CLASSIFICATION OF PARALLEL HYBRID ELECTRIC VEHICLES BASED ON THE POSITION OF THE ELECTRIC POWERTRAIN

Asanov Seyran Enverovich
Turin Polytechnic University in Tashkent

ABSTRACT

According to the Society of Automotive Engineers, a hybrid vehicle can be defined as that vehicle with two or more energy storage systems which must provide power to the propellant system either together or independently. Similarly, the heavy-duty hybrid vehicles group indicates that a hybrid vehicle must have at least two energy storage systems and energy converters. In practice, a hybrid electric vehicle (HEV) combines the great autonomy of conventional vehicles with spark ignition engines, compression ignition engines, fuel cells and solar panels with the speed, performance and environmental advantages of electric vehicles, obtaining an automobile with lower fossil fuel consumption and lower pollutant emissions to the atmosphere.

Key words: parallel hybrid, HEV, hybrid powertrain, vehicle

I. INTRODUCTION

In this configuration, both the heat and electric engines can propel the transmission systems. An electric hybrid vehicle with the parallel configuration has the ICE and electric motor coupled to the final drive axle of the wheels via clutches [1]. Moreover, this configuration allows the ICE and electric motor to supply power to drive the wheels in combined or isolated modes. This way, both systems work in parallel. This configuration supposes a remarkable simplification of the series architecture as the electric generator is no longer necessary. In this sense, the electric motor could work in reverse mode, converting the kinetic energy of the transmission system to electricity which is stored in batteries. Generally, ICE size can be reduced with respect to the series configuration. Depending on the position of the electric powertrain, one classifies parallel hybrid electric vehicles into several types: P0, P1, P2, P3, P4. Each of the types will be described in the next section.

II. CLASSIFICATION OF PARALLEL HEV ARCHITECTURES

At present, according to the position of the motor in the powertrain of an HEV, a powertrain with single motor is mainly divided into five categories named P0, P1, P2, P3, and P4 [1]:

1) P0- In this configuration the electric motor is located in front of the engine and is connected to the crankshaft by belt [2] (Figure 1). P0 configuration has some advantages and disadvantages. Among the advantages are:

- This architecture can be realized by adding or replacing motors on the basis of conventional vehicles;
- The manufacturing cost is low.

However, the drawbacks must also be taken into account:

- Low ratio of saving fuel consumption;
- Low degree of hybridization (DoH).

Audi A8 can serve as an example of P0 HEV architecture.

