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Quasistatic Modeling and Simulation of an HEV(CE_Drivetrain)

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Abstract: Internal combustion engines have dominated the automotive industry since their inception but due to the gradual increase in fuel prices, declining mineral resources and strict emissions regulations create an ideal environment for the development of hybrid electric vehicles. The combination of vehicles is proven by the specification of carbon emissions. This combination of the electric drivetrain and internal combustion engine has garnered widespread attention among researchers and industries which has led to an increase in car numbers in the market. The internal combustion engine plays an important role in a hybrid electric car that has a significant impact on the car's performance. Increasing fuel economy and low levels of air pollution are major challenges to internal combustion engines. This paper will discuss a simple fire model in SIMULINK that focuses on developing a hybrid electric car using an internal combustion engine that results in better fuel-saving and higher efficiency using a quasi-static approach. Firstly, the ground system blocks are designed on Simulink which includes the driving cycle, Electric motor, electric generator, easy hand transmission, internal fire engine, and battery. These sub-systems are integrated to form a complete hybrid electric vehicle model controlled by a control strategy. Various efficient maps and simulations related to fuel consumption, of internal combustion engines are discussed in the paper.

Keywords: Fossil fuel, emission, Hybrid electric vehicle (HEV), Electric motor, generator, Internal combustion engine, QSS toolbox, Matlab, Matlab Simulink.

I. INTRODUCTION

Since the early 1900s, gasoline and diesel engines have proved to be the most efficient car systems in spite of their low performance, gas emissions, low fuel consumption, and relatively inexpensive recurrence. In addition, environmental problems, energy crisis, and increased oil consumption in the growing demand for automobiles in developing countries have encouraged research into alternative energy sources. However technical limitations delay their entry into the market. BEV batteries with high value, large, limited life cycle and long-term recharge attest to their affected constraints. The above set of limits and the need for Eco mobility make BEVs obsolete vehicles in the future. Although EVs use high power and no emissions can be considered the future of the automotive industry but safety, durability, and cost limit their entry into the market [1].

The world is moving toward an era full of modern and up-to-date resources; pollution increases simultaneously when continuous damage is seen in all living things. Ordinary vehicles with internal combustion engines (ICE) contribute significantly to this problem leading to a heat-trapping effect with a significant degree of exhaust. Thus, the concept of electric vehicles (EVs) came up with various energy-saving devices such as batteries, supercapacitors (SCs) or ultracapacitors (UCS), and fuel cells (FCs). The modification of these EVs creates hybrid electric vehicles (HEVs) as a combination of the aforementioned resources with increased efficiency and sufficient assistance in ensuring an uninterrupted power supply to vehicles. With extreme caution, the emission rate of CO2 and CO can be reduced with proper intake of HEVs. Battery life can be successfully extended to a satisfactory level; The longevity of FC can now be easily obtained. Researchers have used a variety of control techniques to provide real-time application over long distances[3].

Such challenges require a hybrid HEV automotive system that comes with an internal combustion engine (ICE) solution, in which the range extender drives a generator and launches a recharge of the battery. The main advantage of hybrid electric vehicles is reduced fuel consumption. Fuel consumption and ICE operating conditions regulate CO2 emissions. ICE operating conditions are more suitable for electric vehicles than conventional vehicles. The ubiquitous presence of universities and easy data flow make MATLAB and Simulink modelling tools relevant. ICE is in line with the fuel source and fuel economy model. Finally, each sub-system is configured as a hybrid of a sedan-type series, and the driving cycle

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is simulated. Researchers are developing strategies and experimenting with solutions that will be included in this to improve vehicle performance[2].

II. RELATED WORK

An important step in tackling these aforementioned problems should be a decrease in the energy used by cars. From mineral oil to him electric power is useful, as is the high energy generation will work much better than a small engine in each car (even if consideration of power transfer). However, the ratio the consumer is not willing to give up easily and quickly refuelling to get the least benefit from saving fuel. Balance can be found at the construction of hybrid electric vehicles (HEVs), which enjoy both easy and wide (due to fuel congestion) from engines, as well as clean and cheap energy electric motors[5].
A cross-sectional analysis between different control strategies is performed based on control characteristics and operating conditions to reflect the advantages and disadvantages of these methods. Parameter comparisons and comparisons are provided in a separate component configuration to present comparative studies based on flexible performance, battery life, energy savings, fuel consumption, pollution, durability, and more. The study also analyzes the test field, improved driving cycles, and mathematical models of each control system to demonstrate reliability for real-time systems. The image reconstruction presented is believed to be a reliable basis for researchers, policymakers, and promoters who continue to develop HEVs through energy-saving control strategies[3].

