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A Novel Design and Simulation of Adjustable Steering Geometry

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Abstract— Designing and Analysing an Electric Kart is a vast platform for the students. So many competitions are used to organize for the students on this platform. It's beneficial to the students to enhance their learning and gain practical knowledge of various systems of Kart like steering system, braking system, transmission system, etc. This thesis presents the effect of multiple parameters on the performance of the steering system of the e-kart. It covers the design and analysis of stresses generated on steering components and to obtain the optimum safe design. The conceptual model of the E-Kart steering system is developed and used to illustrate the purpose of this study. The inner wheel and outer wheel angle of the steering system are studied using the steering equation. The simulation results reveal that the stresses generated on the steering system components are below the permissible stresses to assure that all members are safe for their maximum Stress. Also, several iterations are conducted on meshing to determine its stability, followed by the convergence tool. This research is intended to help undergraduates by giving a neat overview of E-kart's design and Simulation to participate in national competitions. This project work aims to point out the findings and studying on the steering system of the Kart.

Keywords: E-Kart, Designing, Analysis, Adjustable Steering System, Caster- Camber Angle.

I. INTRODUCTION

Electric Go-Kart, (E-Kart) is the eco-friendly kart which was firstly introduced in Los Angeles by Art Ingels and his neighbour Lou Borelli in 1956. In today's world, non-renewable resources are being used on a huge scale which includes the fuel on which vehicle operates [1]. Looking at the world energy outlook perspective, year by year the energy conservation of non-renewable sources is decreasing. With the increase in the usage of these resources there is also increase in greenhouse gases, damage to the environment, potential threat to human health, acid rain [2]. An IC engine emits pollutants such as Carbon Monoxide, Nitrogen Oxides, and Hydrocarbons. Energy build Systems such as Electrical energy is more compatible, clean and more sustainable, that is why E-Kart is a good alternative [3]. It is an electrical four-wheel vehicle, basically a type of mini car. It contains various systems such as Designing, Steering System, Power Transmission System, Braking System; it is used for student kart championships [4]. Karting is commonly discerned as the preliminary-step to F1 car. E-kart is a rear-wheel motor-driven automobile without any suspension and differential [5,6]. In order to fit into a suitable space, the steering mechanism's synthesis aim is to minimize the difference between steering centres across the entire range of steering angle inputs [7]. Several competing needs should be taken into account at once in order to achieve the aim. The search for parameter values is one way to formulate the synthesis issue based on optimisation. Rigid steering axles with Ackermann steering linkages are common on trucks and off-road vehicles. Therefore, synthesis of function generators is a frequent mechanism design issue for car steering systems [8]. Steering error is the difference between the desired and actual pivoting angles that the steering mechanism provides to the wheels [9]. The main objective of the design is to make a kart that is light in weight and performance centrepiece [10]. As it is a four-wheeled vehicle without suspensions the major problem such as vibration study and the design safety is the must parameter to focus on. Hence simulation process is the best method to get the outputs on the considered design [11]. The important factors such as transmissions, chassis design, steering system, and drive types, of the kart are needed to study. Analysis & Simulation is the best way to find out the optimum results of the parameters [12]. In practice if we have to do the changes in the structure of the components of Kart it will consume time as well as the capital, hence simulation on the software is the best way to perform trials and get the output.

II. ANALYSIS OF FUNDAMENTAL STEERING EQUATION

The turning radius of the Ackerman mechanism can be calculated [13,14] by using the trial and error method.

By operating the Kart on Road, we got a Turning Radius of 2.63m.

Then we have to figure out $\emptyset \wedge \theta$.

Checking $\emptyset \wedge \theta$ for fundamental correct steering equation, (to avoid skidding)

If the condition is not satisfied, repeat the procedure until the fundamental correct steering equation satisfies.