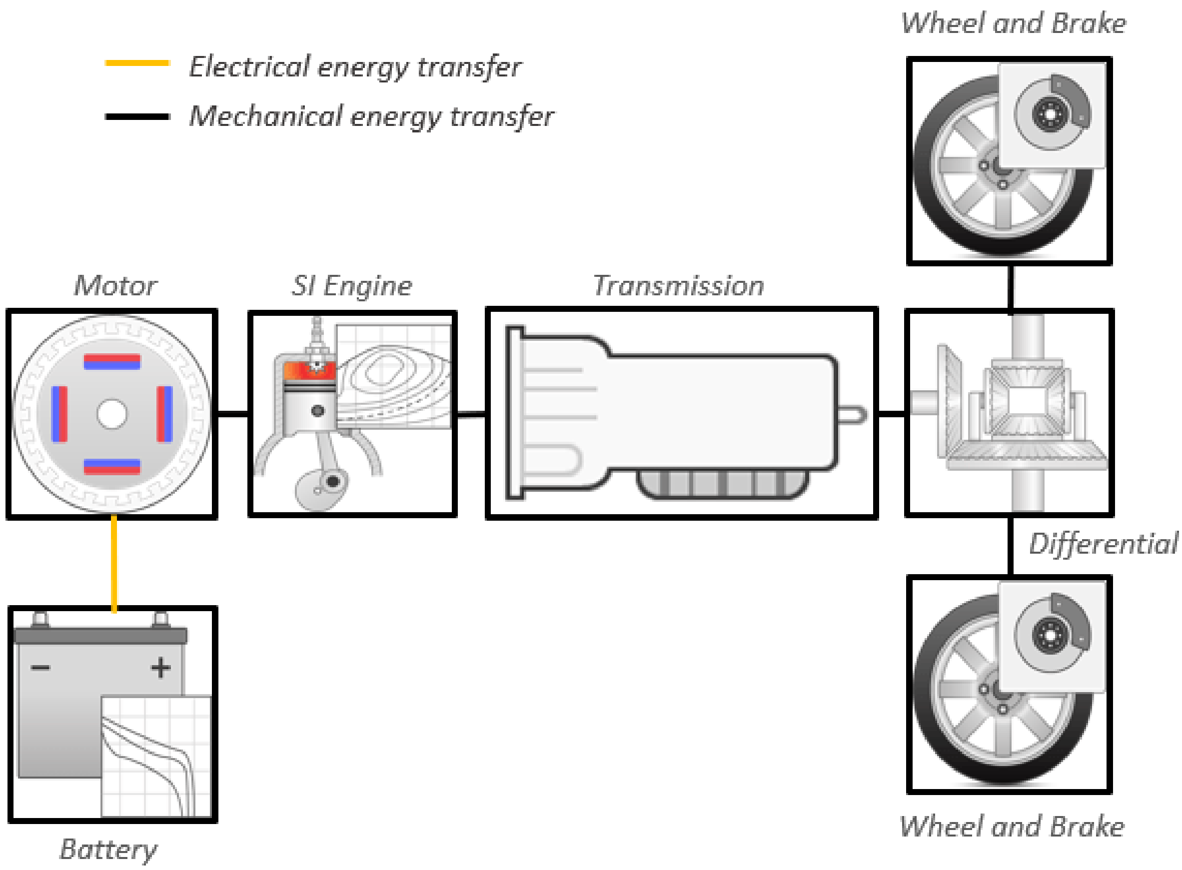

Figure 1. P0 HEV configuration

2) P1 (Figure 2)- The motor is located behind the engine and before the clutch. The motor is mounted on the crankshaft of engine [2]. This configuration improves reliability with respect to the P0 configuration, still having a low cost. Nevertheless, the output power of the electric motor is affected by the internal combustion engine. Typical examples of P1 configuration are Honda CR-Z, Honda INSIGHT, Mercedes-Benz S400.

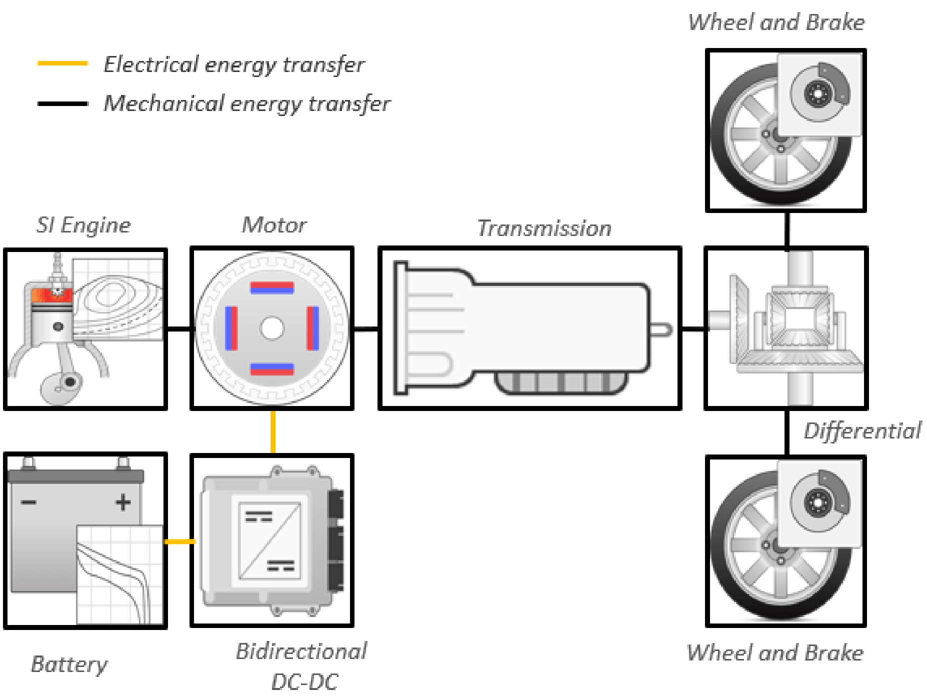

Figure 2. P1 HEV configuration

3) P2 (Figure 4)- The motor is located behind the clutch and in front of the transmission, which is connected to the input shaft of the gearbox [3]. This solution is considered one of the most popular ones among hybrid electric architectures. It increases substantially the degree of hybridization, possesses a high ratio of saving fuel consumption. But the structure of this hybrid powertrain is quite complex and requires a proper space utilization. As an example of HEV P2 configuration, one can find Audi A3 e-tron and Volkswagen Golf GTI on the market.

