DESIGN AND AIR FLOW ANALYSIS HYBRID DRIVE RACING CAR USING DIFFERENT MATERIALS

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ABSTRACT:

Hybrid vehicles have two or more power sources. To improve the reliability and stability of hybrid electric vehicle driving motor system, according to the performance parameters of the regenerative electric vehicle, the driving motor system is designed and analyzed for the hybrid electric vehicle. To propose an integrated system in which the engine torque converted by the transmission is combined with electric motor torque. In this project the hybrid drive racing car model design was done using suitable geometric parameters with NX 12.0 (UG) Software with various materials (Al 2024, Carbon steel). Finally, CFD (Realizable k-ε turbulence model) Analysis was performed with Compressed Air to determine the pressure and Velocity Streamlines

Keywords: hybrid vehicle, NX12.0, CFD

1.0 INTRODUCTION

Automobiles are the most common form of vehicular traffic and transportation, contributing to both individual lives and industrial production. The driving motor system is the backbone of a hybrid electric vehicle. This has given the car a new lease of life and is slowly but surely becoming the cleaner, efficient, and handy vehicle of the century. Hybrid electric vehicles depend heavily on an excellent driving motor system. Hybrid electric vehicles and electric cars rely heavily on their driving motor systems. International and domestic researchers are presently planning the drive system from every viewpoint using the principle of driving motor system design. decided on the method for picking the driving motor's important specs, but didn't run any tests or simulations with those specs. developed a model for the loss of the dual motor system and an equation for the energy efficiency of the dual motors, all while ignoring the internal electromagnetic analysis of the driving motor.

HYBRID CAR:

The use of hybrid technology in automobiles is rapidly increasing. A hybrid vehicle has more than one type of powertrain, typically including an electric motor and a conventional engine (either petrol or diesel). The vehicle's electric motor provides propulsion at low speeds, while the gas engine takes over at more incredible speeds. In addition to reducing fuel use, hybrid vehicles like the Toyota Prius and Honda Civic Hybrid also generate fewer carbon dioxide emissions.

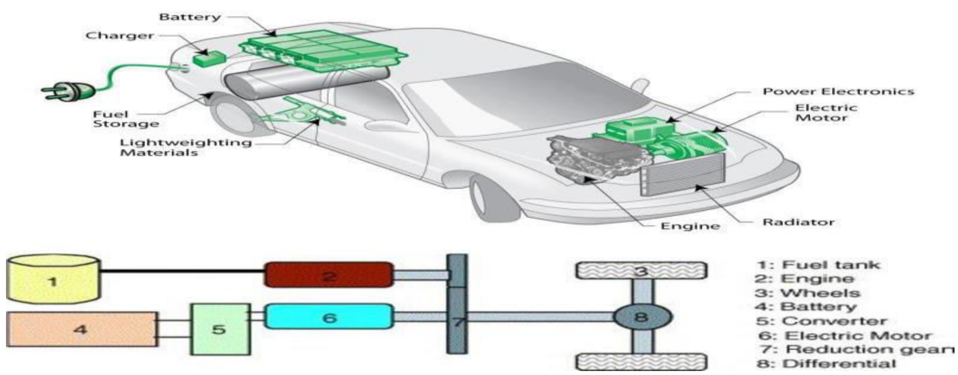

Figure 1: hybrid drive car schematic view

ADVANTAGES OF A HYBRID CAR:

Here are few of the top advantages of having a hybrid car: -

1. Environmentally Friendly: Hybrid vehicles are more eco-friendly than their gasoline-powered counterparts since they produce less pollution and have higher gas mileage. With a combination of gasoline and an electric motor, a hybrid vehicle's efficient operation reduces fuel costs and helps preserve the environment.

2. Financial Benefits: Many rebates and incentives exist to reduce the price tag of purchasing a hybrid vehicle. Saving money on gas means paying less in annual taxes and being excluded from congestion charges.

3. Less dependence on Fossil Fuels: Reduced emissions and fuel consumption from a Hybrid vehicle indicate less reliance on renewable sources. In turn, this contributes to lower gasoline on the domestic market.

4. Regenerative Braking System: When driving a hybrid vehicle, recharging the battery is as simple as tapping the brake. When this occurs, an internal mechanism begins absorbing the kinetic energy and using it to charge the battery, thus negating the need to frequently stop for recharging.

Problem of statement:

Hybrid vehicles have both an electric motor and a gasoline engine, with the latter serving as the primary generator. So, the gasoline engine and electric motor are both underperforming compared to standard gasoline and electric vehicles.

Objectives:

- To study the Hybrid drive racing cars with various applications.
- To the Racing car design was done by using NX 12.0
- The CFD Analysis was done by using ANSYS FLUENT with Various material properties with compressed Air

2.0 LITARATURE REVIEW

Anjul Chauhan, Lalit Naagar, Sparsh **[1]** The first hybrids on the market, which were designed to achieve high efficiency by streamlining and minimizing as much as possible. The Insight used the pioneering Integrated Motor Assist (IMA) technology, which boosts torque at low RPMs where the engine is less powerful. The electric motor of the Insight has a peak torque of 79 lb-ft at 1,500 rpm, up from 66 lb-ft at 4,800 rpm. D. Raghunandan, A. Pandiyan **[2]** Parallel and series configurations of hybrid cars that will be technically possible in the next decade are defined and analyzed with the use of a malleable Advanced Vehicle Simulator (ADVISOR). There is a comparison made between the fuel economy of two diesel-powered hybrid vehicles and that of a diesel-powered internal combustion engine vehicle using the same technology. Shithin PV and Uma Syamkumar **[3]** Integrated starter/generator (ISG) model for dynamic simulation of a hybrid electric vehicle's powertrain in Simulink. It took twenty-two years of hard work to create the PEACS, or parallel electric assistance control strategy. Sathish Kumar And Vignesh **[4]** An engine, motor/alternator, continuously variable transmission (CVT) device, powertrain control module (PCM), and three-helical gear set are the main components of the unique parallel-type hybrid electric power system proposed. Perez, L.; Pilotta **[5]** comprised a hybrid powertrain that could be coupled to change the engine's speed and torque. A planetary gear unit and a generator/motor separate the engine speed from the wheel speed in this powertrain.

