Designing of Power Train of Koenigsegg Gemera Hypercar using MATLAB Simulink

Urdhwa Srikiran Yandamuri, MS Mechanical Engineering (100%)

Sri Nayan Reddy Sama, MS Electrical Engineering (100%)

Charan Teja Reddy Thirumal Reddy, MS Electrical Engineering (100%)

Abstract— This paper delves into the design and optimization of powertrains for Gemera with a focus on enhancing efficiency through MATLAB Simulink. Leveraging Simulink's robust simulation environment, engineers can model, analyze, and refine powertrain configurations to achieve greater efficiency.

Index terms: Powertrain, MATLAB, Simulink, Internal Combustion engine, HEV, EV, Power distribution.

INTRODUCTION

In recent years, there has been a significant push towards the electrification of vehicles, driven by a combination of factors including environmental concerns, technological advancements in battery technology, and electric drivetrains that have made electrification increasingly practical for a wide range of vehicle applications, and regulatory mandates. This global push reflects the urgent need to transition towards sustainable transportation solutions to mitigate climate change and reduce our dependence on fossil fuels.

One of the primary reasons for the push towards electrification is to reduce greenhouse gas emissions and take a toll against global warming. Electric vehicles (EVs) offer the potential to drastically reduce or even eliminate tailpipe emissions, especially when powered by renewable energy sources such as wind or solar. This aligns with international efforts to meet ambitious emissions reduction targets outlined in agreements such as the Paris Agreement.

Electric vehicles (EVs) have gained significant momentum in recent years, offering competitive performance, range, and charging infrastructure that make them increasingly viable alternatives to traditional internal combustion engine vehicles. In the realm of high-performance automotive engineering, few names resonate as strongly as Koenigsegg Gemera, particularly when discussing powertrain design and optimization. The unique nature of Gemera's powertrain, exemplified by MATLAB Simulink's capacity for modeling, simulation, and optimization, stands at the forefront of automotive innovation. MATLAB and Simulink serve as the foundation for power system simulation and optimization, paving the way for advancements in efficiency and optimization in vehicle design. This is especially relevant given Gemera's ambition to redefine the limits of what a hybrid car can achieve, with a focus on power, efficiency, and the 0-60 metric, all of which are pivotal in highlighting the car's exceptional performance.

Koenigsegg Gemera Hypercar Specifications

In the domain of high-performance automobiles, the Koenigsegg Gemera is a revolutionary marvel that redefines the limits of performance, innovation, and sustainability. This hyper car represents a change in thinking in automotive engineering and embodies Koenigsegg's unwavering commitment to excellence. The Gemera is the first four-seater hyper car built by Koenigsegg, featuring a hybrid engine, advanced suspension, and innovative technology. The Gemera's ground-breaking powertrain module, which masterfully integrates internal combustion and electric motor technologies, delivers exceptional performance, and heralds a new era of environmentally conscious driving.

The powertrain module of the Gemera is a remarkable example of engineering ingenuity, it is powered by a compact engine that weighs only 70 kg (150 lb.), designed to deliver exceptional performance, meticulously designed to blend conventional internal combustion power with electric drive. The Gemera's emphasis on sustainability does not come at the cost of thrilling performance, making it a stark contrast to traditional hyperarcs in the Luxury automotive industry.

The Koenigsegg Gemera hyper car specifications that engineers can consider when designing their powertrain module using MATLAB. These specifications are critical in the design of a powertrain module that meets the Gemera's unique requirements while delivering top-notch performance.

Specification	**Details**
Mass	1988Kg
Engine	Twin turbo free valve 3-cylinder ICE
Electric Motors	3 E-motors -One for each rear wheel -One on the crankshaft
Total power output	1700hp
Electric power output	1100hp (combined)
Range	ICE-range- 590miles E-range- 31miles Total range- 621mile
wheels	Front- 21" *10.5" Rear- 22"*11.5"
Battery	16.6KWh
Frontal area (Af)	1.98
Aerodynamic drag coefficient (C0)	0.009
Drag coefficient (CD)	0.2
Input Torque by ICE	600Nm
Input Torque by E-motor	1100Nm

1. **Powertrain Configuration**: The Gemera boasts a pioneering powertrain setup comprising a twin-turbocharged 2.0-liter three-cylinder engine combined with three electric motors. The internal combustion engine alone produces an impressive 600 horsepower, while the electric motors contribute an additional 1,100 horsepower, resulting in a combined power output of 1,700 horsepower.

2. **Electric-Only Range**: One of the standout features of the Gemera is its ability to operate in electric-only mode for a substantial range. With a claimed electric range of around 50 kilometers (31 miles), the Gemera caters to consumers seeking eco-friendly driving solutions without compromising on performance.

