system for the automobile.

Thanks to the aluminium materials used for the complete construction of chassis frame, roll-bar and roll-cage systems, vehicle body shell, wheel rims, and etc., the electric automobile became lighter, that is, the energy efficiency rate has been advanced and increased. Moreover, the automobile attained a great resistance against corrosion effects because of the aluminium material usage.

The overall dimensions of the Electric Automobile are as follows: The length of the vehicle is L= 380 cm, the width is W= 155 cm and the height is H=135 cm.

The Electric Automobile has 2 (two) pieces of electric motors, each has a nominal power of 1.5 kWe and 60 V, therefore the vehicle has 3 kWe motor power in total. One of these motors is located at the front axle and the other is located at the rear-axle. Each axle of the vehicle is driven by seperate electric motors, therefore, either both axles can be driven simultaneously or each axle may be driven independent of each other. If only the front axle is operated, the automobile is driven as 4x2 traction system with front-wheel-drive (fwd), if only the rear axle is operated the automobile is again driven as 4x2 traction system with rear-wheel-drive. If both the front axle and also the rear axle are operated together simultaneously, the automobile is driven as 4 x 4 – Four Wheel Drive (4wd – 4 matic) traction system which is a very unique feature and important specification of this energy-efficient electric automobile project.

There are also 2 (two) motor drive units and each of these drive units control each electric motor. The motor drives are capable of 72 V and 60 A. That is, two motor drive units operate these two electric motors independently. The most important and valuable factor of such a unique 4 x 4 – Four Wheel Drive (4wd – 4 matic) traction system is the synchronization control of the 2 motors by using the 2 seperate motor drive units. The gas pedal and all the connected electrical and mechanical systems are very special and unique, so has the simultaneous capability of a synchronizer for the motors and motor drive units as well as for the battery unit and BMS (Battery Management System) system.

As the powertrain system, there are 2 (two) gear boxes and also 2 (two) differantial units. Each gear boxes and each differantial units are connected with each of electric motors, one is connected on front axle and the other is on rear axle.

This electric automobile has a Lithium (Li-Ion) Battery system and has totally 7100 Wh energy storage capacity. The battery package has also 98.6 Ah energy storage capacity and has a nominal voltage of 72 V. The battery charging unit is 72 V – 17 A. The minimum and the maximum voltages of the battery package unit are 58 V and 84 V,

respectively. The maximum continuous current is 400 A. The energy density rates of the battery cells are excellent. There is a BMS (Battery Management System) used for controlling the cell voltages, current rates, operating temperatures and the energy capacity percantage of the battery unit. The Vehicle Control Unit (VCU) has also been uniquely designed, produced and installed on the automobile.

The automobile has an approximate weight of 500 kg and has reached up to a maximum speed of 78 km/h on the track and has a nominal continuous speed of 65 km/h. In accordance with the technical specifications, the vehicle has a total driving distance range of 250 km. The total cost of travelling a 100 km of distance by this automobile is changing between 0.20 USD and 0.30 USD, depending upon the local electric prices. These travel cruise costs are very economical and cost-effective, as well as this automobile has no emmissions, that is, it is totally environmentally friendly. The higher energy transfer capability and also the higher energy efficiency rate of the automobile have provided these economical and cost-effective results.

Aluminium welding method, TIG - tungsten inert gas (gas tungsten arc welding - GTAW) welding method and also the gas metal arc welding GMAW methods including both MIG and MAG have been used for different welded joint connections which are located at different parts of automobile.

The required WPS (welding procedure specification) documentations and the welding maps have been prepared before the welding operations in order to be able to identify and match the proper weld joints, welding methods, specifications and welding parameters. The NDT (non-destructive testing) methods have also been applied after the welding operations have been completed.

The bolted joints have been connected with bolts, nuts and washers which have a 8.8 mechanical strength quality. These stringent technical applications and quality norms, standards have also caused the automobile has got a very robust structure and has got a great mechanical resistance as well as it has a great energy efficiency capability.

All the technical drawings and also all the engineering calculations have been prepared during the design stage of the project. The mechanical strength analysis and also the aerodynamical analysis have been realized by means of engineering softwares. The mechanical strength analysis has been concluded with very safe results and the aerodynamic wind test gave an air friction coeeffient (Cw) of 0.68 for the automobile. This analysis result (Cw=0.68) is very suitable since the standards anticipates a minimum and maximum values between 0.25 and 1.25, respectively. This excellent mechanical design and great aerodynamical structure have also made valuable contributions for the robustness of the automobile as well as the energy efficiency capability.

Conclusion

The electric automobile has double-centered hydraulic brake system and it is safe enough. The brake test, supension test, dynamometer test, 4 x 4 – Four Wheel Drive (4wd) traction and also 4 x 2 – Two Wheel Drive (2wd) traction tests by dyno system have been realized. A total torque value of between 110 and 120 Nm has been determined for the automobile as a result of the dyno traction torque test. Both the steering wheel system and also the connected front alignment system of the automobile have been uniquely designed and manufactured as hand-made. The automobile has been painted by oven-drying system.

The Electric Automobile has excellent robustness, traction and energy efficiency capabilities. Moreover, the automobile has a very unique, vintage style exterior physical appearance as well as it has an excellent interior design with a great useful control panel. All the academical scientific and technical research, documentation, engineering and design studies, all the technical production period, all the procurement processes and also advisory, supervision, administration and project management are completely unique to this original electric car.

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