Engine torque is isolated from wheel torque via a second gear unit and traction motor mounted on a shaft. Viehmann, A.; Rinderknecht **[6]** Transmission of power in hybrid power systems typically includes a gas-powered engine, an electric motor, and variously, a continuously variable transmission (CVT), a rubber V-belt, and chain drives. All it takes is a little ingenuity and a little bit of knowledge of how the system works, and you'll be able to utilize it to your advantage. Travis, E.; Torrey **[7]** introduced an innovative method for addressing the issue of power control strategy in a series hybrid electric car. They established a cost structure and three distinct operational modes. They developed a classifier based on a support vector machine to help decide which mode of operation to employ throughout driving cycles (SVM). Jing, L.; Xin-ran, W.; Lin-hui **[8]** investigated the hybrid electric vehicle's energy management plan. They summed up three different energy management strategies and compared the repercussions of choosing one strategy over another in light of the intensity and duration of the duty cycle over which the vehicle is expected to operate. Zainab, A.; El, A.; Daniela **[9]** shown a method for developing electric and hybrid car drivetrains that takes vehicle dynamics into account. The approach seeks to establish the electric powertrain's ideal torque-speed profile. The study demonstrates the benefits of lengthy periods of continuous power operation during the acceleration and cruising phases. Wu, G.; Zhang, X.; Dong **[10]** resulted in an assessment of the energy and power needed for moving an automobile. A variety of commercial line options for electric and hybrid automobiles in urban areas are surveyed. When considering urban driving cycles, average and peak power demands differ significantly, making comparisons difficult for energy assessments.

3.0 METHODOLOGY

A hybrid vehicle combines several propulsion systems. Hybrid vehicles have recently gained popularity among car manufacturers due to their energy efficiency. These vehicles combine the power of an internal combustion engine (ICE), which produces high torque at high speeds, with the power of an electric motor, or motors, which produce high torque at low speeds. This allows the vehicles to make up for the lack of low-speed torque in gasoline-powered vehicles, resulting in high torque and acceleration at lower speeds. Modern hybrid general-purpose vehicles have been aiming to reduce fuel consumption by downsizing the internal combustion engine (ICE) because of these advantages. Hybrid systems have been the subject of extensive study for energy management and improved fuel efficiency, with a primary emphasis on creating more pleasant driving experiences. nonetheless, conventional series, parallel, power split, and series-parallel hybrid powertrains were also the subjects of these research.

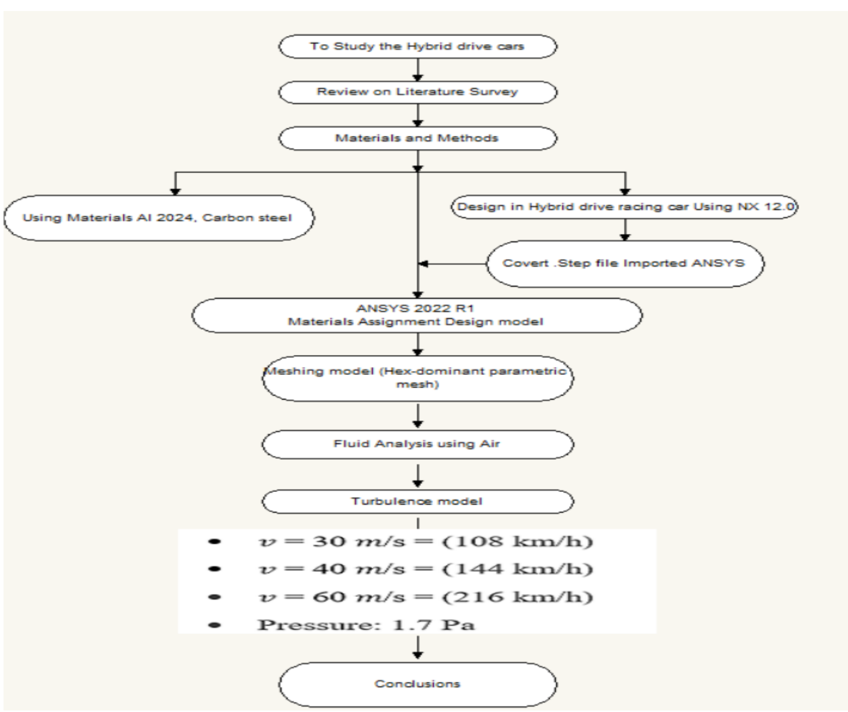

Figure 2: Design flow chart

Structure of the Hybrid System

In most cases, the ICE's torque is minimal at low rotational speeds but grows with increasing rotational speed up to its maximal torque. The electric motor, on the other hand, has a high torque at low rotational speeds and a low torque at high speeds. A parallel hybrid diesel-electric propulsion system is compared to a conventional diesel engine in terms of performance, consumption, and weight. There is a diesel IC engine, electric motor, rechargeable battery pack, and propeller in each of the parallel hybrid diesel-electric propulsion systems.