III. DESIGN AND METHODOLOGY

Quasi-static Approach :

To complete this project the main goal as we will make HEV more efficient so according to our goals, we are choosing the way back. The main model back tool used by QSS TB namely the Quasi-Static Simulation Toolbox. This toolbox gives us improved results. It also provides fuel consumption maps/data depending on the different powertrain systems. This toolbox is also used for ongoing research projects based on efficiency. The quasi-static method is to make things easier to choose a powertrain. In traditional methods, we want to take numerical and numerical values to make a visible car design[3].

V-chart:

The term model-based design is often used to emphasize the benefits of models - assisted design techniques in the product development cycle. An exemplary product of the development cycle used in system engineering ("V-chart") is shown in fig (i). The model-based design methods used in this cycle are not limited to software-supported strategies. It is a common practice to install prototypes of selected hardware parts of the model to explore the different physical features of the real system. The process, known as hardware-in-the-loop testing, is applied to part/system validation and validation in the second half of the development cycle. By combining hardware and software design in the loop, the quality and efficiency of the product development cycle can be greatly improved. Despite their practicality, physical models ultimately do not represent well- real systems. The level of accuracy usually depends on the difficulty of the model[1].

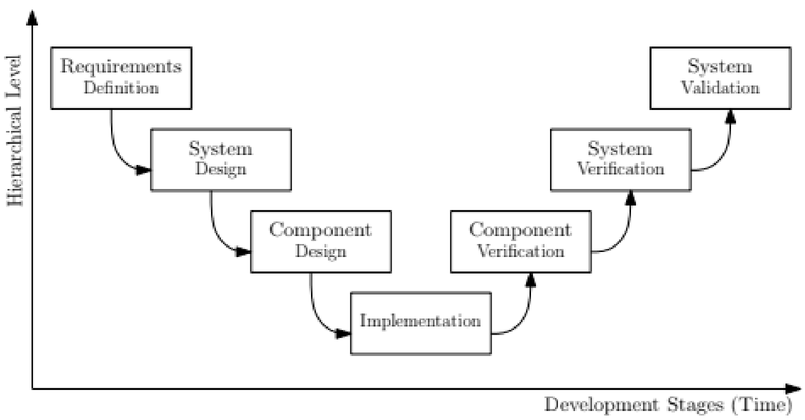

Fig 1: Methodology for model-based development cycle, used in many Automotive industries

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This methodology consists of two distinct phases:
1. Solving an optimization problem to detect the best powertrain components characteristics and choose the best rules-based control strategy.
2. Application and calibration of the control strategy parameters and adjustment of the whole drivetrain, and in particular of the powertrain components characteristics In this paper, the first phase will be presented, which is composed of three main steps:

Control Strategy:

The Thermostat Control Strategy (TCS) is the most typical control strategy for the HEV series and is known for its simplicity, robustness, and excellent fuel economy. Its main principle is to use PS at a single constant operating point (COP) , to maximize fuel economy and use SS as a balancer. It will continue to operate in this mode until the SOC rises to the upper limit (SOC_U), and after, it will shift to the SS-only operation mode. This mode con sums SOCs quickly and returns to running PS on PPS co, p when the lower limit (SOC_L) is reached.