Track width (W) = 0.889m

Wheel base (H) =1.066m

Tire Rod Length C =0.635m

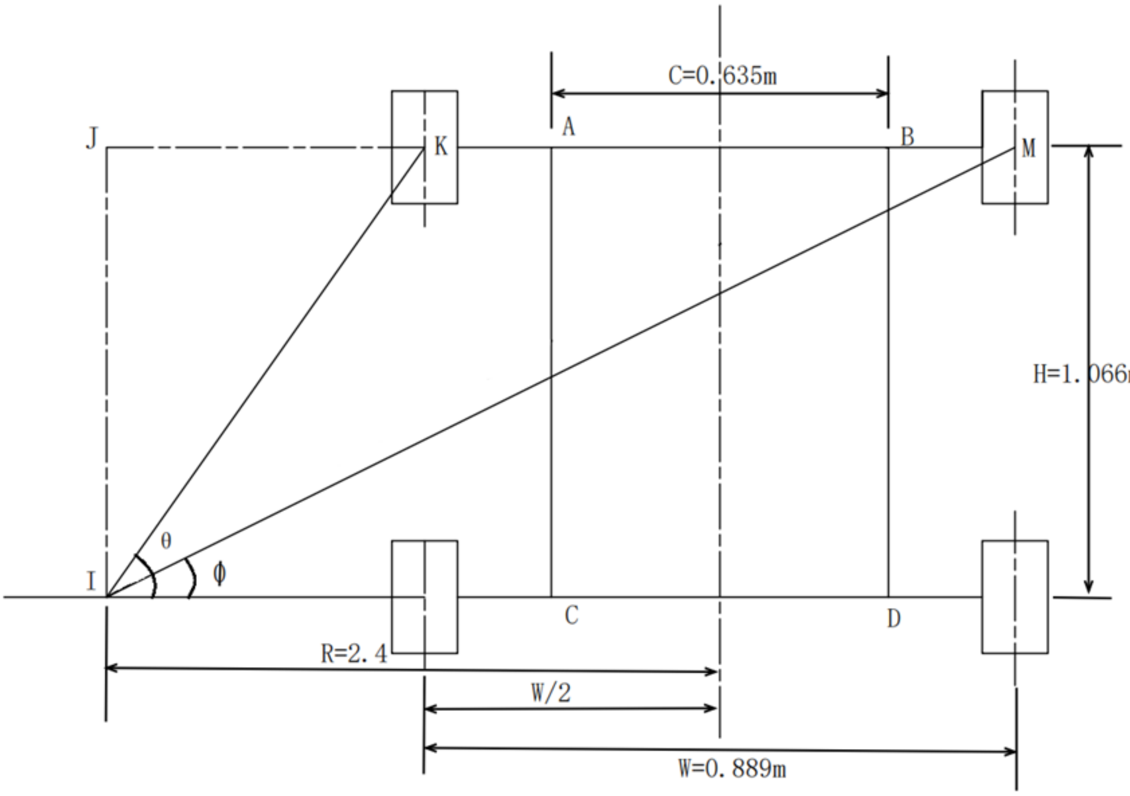

Fig. 1. Analysis of Fundamental Steering Equation

$$tan(\theta) = \frac{H}{R - \frac{W}{2}}$$

$$tan(\theta) = \frac{1.066}{2.63 - \frac{0.889}{2}}$$

$tan(\theta) = 0.487, \quad \theta = 25.96°$

$$tan(\emptyset) = \frac{H}{2.63 + \frac{W}{2}}$$

$$tan(\emptyset) = \frac{1.066}{2.63 + \frac{0.889}{2}}$$

$tan(\emptyset) = 0.346, \quad \emptyset = 19.08°$

$cot\emptyset \text{ - } cot\theta = \frac{C}{H}$

The above equation is a fundamental equation for correct steering [15]. If this condition is satisfied, there will be no skidding of the wheels when the vehicle turns.

$cot(19.08) - cot(25.96) = 0.83 \ldots\ldots$ *(1)*

$$\frac{C}{H} = \frac{0.635}{1.066}$$

$\frac{C}{H} = 0.6 \quad \ldots\ldots\ldots\ldots$ *(2)*

From equations (1) & (2), the fundamental correct steering equation is not satisfied.