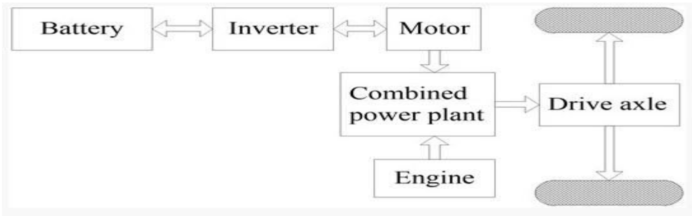

Figure 3: Mixed hybrid drive mode

An alternative to the common planetary gear gearbox seen in passenger cars is the hybrid mechanism that is being proposed. When compared to the proposed hybrid mechanism, planetary gears have numerous design restrictions and are difficult to maintain.

Forces On Vehicle:

When driving at high speeds, the vehicle experiences a number of forces acting in various directions. The graphic representation of the forces operating on the vehicle body is shown in the figure above. The free body diagram up top shows that the car is subject to three primary forces:

- Drag (X- axis)
- Lateral (Y- axis)
- Lift (Z- axis)

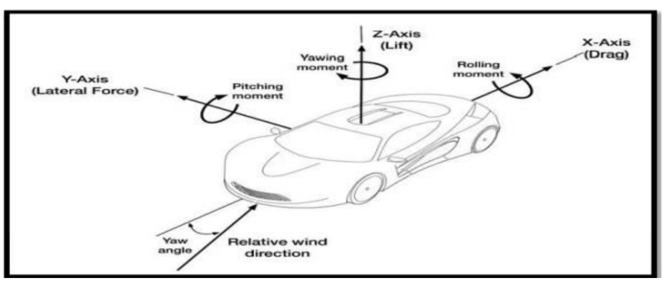

Figure 4: Forces and Moments on Vehicle

Aerodynamic drag force: It's the force that's trying to stop the car from moving forward by acting in the opposing direction of its motion. Considering this force is crucial when constructing the vehicle's outer body, since it accounts for approximately 65% of the total force operating on the entire body. Following is the formula for calculating the aerodynamic drag force**:**

$$\mathbf{CD} = \frac{D}{\frac{1}{2}.\rho.A.V^2} \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \mathbf{(1)}$$

Lift force:

Its effect on the car is vertical. When applied in a positive direction, this force lifts the vehicle into the air; however, when applied in a negative direction, it may create an excessive amount of wheel down force. To prevent an excessive amount of lift or down force, engineers strive to keep this value within the required limit. The standard way to express this force is as:

$$\mathbf{C_L} = \frac{L}{\frac{1}{2}.\rho.A.V^2} \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \mathbf{(2)}$$

Cornering force or side force:

The lateral force, which is perpendicular to the wheel axis, is generated by a tyre of a vehicle when it turns or corners. Tyre slip causes cornering force, which is directly proportional to the slip angle when the slip angle is small. a particular relaxation length, cornering force builds up at a certain rate. Most definitions of this force utilise the formula as:

$$P_Y = ½. \rho. V^2. A. C_Y \text{.........................} \textbf{(3)}$$

USING MATERIALS:

Aluminum alloy 2024 Material Properties:

Tensile strength: 90 MPa
Compressive Strength: 120 MPa
Density: 2770 Kg/m3
Modulus of elasticity is 68.9 GPa
Young's modulus: 70 GPa
Poisson's ratio, μ :0.33

Carbon Steel Material Properties:

Compressive Strength: 1320 - 3100 MPa
Ultimate Tensile Strength: 685 MPa
Density: 7850 Kg/m3
Bulk Modulus :160 GPa
Modulus of elasticity: 13.8 - 235 GPa
Flexural Yield Strength: 159 - 5130 MPa
Young's modulus: 70 GPa
Poisson's ratio μ: 0.295

DESIGN REQUIREMENTS

Initial needs for the platform were created based on an examination of the need to deploy logistic and engineering platforms inside the military. The following are the specifications and goals for the unmanned land vehicle's drive system:

- Total weight of vehicle – 800 kg,
- power from a 680hp
- V6 twin-turbocharged engine.
- Maximum height: 996.7 mm
- Maximum width: 1500 mm
- Maximum length: 3000 mm
- Wheelbase: 2380 mm
- Track: (front)/ (rear): 1406 mm1356 mm
- Gross vehicle weight: 1360 Kg
- Bore x stroke: 71 mm X 82 mm
- Maximum output: 62 kN / 6000 rpm
- Maximum torque: 109 Nm / 4000 rpm

Boundary Conditions:

It is the purpose of the computational fluid dynamics (CFD) study to investigate the airflow and temperature conditions within the vehicle's surface under different boundary conditions in the suggested hybrid vehicle model. When running a simulation, it's necessary to set boundary conditions, such as the maximum allowable temperature, pressure, cooling time, and air vent velocity, among other things. Both the starting air velocities and the temperature are referred to as to. We used the Hybrid model's top and wall surfaces for convective heat transfer as our boundary condition. Approximately 300 W/m2 of solar radiation is emitted outside the cabin, which is thermal radiation.