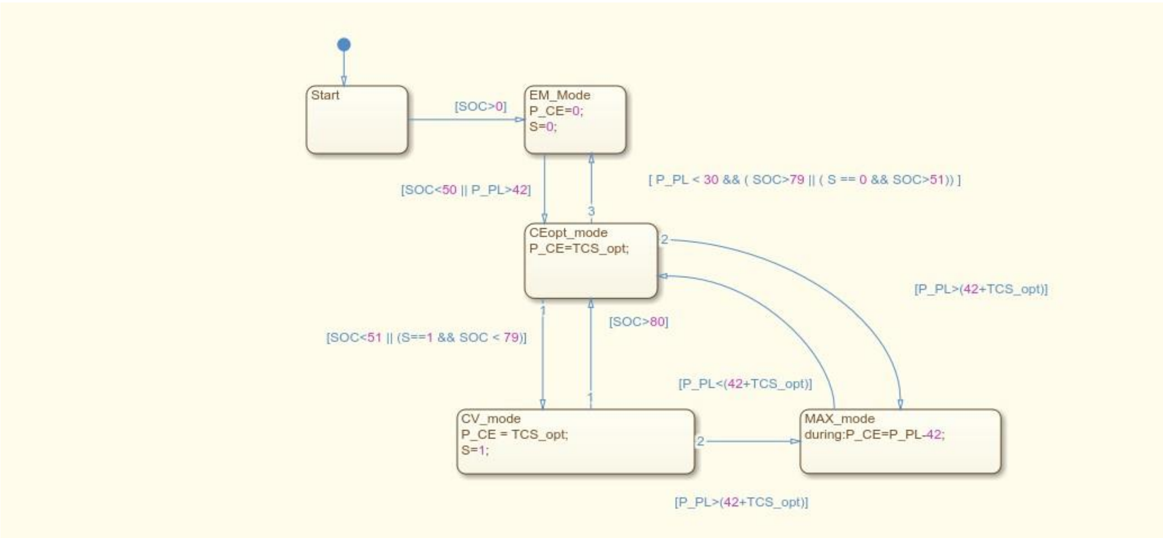

Fig 2: Stateflow model of our Control Strategy

IV. ARCHITECTURE:-

The Model starts with the Drive cycle of Europe NEDC and then connects with the Vehicle block, the vehicle block sends Torque and Speed requirements to the Combustion block which is connected to the tank and is in a feedback loop with the drive cycle.

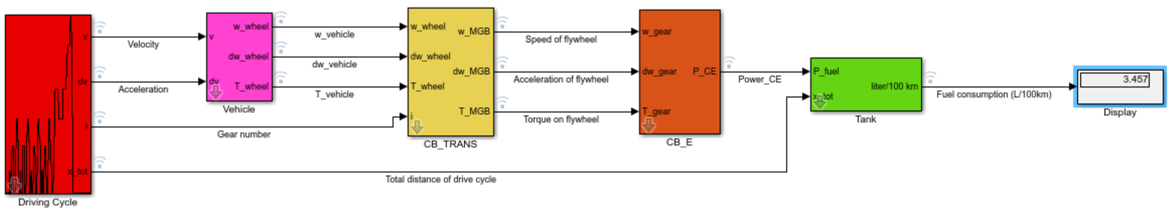

Fig 3: Combustion Drivetrain of HEV

A) Combustion Engine:

Use the QSS Toolbox to reverse engineer and calculate the total power and force required to drive the vehicle. We also got all the charts used to create an efficient vehicle model. Therefore, when using rearward modeling, start by designing an HEV that assumes the motive force needed to move or accelerate the vehicle. Therefore, to optimize the motor's

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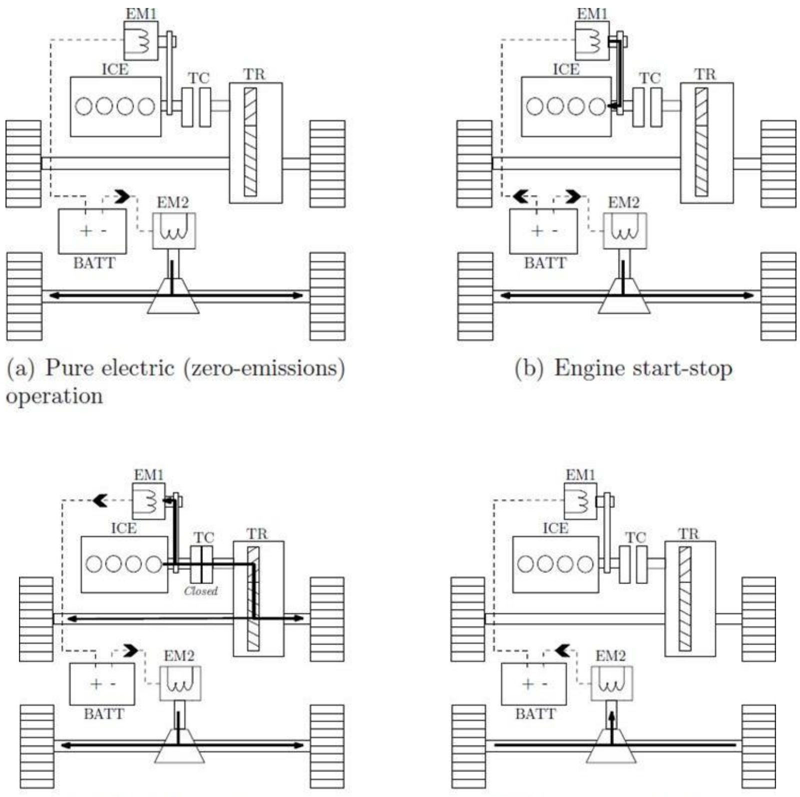
efficiency, it is necessary to simulate the acceleration force, drag force, and gradient force obtained from various models. This is what we do. With the QSS toolbox, there is no need for traditional calculation methods to calculate all these forces. After all the values have been entered into different models, QSS will generate a graph and simulate the resulting values. Then check all these final results in the driving cycle, put them all in the model you created, modify another model to run the simulation, check the entire model, and then compare the overall efficiency with the optimization.