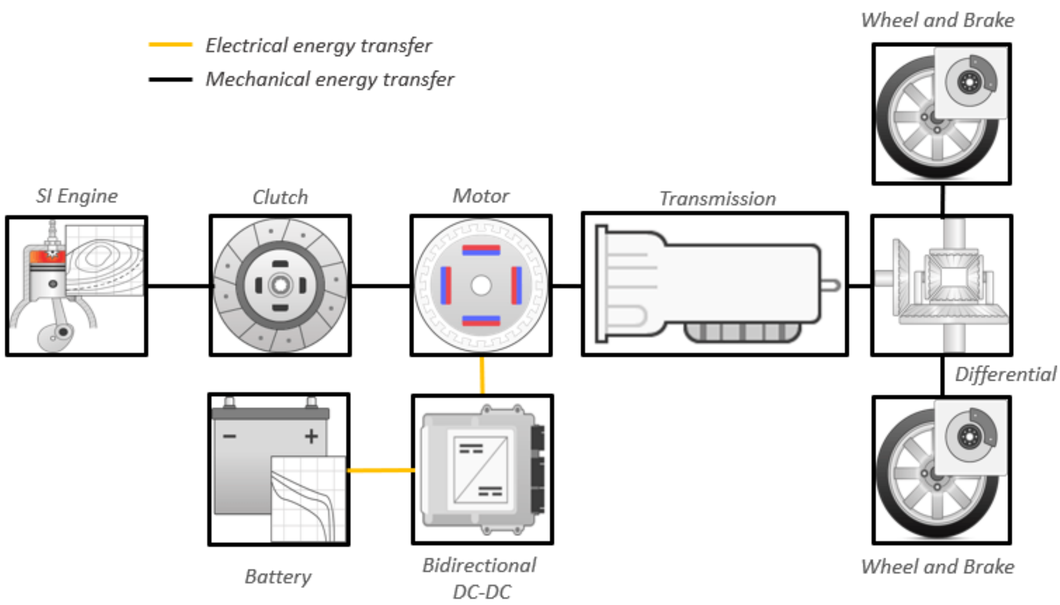

Figure 3. P2 HEV configuration

4) P3 (Figure 4)- The motor is located behind the transmission, which is connected to the output shaft of the gearbox. The given architecture has a higher degree of

hybridization compared to P2 architecture [3]. Besides, a better fuel economy can be achieved. However, it is required to redesign the transmission of conventional vehicles.

