CLASSIFICATION OF PARALLEL HYBRID ELECTRIC VEHICLES BASED ON THE DEGREE OF ELECTRIFICATION

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Abstract: Nowadays a lot of attention is paid to the use of alternative energy sources in the automotive engineering field. Electric vehicles and Hybrid Electric Vehicles (HEV) are quite popular for their reduced fuel consumption and a lowered level of gas emissions produced. In general, HEVs can be classified by the position of the electric drive components (architectural classification) and by the degree of hybridization (depending on the power provided by the battery and the electric drive). This paper provides a short overview of how one can classify HEVs basing on the degree of hybridization.

Keywords: HEV, mild hybrid, micro hybrid, full hybrid, plug-in HEV

I. INTRODUCTION.

In addition to the electrical component of an HEV, the conventional internal combustion engine (ICE) layout is still present in modern HEV models. The combustion components are expected to have a significant importance in future HEVs by helping to manage the limitations of pure battery electric vehicles (BEV). In this regard, the combustion system is still necessary for extending the autonomy offered by the electric counterpart. Besides, electricity cost in many countries is still quite high and few competitive with traditional fuel prices. In this context, vehicle manufacturers and engineers have developed many configurations for coupling both systems. The various configurations with the application of an ICE engine and an electric drive in an HEV find themselves successful in autonomy, as the ICE has the mission of recharging the batteries in a standard configuration and provides the propulsion force in conditions of constant running and overtaking.

Customarily, the HEVs can be classified according the hybridization level and architecture. The first category makes reference to the degree of electrification of the vehicle, in other words, the greater importance of the electrical part the high degree of hybrid the vehicle is [1]. While the second category is more referred to the components involved in the vehicle and the way in which they interact among them. [2] . In the subsequent sections the former classification type will be discussed.

II. CLASSIFACTION OF HEV BASED ON THE DEGREE OF HYBRIDIZATION.

i. **Micro Hybrid**. The vehicles in this classification encompass the alternator and the start button in the same set [3]. A small electric motor is other key feature of this kind of vehicles. In this sense, the engine only serves to charge the battery system as much as possible during braking phases, besides providing the so-called ‘Stop and Start’ service, which is devoted on restoring the ICE before starting the running. In this sense, any automobile that provides such kind of capability could be encompassed into this category. One feature of the ‘Stop and Start’ service is the moment during which the engine is put on below 6 km/h, and starts automatically with the help of the electric motor when it needs to accelerate again. Finally, it is worth remarking that vehicles within this category usually present a petrol economy between 5% and 8% [4].

ii. **Mild Hybrid**. In the second category, the mild-hybrid vehicles have a more powerful electric motor and are usually equipped with a higher capacity battery system. This configuration allows the electric system to support the ICE even during acceleration phase [5]. However, the electric counterpart is not able to completely fulfill the function of ICE, because it lacks the sufficiently capacity for propelling the vehicle by itself. In this kind of HEV, the electric system is also used to start the propulsion of the vehicle and initialize the whole traction system. This type of hybridization system allows to recover the kinetic energy of the vehicle through the braking phase with reversible electrical components, in the same way the gasoline economy is favorable because it typically ranges from 20% to 25% [4].

iii. **Full Hybrid**. In this category, the vehicles typically include an ICE (MEP-MEC) and an electric motor both connected to the transmission. Additionally, this scheme incorporates a generator and a high-capacity battery. The full hybrid vehicles usually can operate under pure-electric mode up to 30 or 40 km/h, beyond this speed range, the electric system needs to be supported by the heat engine. During acceleration, the electric motor supports the thermal system, whereas in braking the kinetic energy is converted into electric energy and is stored in batteries. The electric motor is also useful during starting processes, which makes this configuration very suitable for long trips with frequent start-stop transitions. Both systems are mechanically connected with the wheels, allowing to circulate in electric mode, being the most efficient solution allowing to reduce the gasoline consumption by~45%. The Toyota Prius supposes a notorious example of this kind of hybridization level. This vehicle uses a permanent electric motor coupled to the transmission and a petrol engine that gives movement to a generator, also incorporating a 200 V battery located at the rear. The size of the heat engine can be reduced, applying the concept of downsizing and large capacity battery.

iv. **Plug-in-Hybrid**. The vehicles within this category present an architecture very similar to the full-hybrid level. However, the plug-in-hybrid has the capability of being connected to an upscale electric grid [3]. This way, the battery system can be recharged from the traction system during breaking stages or directly from the electric grid. One interesting feature of this kind of vehicle is the possibility of exploiting the on-board storage system for grid supporting tasks. For example, the vehicle batteries could be exploited as storage facilities in smart homes through bidirectional chargers, thus supporting the labor of onsite renewable generators on pursuing a more efficient energy management in dwellings [6].

III. CONCLUSION

Each of the types of Hybrid Electric Vehicles listed in the paper possess both advantages and disadvantages. As long as the degree of hybridization increases, a larger electric motor and battery will be required. It becomes quite obvious that even though the fuel economy of full HEV and plug-in HEVs are much higher with respect to mild and micro hybrids, the manufacturing and maintenance cost of the former ones will be significantly higher. From this point of view, the choice of the degree of hybridization is a sort of a trade-off between the cost and the fuel economy.

IV. BIBLIOGRAPHY

[1] E. D. Tate, M. O. Harpster и P. J. Savagian, «The Electrification of the Automobile: From Conventional Hybrid to to Extended-Range Electric Vehicles.,» *SAE International journal of passenger cars*, pp. 156-166, 2008.

[2] A. Seyran, «CLASSIFICATION OF PARALLEL HYBRID ELECTRIC VEHICLES BASED ON THE POSITION OF THE ELECTRIC POWERTRAIN,» *RESEARCH AND EDUCATION*, pp. 95-99, 2022.

[3] S. Onori, L. Serrao и G. Rizzoni, Hybrid Electric Vehicles: Energy Management Strategies, Springer, 2016.

[4] I. A. Kulikov, L. Y. Lezhnev и S. V. Bakhmutov, «Comparative Study of Hybrid Vehicle Powertrains with Respect to,» . *Journal of Machinery Manufacture and Reliability*, 2019.

[5] J. Zhao, X. Xi, Q. Na, S. Wang, S. Kadry и P. Kumar, «The technological innovation of hybrid and plug-in electric vehicles for environment and carbon pollution control,» *Environment Impact press*, 2021.

[6] M. Tostado-Véliz, R. S. León-Japa и F. Jurado, «Optimal electrification of off-grid smart homes,» *Applied energy*, 2021.