3. **Seating Capacity and Comfort**: Unlike the traditional hyper car, the Gemera offers a practical four-seat configuration, making it suitable for families or small groups of enthusiasts. The interior is meticulously crafted with high-quality materials and boasts luxurious amenities, ensuring a comfortable and refined driving experience.

4. **Acceleration and Performance**: With its powerful hybrid powertrain, the Gemera accelerates from 0 to 100 kilometers (about 62.14 mi) per hour (0 to 62 mph) in just 1.9 seconds, making it one of the quickest production cars ever built. Its top speed exceeds 400 kilometers (about 248.55 mi), highlighting its unparalleled performance capabilities.

The Gemera targets a niche segment of ultra-high performance hyper cars that prioritize innovation, exclusivity, and luxury. It appeals to discerning customers who seek innovative technology, exceptional performance, and practicality without compromising on comfort or sustainability.

By analyzing various parameters such as power delivery, efficiency, and vehicle dynamics, engineers can optimize the powertrain design to meet performance targets while adhering to regulatory standards and market demands.

Powertrain Block Diagram

The Gemera which incorporates both a gasoline engine and electric motors, has a complex powertrain. Therefore, we will use a Simulink model to represent the hybrid powertrain. The power train consists of an internal combustion engine, three electric motors, and their associated controllers. The battery pack provides power to the electric motors and accessories. The driving system transfers power from the motors to the wheels. Charging units enable recharging of the battery pack.

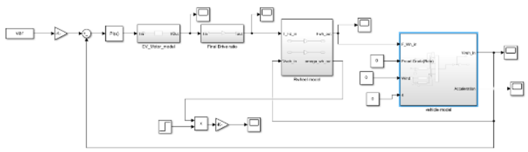

Fig.1 Vehicle Architecture

```
% Vehicle parameters of Gemera
m=1988;% mass
rwh=0.5334;% wheel radius
Cd=0.2;% drag coefficient
Af=2;% frontal area
Rho=1.16;% air density
g=9.8;% gravity
C0=0.009; % aerodynamic drag coefficient
C1=1.75*10^-6;% aerodynamic drag coefficient
T_fd_IC=1100;%input torque by ic engine
T_fd_EM=600;% input torque by electric motor
load('matlab');
var.time=Sch_Cycle(:,1);
var.signals.values=Sch_Cycle(:,2);
```

Fig.2 Vehicle Parameters

The Simulink model will consider the following components:

1. Gasoline Engine Model:

- We will use a first-order transfer function to model the engine's dynamics, which would include factors such as the engine's torque curve, fuel consumption, and exhaust emissions.

- The engine dynamics would also consider the engine's operating conditions, such as the engine's temperature, pressure, and speed.

- Since specific parameters for the engine dynamics are not available, we will use generic parameters for this example.

2. Electric Motor Model:

- We will use a similar model approach to the electric motors, using a first-order transfer function.

- The electric motor dynamics would consider factors such as the motor's torque curve, efficiency, and power consumption.

- The electric motor model would also consider the motor's operating conditions, such as the motor's temperature, speed, and power output.

- Again, specific parameters for the electric motors are not available so we will use generic parameters.

3. Hybrid Powertrain Integration:

- We will combine the outputs of the gasoline engine and the electric motors to represent the total power output of the hybrid powertrain.

- The hybrid powertrain integration would consider the power distribution between the engine and the motors, which would depend on the driver's throttle command and other factors such as the battery charge level and the engine's load.

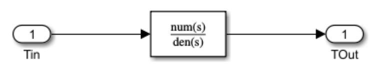

Fig.3 Input vehicle subsystem

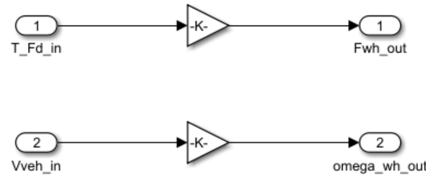

Fig.4 Wheel Subsystem

Calculations

Battery Modeling: Considering the practical capacity of the battery,

$$Q=I*t_{out}$$

Which leads to, $t_{out}=Q/I \rightarrow (1)$

Substituting (1) in Puekerts Equation,

$$I^n.t_{out}=\lambda$$

Given, λ=1228 and n=1.07

We get, $Q = \frac{1228}{I^{1.07-1}}$

To calculate the range:

Depth of Discharge:

DoD(t)= $[\int_0^t \frac{t^n}{\lambda} dt]$ *100%.