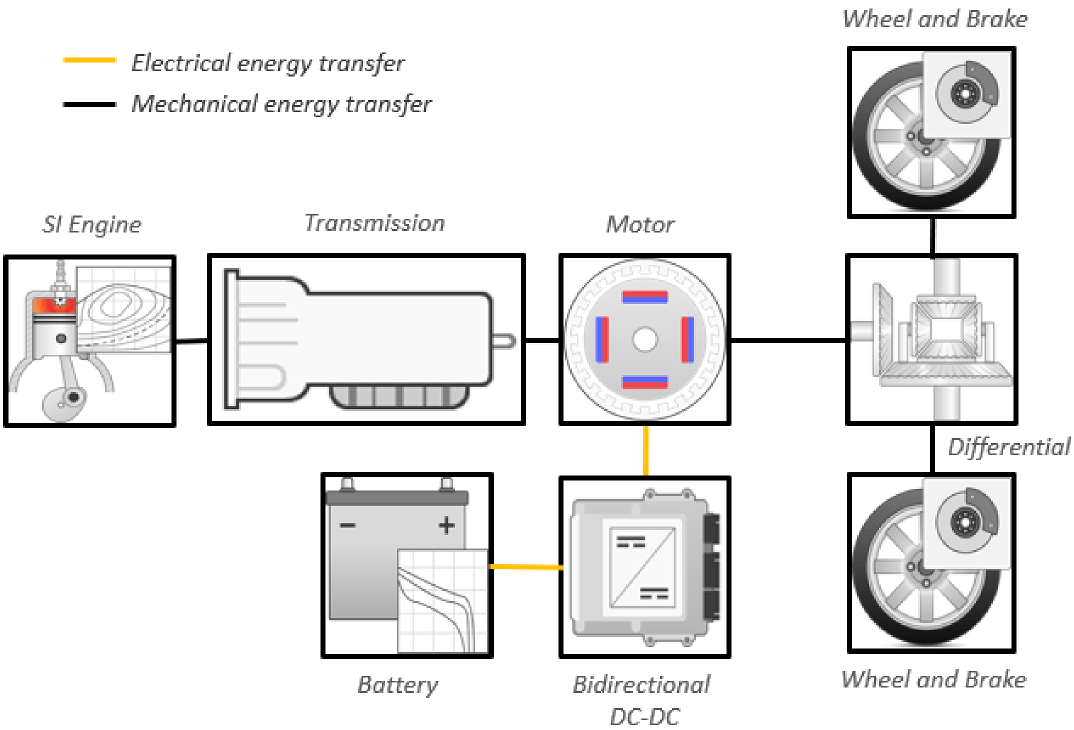

Figure 4. P3 HEV configuration

5) P4 (Figure 5)- the electric motor has no connection to the internal combustion engine. Moreover, ICE and electric motor drive different axles. For front-driven vehicles the electric motor is mounted on the rear axle. An obvious advantage of this architecture is that EV mode can be achieved (when ICE is switched off). This architecture is, however, is quite costly in comparison with others. Among modern HEVs BMW i8 and Porsche 918 Spyder show themselves as good examples of P4 architecture.

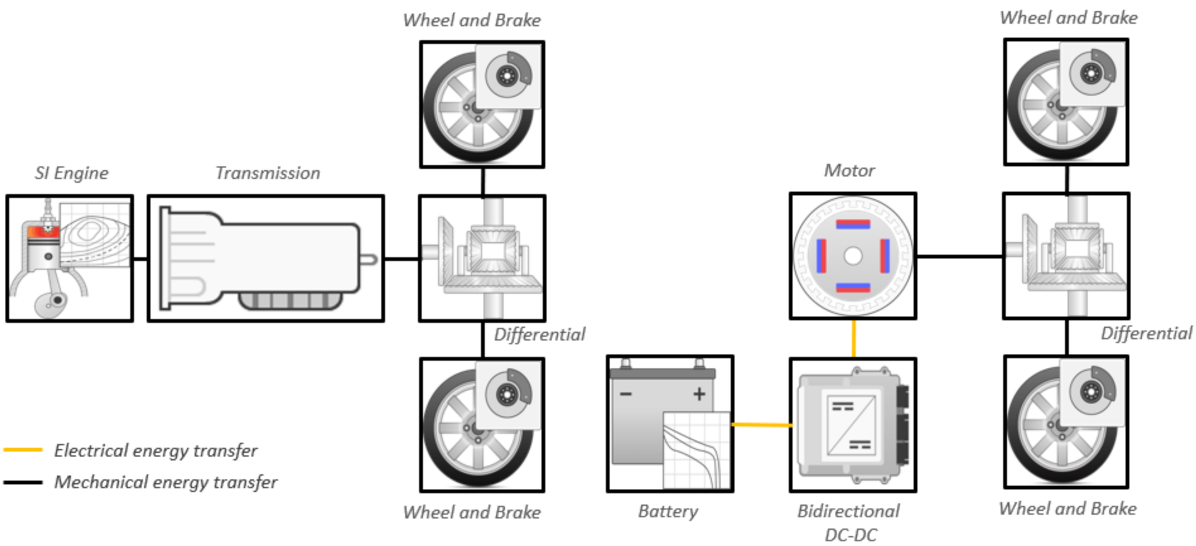

Figure 5. P4 HEV configuration *[4]*

III. CONCLUSION

Each of the listed architectures have their place on the world market today, with their positive sides and drawbacks. With certainty it can be said that among the major international vehicle companies, European companies mostly prefer the P2 configuration, while Japanese and American companies prefer the so-called dedicated hybrid transmission (DHT) configuration. Among them, the most representative ones are Toyota's THS (Toyota Hybrid System), Honda's i-MMD (intelligent Multi Mode Drive) and GM's Voltec.

IV. BIBLIOGRAPHY

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