Findings from the Calculation

The current turning radius, i.e., 2.44m is not satisfying the steering equation. It implies a correction in an Inner wheel radius & Outer wheel radius angle, so the Inner wheel radius & Outer wheel radius angle is required to satisfy the fundamental steering equation [9].

After using the trial and error method for several iterations, we got the value of θ&$\emptyset$.

$\theta = 30.6° \quad , \emptyset = 23.456°$

$cot(23.456) - cot(30.6) = 0.6$ .....*(3)*

$\frac{C}{H} = 0.6$....*(equation 2)*

Therefore, from equations (2) & (3), it is clear that the θ &∅ values match the steering system's fundamental equation.

$$tan(\theta) = \frac{H}{R - \frac{W}{2}} \qquad tan(\emptyset) = \frac{H}{R + \frac{W}{2}}$$

$$tan(30.6) = \frac{1.066}{R - \frac{0.889}{2}} \qquad tan(23.456) = \frac{1.066}{R + \frac{0.889}{2}}$$

$R = 2.2m.$ $\qquad$ $R = 2.012m.$

Hence, the optimum turning Radius, **2.012m,** is obtained.

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III. PROJECTED DESIGN FOR CASTER AND CAMBER ADJUSTMENT

We have designed the 3D model of steering system components in the pre-processor: Tie-rod, Stub axle, Steering Column, C-clamp. Crea and Catia software are used in the pre-processor [16].