- Using materials: Aluminum alloy, Carbon fiber
- Air flow velocities with different car body materials
- v = 30 m/s = (108 km/h)
- v = 40 m/s = (144 km/h)
- v = 60 m/s = (216 km/h)

- Viscosity: 1.7 Pa
- Pressure And Velocity Stream Lines
- Modelling Software: NX 12.0 (UG)
- Simulation Software: Ansys Fluent 2022 R1
- Material medium: Air
- density of air is set as 1.185 kg/m^{-3}
- Inlet Temperature (T) = 309 K
- $k-\varepsilon$ Turbulence model

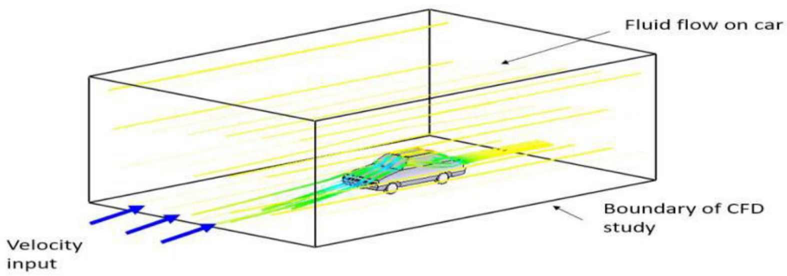

Figure 5: Boundary Condition of CFD analysis

Design model in NX 12.0

Model was created in NX12.0 software using design cues from contemporary TATA vehicles. The model was sent to Ansys for additional air flow study after its creation. Ansys Design Modeller was used to open the geometry and establish an enclosure in order to execute the Air. The necessary flow conditions dictated the naming of the inlet, outlet, and boundary walls.

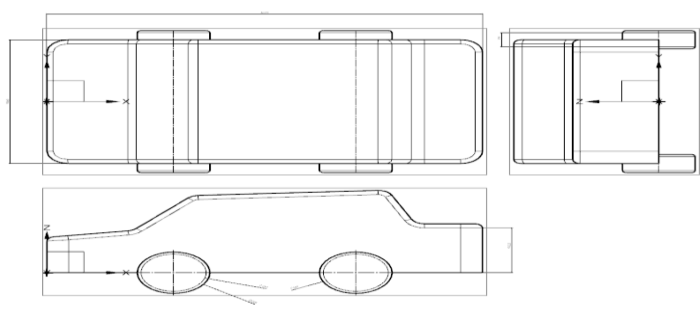

Figure 6: Geometric view of racing car in NX 12.0

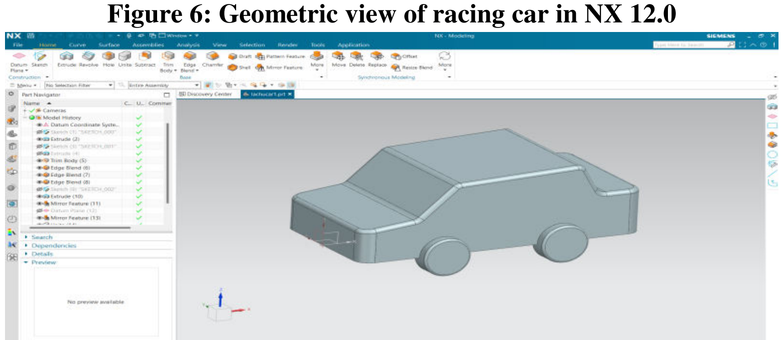

Figure 7: Design model in NX 12.0

Meshing model:

In the Hybrid model, a hex-dominant mesh was manually generated. In order to simulate a virtual wind tunnel, the airflow surrounding the vehicle is mesh-mapped. This process allows for more precise meshing of complex geometries while maintaining an appropriate overall mesh size, and it also provides the user greater control. For this application Hex-dominant parametric mesh is used to demonstrate the alternative meshing options in Hybrid model however users are always welcome to use Standard Mesher in their simulations.

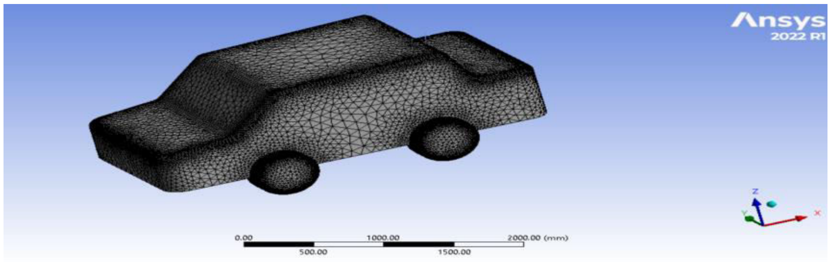

Figure 8: Meshing model

4.0 RESULTS AND DISCUSSIONS

In this Chapter to discusses the hybrid drive racing car Air flow Analysis using ANSYS 2022 R1 Software with various materials and flow conditions applied to the imported model to Analyze to velocity conditions and validated the results.

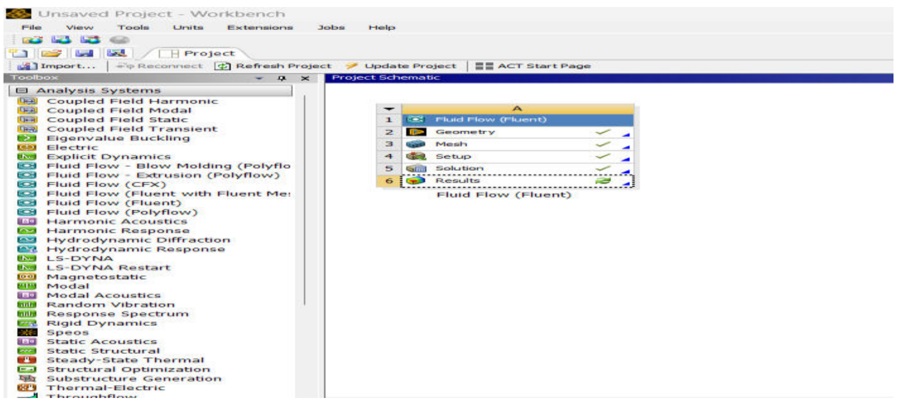

Figure 9: Ansys fluent flow Layout window

CFD Analysis:

Computational fluid dynamics (CFD), a robust numerical analysis approach, can be used to address engineering and environmental challenges. It is an approach to design optimization through simulation. It models and predicts different fluid flow, heat, mass, and momentum transfer, and other related problems using numerical equations and digital computers implemented as iterative algorithms. CFD is a widely used technique in the scientific and technical sectors for the design of many kinds of renewable energy technology. The pre-processing phase includes tasks like making geometry, giving materials, making meshes, and giving load and boundary conditions. This is followed by computers automatically processing the collection of methods and computing the governing equations, such as the Navier-Stokes equation. Lastly, the post-processing stage involves visualizing and interpreting the received results.