$F_{cyc} = [\int_{t_0}^{t} \frac{t^{1.07}}{1228} dt]$*100%

F_{cyc} = 3688.1%

Battery Power = $\frac{Battery\ discharge}{\frac{1}{60}}$ KW/h

Aerodynamic force,

$F_{AD} = C_d*\frac{1}{2}*\rho*A_F*u^2$

Rolling Resistance,

$F_{rr} = C_n*m*g$

Simulation Results

Through simulations, we virtually test the Koenigsegg Gemera's energy consumption patterns under different driving scenarios.

Fig.5 Current Profile Graph

By quantifying the electric current drawn from the battery, we gain valuable insights into the factors that affect the Gemera's operational efficiency and range capabilities.

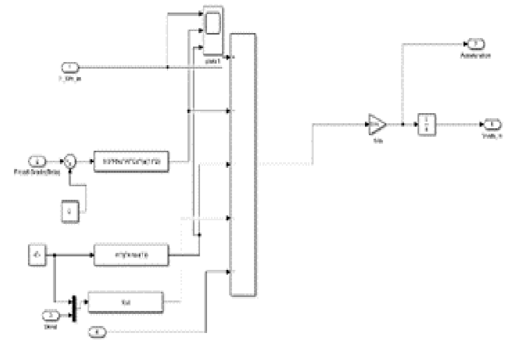

Fig.6 Vehicle Subsystem

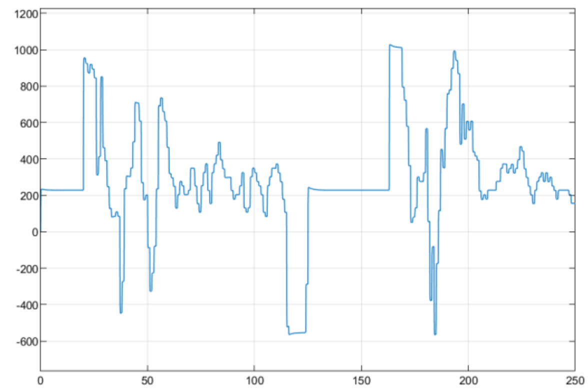

Fig.7 Motor Vehicle Subsystem Block Graph

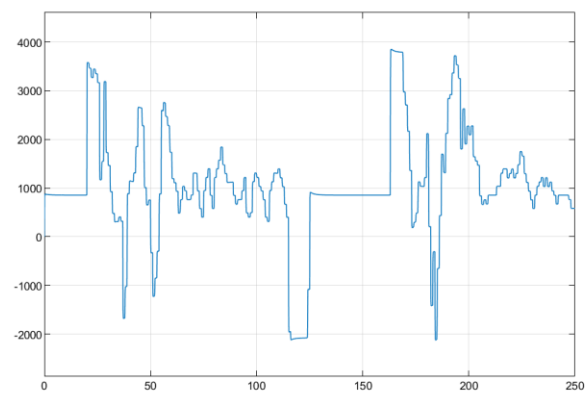

Fig.8 Wheel Subsystem Graph

Vehicle Range Determination

We use empirical data, theoretical frameworks, and class discussions to determine the Koenigsegg Gemera's range under various driving conditions. With meticulous attention to detail and careful selection of assumptions, we provide stakeholders with actionable insights into real-world performance expectations.

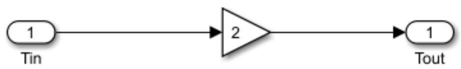

Fig.9 Final Drive Ratio

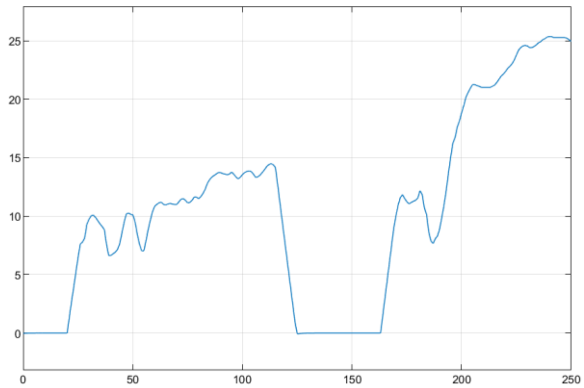

Fig.10 Drive Profile

Conclusion

The Koenigsegg Gemera is a vehicle that sets the bar high for the potential of electrification. It highlights an exceptional combination of speed, power, and environmental sustainability. Our team invested considerable time and effort in conducting a meticulous analysis and simulation of the vehicle's subsystems, efficiency dynamics, and operational characteristics. The Gemera represents a giant leap forward in the automotive industry, setting a new standard for sustainable and exhilarating mobility.

Submission and Collaboration

This project is a testament to the dedication and expertise of each team member. Through equitable task distribution and seamless coordination, we present a precise and comprehensive report that embodies the spirit of academic excellence and collaborative endeavor.