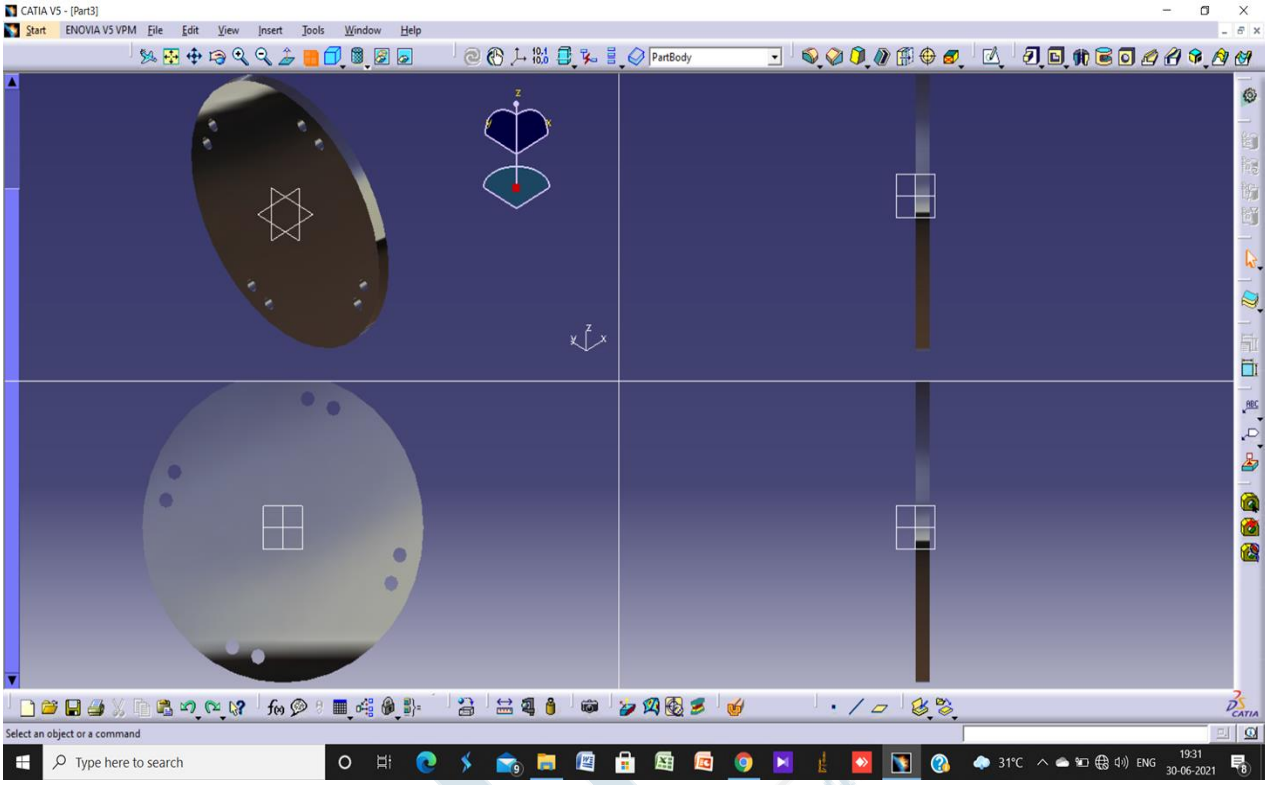

Fig. 2. Caster Flange

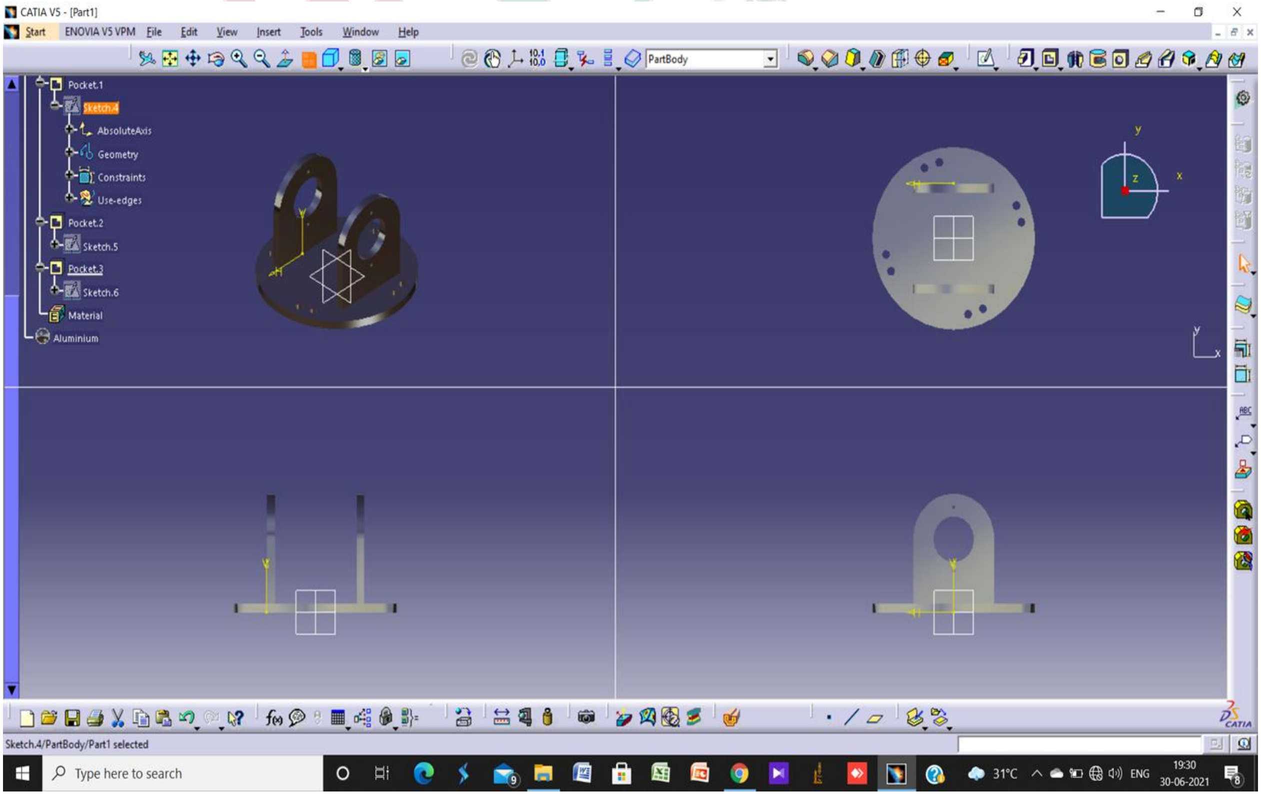

Fig. 3. Adjustable C-Clamp

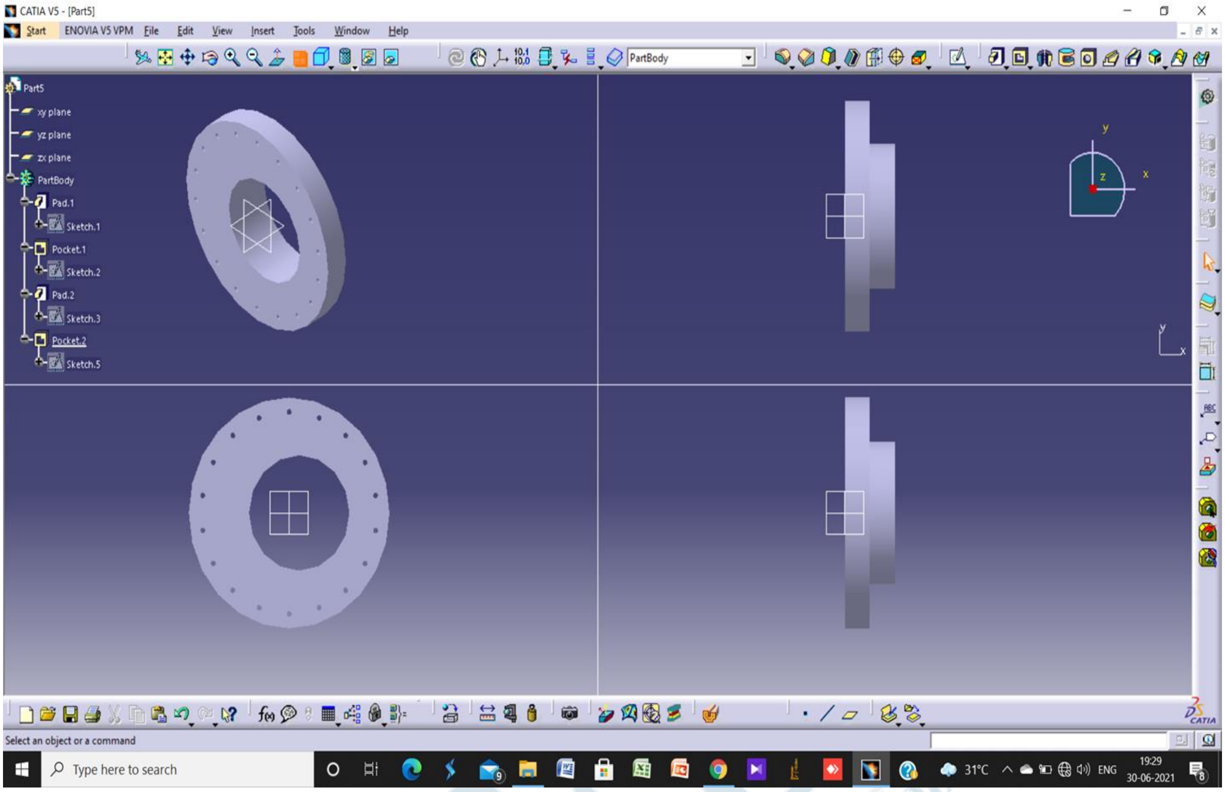

Fig. 4. Camber Flange

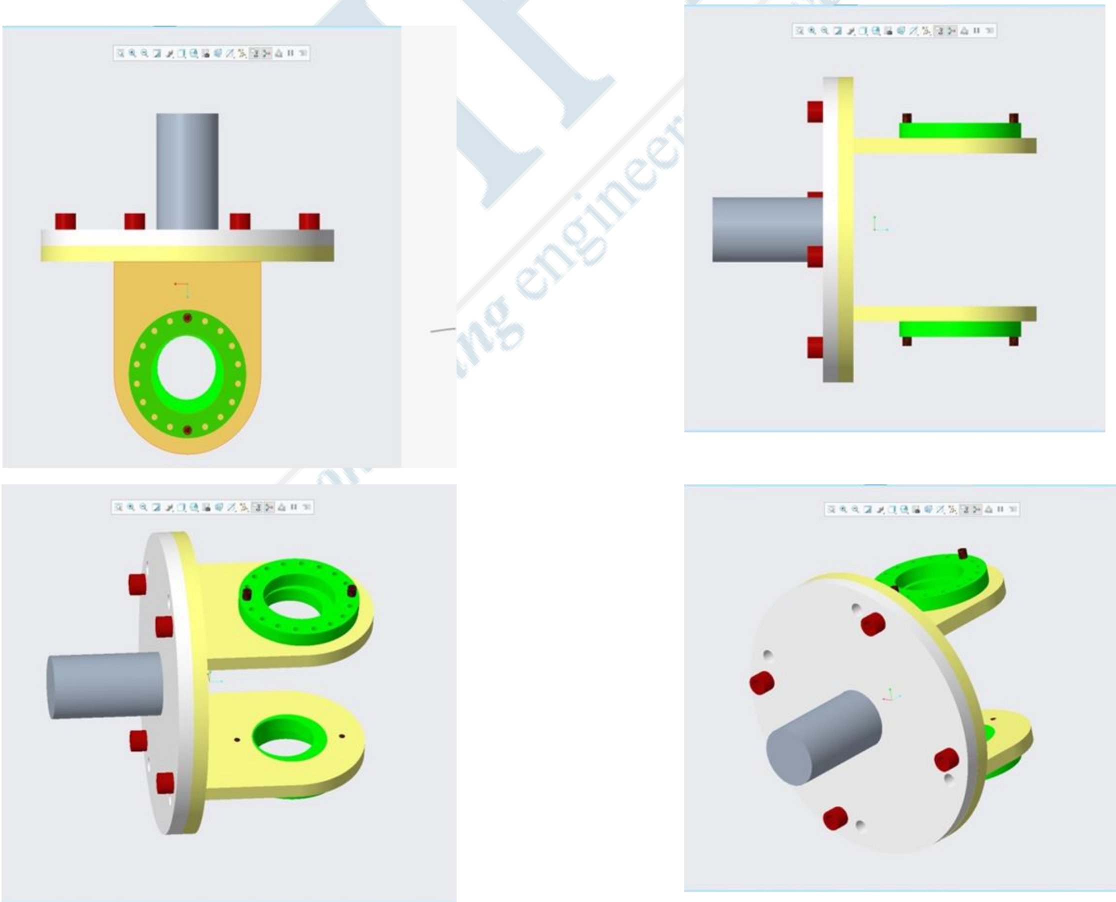

Fig. 5. Assembly of Adjustable Steering C-Clamp

IV. SUMMARIZED RESULT DATA

We have designed the various components of the steering system and perform Simulations on it. Firstly, we have done a Simulation on stub axel for forces acting on stub axel. And we have found that all stresses are below the allowable Stress of that material. Likewise, we have also done Simulation on the steering column, C clamp and Tie rod, and we have found that all components are safe, i.e. Stress is below the allowable Stress of that material. We have shown all these values in table format.

Table : 1 Summarized Result Data

PARAMETERS	VALUES
Ackermann angle	30.91
Ackermann percent	85 %
Turning radius of inner front wheel	1.89 m
Turning radius of outer front wheel	2.61 m
Turning radius of inner rear wheel	1.65 m
Turning radius of outer rear wheel	1.91m
Mechanical trail	13.34 mm
Actual turning radius	2.012 m
Force on front tyres	249.9 N
Lateral force on front tyres	117.3 N
Steering efforts on static condition	11.1 Nm

V. CONCLUSION

In this review paper an exhaustive review is carried out to find out the effect of various parameters on the performance of E-Kart. Parameters such as Steering system, braking system, transmission system, chassis and their analysis was considered in many literature reviews, but in the analysis section it was not more explored. In analysis section most of the authors have analyzed the chassis of the vehicle, others parameters needs to be consider in analysis such as –

- Analysis of Fundamental Steering Equation.
- Satisfying Fundamental Steering Equation.
- Equating Optimum Turning Radius.
- Calculation of forces on Stub Axel.
- Inner Wheel angle and Outer Wheel angle.
- Calculations of Caster-Camber Angle.