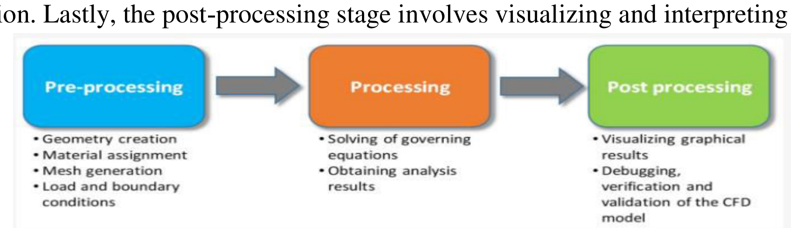

Figure 10: Computational fluid dynamics stages

Aerodynamic issues can be solved with the help of computational fluid dynamics (CFD) software and mathematical formulae. To perform CFD calculations, one must follow these steps:

- Data entry into the computer.
- Mathematical Modelling.
- Interpretation of the modelling into computational algorithms and codes.

- Computer aided calculations.
- Data acquisition.
- Post calculation analysis.

Increasing the iteration count to 10 or 20 really improved the mesh. In order to better depict the flow, this raised the mesh count and reduced the mesh location on various pieces of the vehicle. To bring the CFD analysis's findings into FEM, mesh distributions are used.

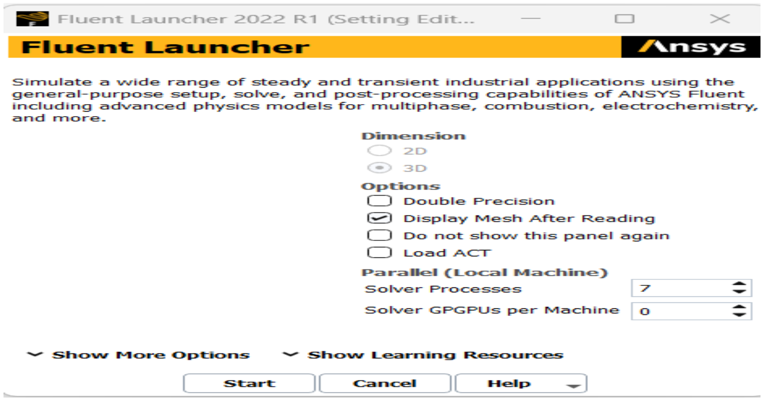

Figure 11: Boundary condition Calculated Layout

Turbulence Model

Turbulence is caused by the airflow being detached from the vehicle. Compared to the frontal smooth airflow, the detachment flow is quite turbulent. When airflow separates from the mirror's flat side, it hits the rear of the vehicle. The parameters can be adjusted individually on a fine-quality mesh. The aerodynamic study makes use of a K-Omega-SST turbulence model in conjunction with a steady-state incompressible fluid flow analysis type.