B) **Gearbox**:-

Use the QSS toolkit in reverse order to optimize the gearbox or to create a more efficient gearbox. First, get all the rough data such as vehicle mass, drag, gearbox, etc., then create a model to select the stage and ratio, and then derive from the manual gearbox. Then, for the final stage torque with the highest speed, we proceeded to the calculation of the starting torque, and after this calculation, we derived the torque-velocity equation under the conditions of various drive stages. After running a gearbox simulation in the engine simulation to create a model, check or simulate this model to get optimizations. After reviewing all models, we will adopt a model that provides an unbreakable power source for more efficient and efficient propulsion.



(a) Pure electric (zero-emissions) operation

(b) Engine start-stop

(c) Hybrid operation

(d) Regenerative braking

Fig 4: Typical HEV operating modes (TC: torque coupler, BATT: battery)

V. EXPERIMENTAL RESULT

We have opted for the Europe_NEDC drive cycle for running the tests. The testing started with individual sub-system testing of the Combustion Engine and once we got the satisfying results we proceeded with the further testing and got several iterations to get the fuel consumption required by the system. The experimental results clearly show us that the performance of the model is as expected and is able to give us the torque and speed requirement based on the driving cycle provided. It also provides us with information on fuel consumption and torque requirement at every point and their efficiency. The results also tell us about the fuel requirements, which can help us to size/optimize the engine and transmission accordingly with some optimizations to get the best results.

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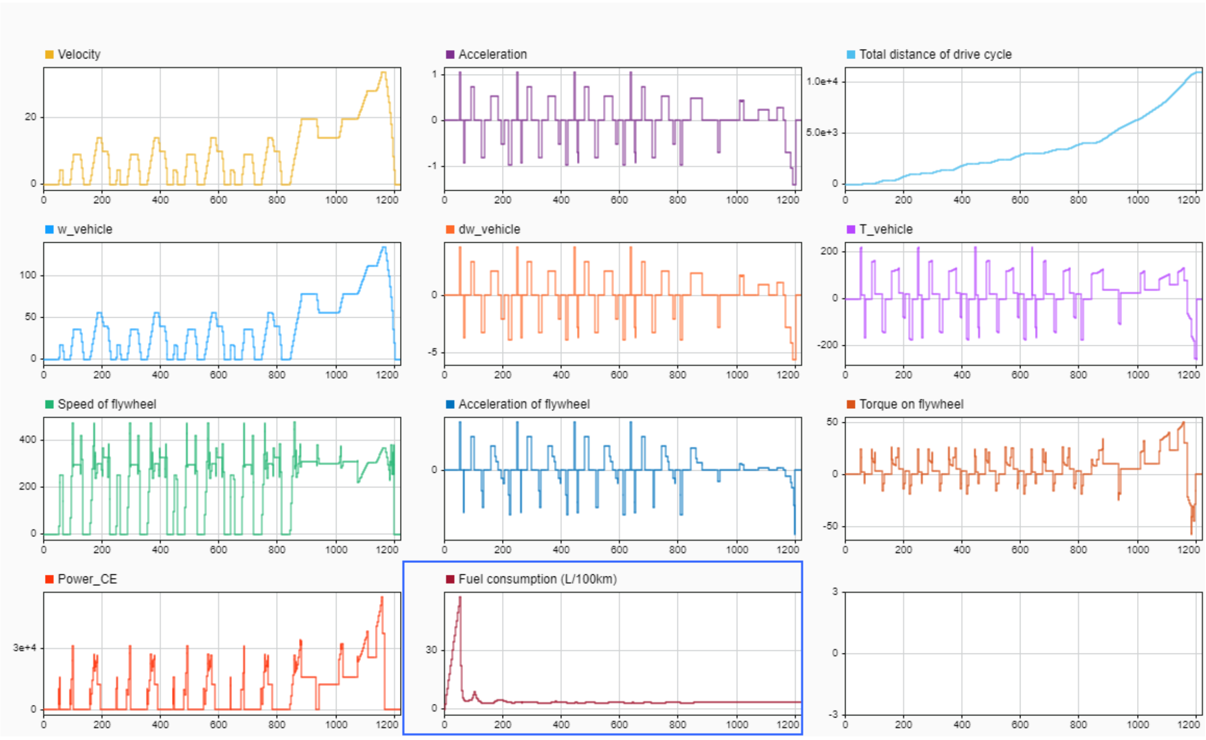
VI. CONCLUSION

We successfully modelled a Hybrid electric vehicle on Matlab. This model helps us to size the components of the hybrid-electric vehicle like Battery, EM, Generator, Combustion engine, etc. without investing in manpower and physical vehicle and testing. This also helps us validate the model, use existing models, and improve the efficiency of the model.



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