REFERENCES

[1] Alexandru, P., Macaveiu, D. and Alexandru, C., 2012. Design and simulation of a steering gearbox with variable transmission ratio. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 226(10), pp.2538-2548.

[2] Fényes, D., Fazekas, M., Németh, B. and Gáspár, P., 2022. Implementation of a variable-geometry suspension-based steering control system. Vehicle System Dynamics, 60(6), pp.2018-2035.

[3] Sah, K., Kaushal, R., Chauhan, P. and Chawla, V.K., 2022. Modeling and Simulation of Steering and Front Wheel Assembly for FSAE Vehicle. In Advances in Mechanical and Materials Technology (pp. 537-555). Springer, Singapore.

[4] Hossain, T., Habibullah, H. and Islam, R., 2022. Steering and Speed Control System Design for Autonomous Vehicles by Developing an Optimal Hybrid Controller to Track Reference Trajectory. Machines, 10(6), p.420.

[5] Chen, Y., Chen, S., Zhang, T., Zhang, S. and Zheng, N., 2018, June. Autonomous vehicle testing and validation platform: Integrated simulation system with hardware in the loop. In 2018 IEEE Intelligent Vehicles Symposium (IV) (pp. 949-956). IEEE.

[6] Bai, K., Cheng, X., Xue, Z., Song, H., Sang, L., Zhang, F., Liu, F., Luo, X., Huang, W., Huang, Y. and Zhang, Y., 2020. Geometrically reconfigurable 3D mesostructures and electromagnetic devices through a rational bottom-up design strategy. Science advances, 6(30), p.eabb7417.

[7] Gao, J., Liu, Y., Zheng, Q. and Liang, C., 2022. Advances in aerodynamic, structural design and test technology of variable geometry turbines. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy, 236(2), pp.364-390.

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[8] Zhao, J.S., Liu, X., Feng, Z.J. and Dai, J.S., 2013. Design of an Ackermann-type steering mechanism. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 227(11), pp.2549-2562.
[9] Zhang, Q., Zhang, M., Shi, X., Gao, S., Luo, Q., Chen, L., Wan, J. and Wang, X., 2021. A Low-Profile Beam-Steering Reflectarray with Integrated Leaky-Wave Feed and 2-Bit Phase Resolution for Ka-band SatCom. IEEE Transactions on Antennas and Propagation, 70(3), pp.1884-1894.
[10] Reza Kashyzadeh, K., 2020. Effects of axial and multiaxial variable amplitude loading conditions on the fatigue life assessment of automotive steering knuckle. Journal of Failure Analysis and Prevention, 20(2), pp.455-463.
[11] Smith, S.W., Pavy, H.G. and von Ramm, O.T., 1991. High-speed ultrasound volumetric imaging system. I. Transducer design and beam steering. IEEE transactions on ultrasonics, ferroelectrics, and frequency control, 38(2), pp.100-108.
[12] Fényes, D., Németh, B. and Gáspár, P., 2016. Control-oriented modelling of the variable-geometry Suspension for independent steering purposes.
[13] Zheng, H. and Yang, S., 2020. Research on race car steering geometry considering tire side slip angle. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of sports engineering and technology, 234(1), pp.72-87.
[14] Zhong, J., Li, L., Nishida, R. and Shinshi, T., 2020. Design and evaluation of a PEA-driven fast steering mirror with a permanent magnet preload force mechanism. Precision Engineering, 62, pp.95-105.
[15] Du, H., Zhao, X., Zhang, X., Zhang, Y. and Rong, J., 2015. Effects of fatigue on driving performance under different roadway geometries: a simulator study. Traffic injury prevention, 16(5), pp.468-473.
[16] Gadola, M., Chindamo, D., Vitale, F. and Bonera, E., 2019, May. The Design of A Motorcycle Featuring Fully Independent Adjustability for Front Suspension and Steering Geometry. In IOP Conference Series: Materials Science and Engineering (Vol. 538, No. 1, p. 012064). IOP Publishing.

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