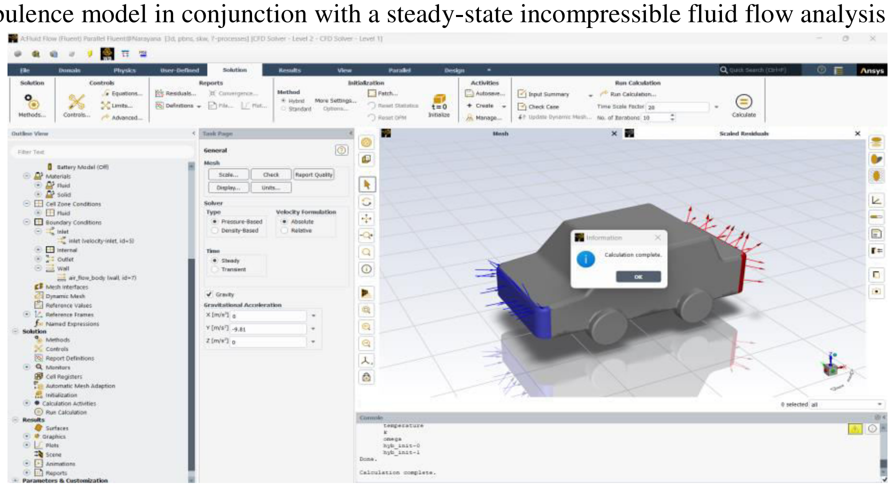

Figure 12: K-Omega-SST turbulence model

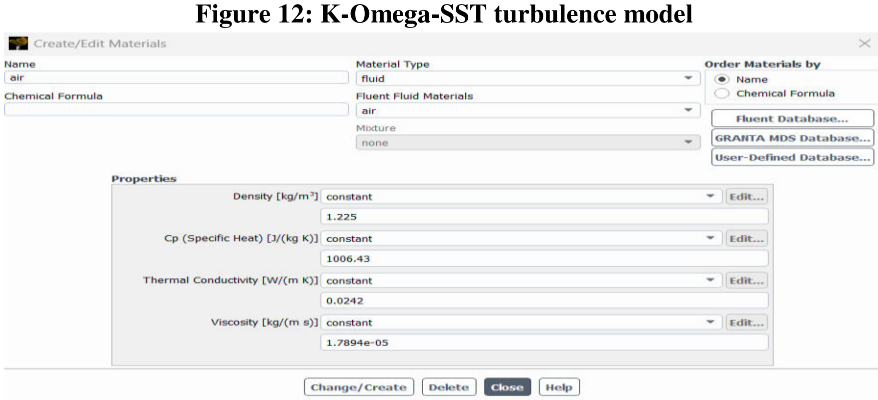

Figure 13: Air flow Properties

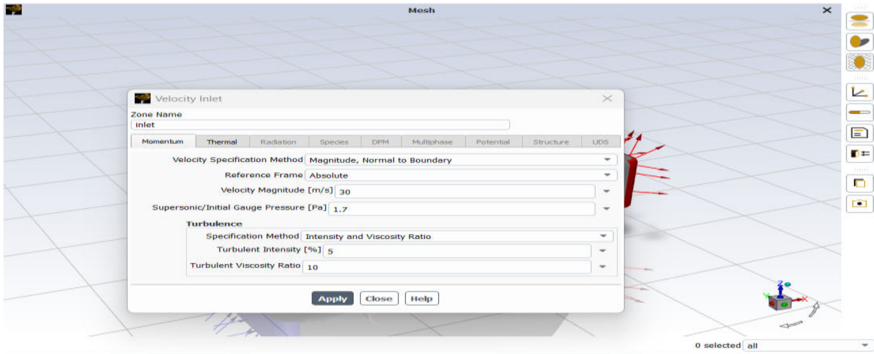

Figure 14: Inlet boundary conditions

Air flow Analysis hybrid drive racing car using Al2024 material at different parametric Conditions

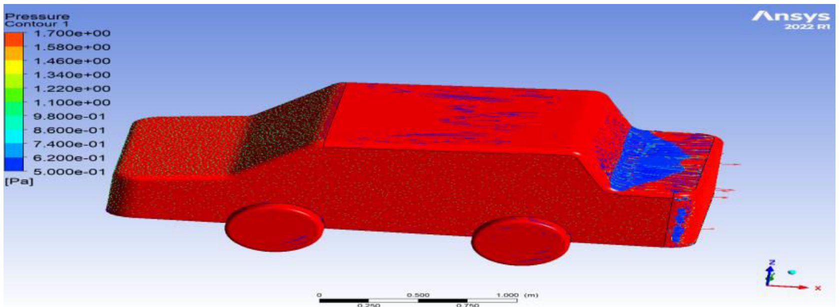

Figure 15: Pressure Contour

The illustration depicts pressure contour and shear stresses that lack the necessary level of detail. When the pressure is 1.7 bars, the local drag contributions can be broken down according to the car body of a generic car.

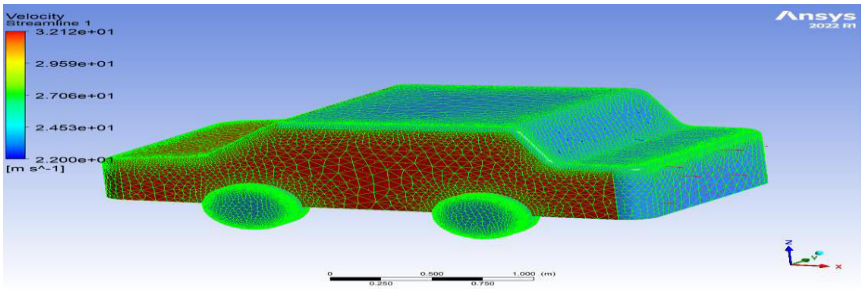

Figure 16: Velocity streamline at 30 m/sec

The required amount of detail is lacking in this figure with respect to the Velocity Stream line. At 1.7 bar pressure circumstances and 108 km/hr, the local drag contributions can be broken down according to the car body for a basic car.

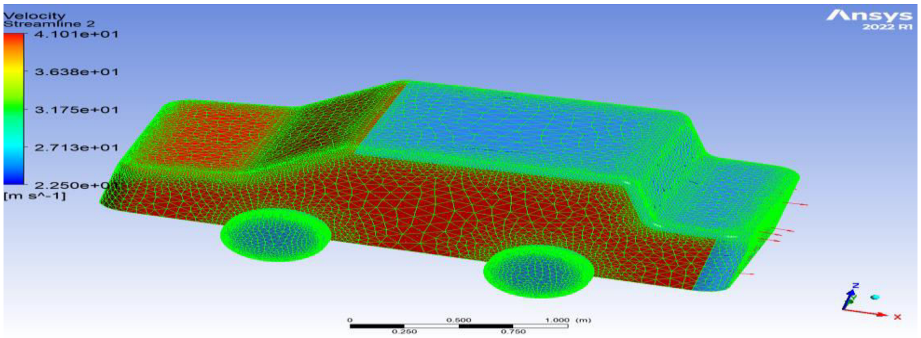

Figure 17: Velocity Stream line at 40 m/sec

The streamlines of the airflow are shown in this picture as a line that is always parallel to the velocity stream line; they decrease from 144 km/hr in 2.250e+001 min.

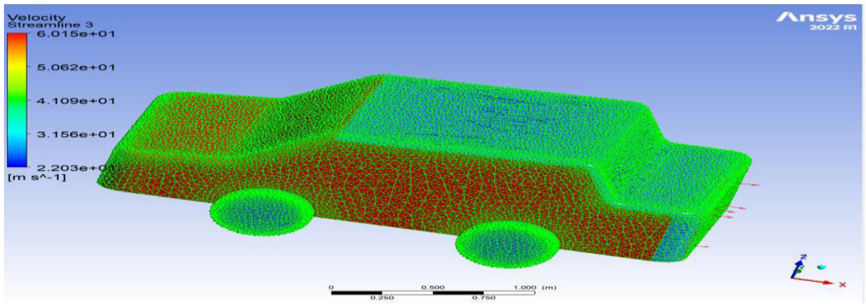

Figure 18: Velocity Stream line at 60 m/sec

Figure displaying distributions of the velocity stream line shows that at a pressure of 1.7 bar and a velocity of 216 km/hr, the worldwide pattern of the flow inside the surface changes considerably with variation for a single air vent, and this change occurs only in the horizontal plane.

Air flow Analysis hybrid drive racing car using Carbon steel Material at different parametric Conditions

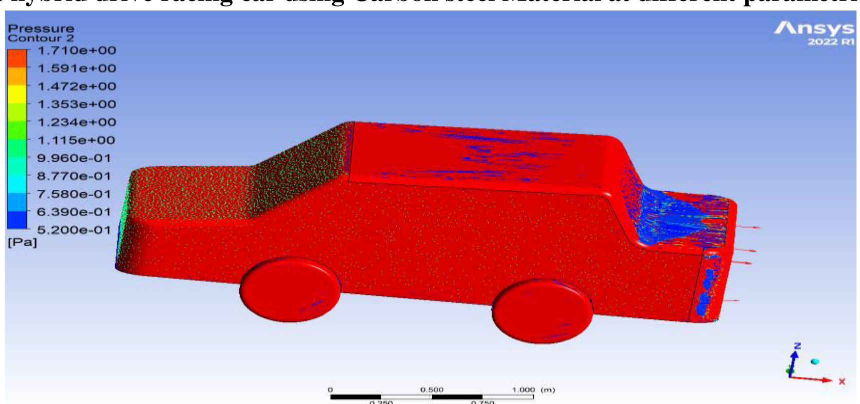

Figure 19: Pressure Contour

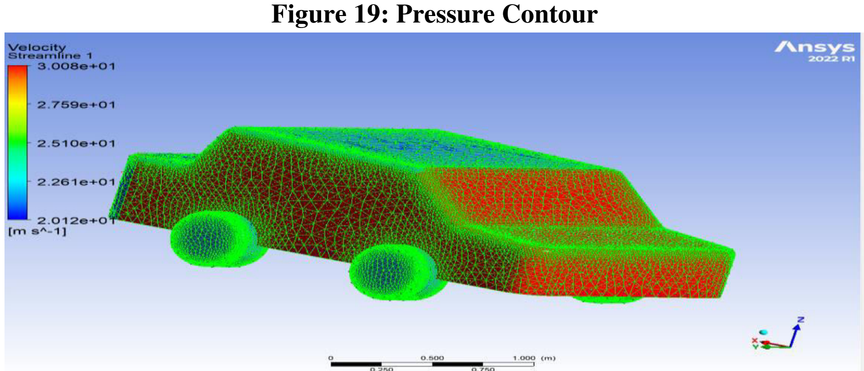

Figure 20: Velocity Stream line at 30 m/sec

The streamline of the fore body is more clearly defined from the flow in this figure. At 108 km/h, the wake or separation region is significantly different with a wider blue area and higher intensity. When the base pressure is high, the magnitude of drag increases.

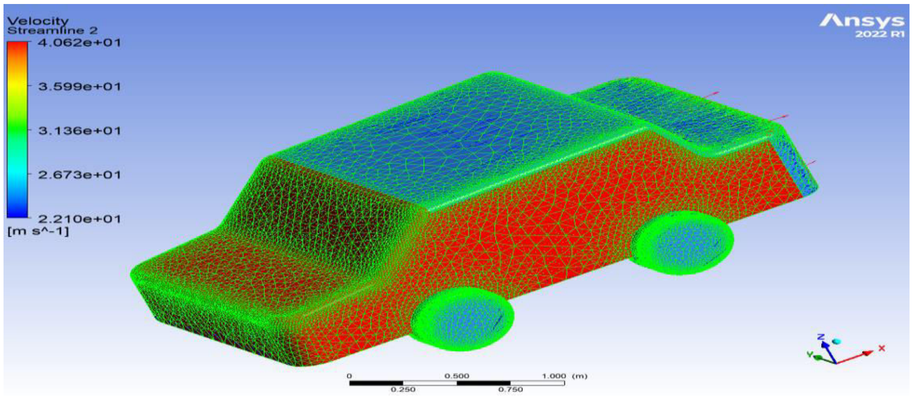

Figure 21: Velocity Stream line at 40 m/sec

In this figure, the flow is separated better from the streamline of fore body. The wake or separation region at 144 km/h is clearly different, with a larger area of blue colour and a greater intensity. Increasing drag force is affected by high base pressure drag

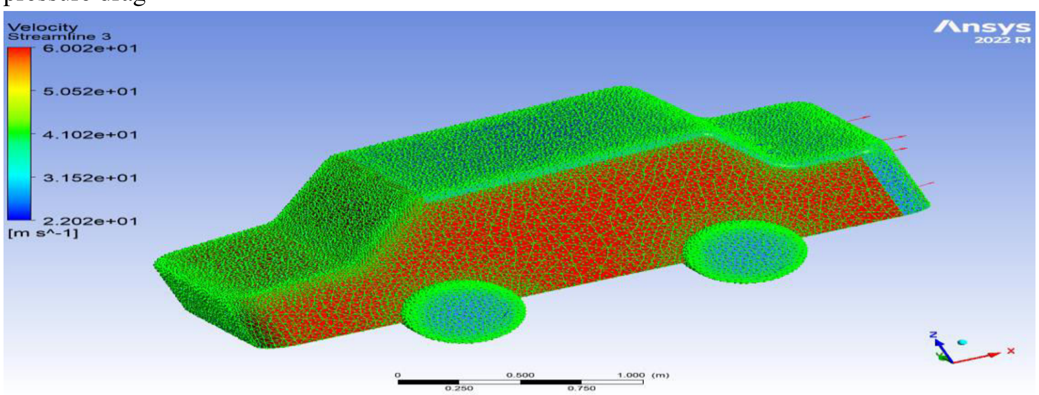

Figure 22: Velocity Stream line at 60 m/sec

The improved separation flow from the streamline of the forebody is depicted in this picture. At 216 km/h, the wake or separation region looks very different, with a large and more intense blue area than the others. This has an effect on the growing drag force and indicates that the base pressure drag is significant.

Table 1: Air flow analysis using hybrid Car with different Materials various maximum and minimum flow velocity conditions at pressure 1.7 pa

Parameters	Pressure contour (Pa)	Air flow analysis Car maximum Velocity streamlines		
		30 m/sec	40 m/sec	60 m/sec
Al 2024	1.700e+00	3.212e+01	4.101e+01	6.015e+01
Carbon steel	1.710e+00	3.008e+01	4.062e+02	6.002e+01
Air flow analysis Car Minimum Velocity streamlines				
Al 2024	5.000e-01	2.200e+01	2.250e+01	2.203e+01
Carbon steel	5.200e-01	2.012e+01	2.210e+01	2.202e+01

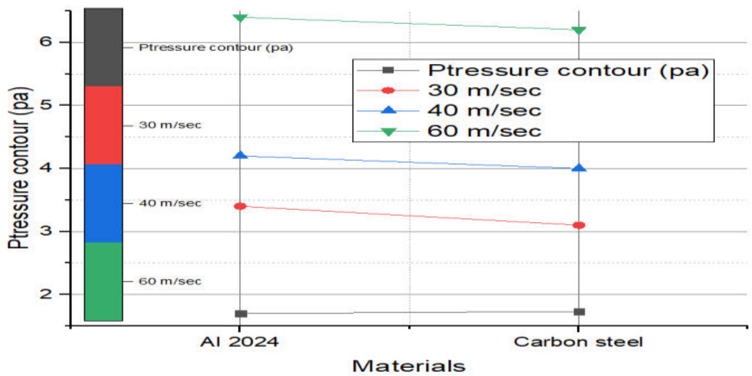

Figure 23: Air flow analysis using hybrid Car with different Materials maximum flow velocity conditions at pressure 1.7 pa

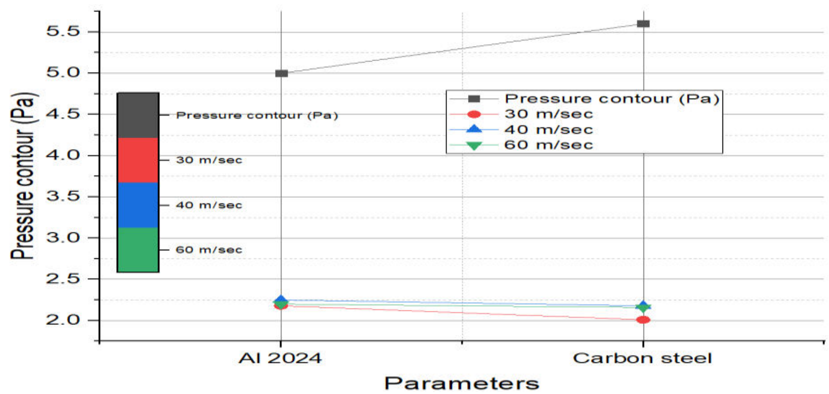

Figure 24: Air flow analysis using hybrid Car with different Materials minimum flow velocity conditions at pressure 1.7 pa

Analysis of range using a contour graphic of velocity stream lines as can be seen in the picture, the velocity contour plot looked very much the same for all of the analyzed velocities. High and low velocities are represented by red and blue, respectively, in the velocity contour map. At the top speed of 108 km/h, a minor variation in the velocity contour plot is observed. It's easy to make out the distinction between the laminar flow behind the body and the turbulent flows that formed afterward from the separation point above the rear windshield or the apex of the roof. There is less blue in the wake area than in other regions.

CONCLUSIONS

The analysis in this study highlights the importance of CFD Analysis in the design process. To begin, we used NX 12.0 to create an aerodynamically-oriented 3D model; then, we discretized it; and last, we utilized Ansys to analyze its streamlines and pressure distribution at realistic speeds. This vehicle's ANSYS model was used to simulate its body structure in a frontal collision. The CFD (Realizable k-ε turbulence model) Analysis using Compressed Air find out the pressure and different Velocity Streamlines observed that simulation clearly better result from carbon steel at 60 m/sec (206 km/hr) compared to aluminum 2024 and its performance very well because it is a strong and durable material and heavier weight prevents it from being used to construct an automobile's whole body.

Future Scope

The use of hybrid technology in automobiles will improve the transition from conventional to alternative fuels. The next-generation hybrid will save users money at the pump and on the road while giving them more opportunities to reduce their impact on the environment.

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