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Perspectives and Limitations of a Fully Electric Low Voltage Propulsion Architecture

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Abstract

In the context of CO2 emissions reduction, investigations are currently made in various directions among the automotive sector: internal combustion engine efficiency improvement, downsizing, electrification, vehicle weight reduction. Meanwhile, a new type of vehicle is emerging in the automotive sector. This study analyses the perspectives and limitations of a low voltage electric vehicle (<60V), with only two people capacity. One of the main challenges of this new type of vehicle is to identify the best suited powertrain architecture, given the different constraints and needs (power, mass, acceleration, range, etc.). With the advantage of reducing the safety constraints linked to high voltage applications, but at the expense of higher currents when power level increases, a proper powertrain components sizing is mandatory, therefore limiting the advantages of such architecture. To better evaluate the evolution of the powertrain parameters, a simulation tool has been built to analyze the implications on the performances, efficiency and cost.

Introduction

The reduction of energy consumption by increasing the overall efficiency, and the reduction of greenhouse gas are two of the greatest challenges for the transport sector over the next decades. The highly developed automotive industry and the large number of automobiles in use around the world have caused and are still causing serious problems for society and human life. Deterioration in air quality, global warming, and a decrease in petroleum resources are becoming alarming concerns to human beings [1]. Road transport constitutes the highest proportion of overall transport emissions (around 71% in 2018), but this is expected to de crease as road transport decarbonizes faster than the other transport modes [2].

Air pollution has been high on the European agenda in the past years, as harmful emissions in many cities and regions across Europe still exceed the limits set at EU level back in 2008. Although Europe has seen undeniable progress in improving air quality, progress has however been slow and official data show that up to 95% of the EU population are still exposed to levels of air pollution the WHO considers dangerous [3]

Evidence on the dangerous effects of air pollution on public health has expanded massively over the past decades. Air pollution is estimated to decrease life expectancy of every person in Europe by an average of almost one year. In order to overcome the problems regarding the public heath, many solutions were implemented, especially the Low Emission Zones (LEZ) and this last solution is appreciated and has the support of the citizens. If the LEZ are well-designed, they can deliver significant air quality improvements, however, even if it is necessary to implement, sometimes is not sufficient to overcome the magnitude of air quality and climate challenges, therefore a gradual transition towards Zero Emission Zones is necessary [4].

Firstly, knowing that city congestion and pollutant emissions are the major preoccupations, new ways of urban mobility must be implemented, such as sharing services for cars, bikes, or scooters and of course a well-organized public transportation network. One of the most problematic aspects is that some persons, the commuters in our example, are bounded to their personal vehicles, and for this important sector, only the regular passenger cars are available.

Secondly, a study conducted by the European Environment Agency [5] calculated an average of the typical European car to be 1.2 passengers for commuting to/from work, 1.7 for family trips, and 2 for travel and leisure.

In this context, a new type of vehicle has emerged. At the crossroad between small car from M1 class and Low Speed Electric Vehicles (LSEV), these types of vehicles, symbolized by the Renault Twizy, Citroën AMI, or even prototypes from Valeo, the common point being the electric low voltage architecture (<60V). While being sufficient to deliver the performances needed for their main usage (commuting and car sharing), this architecture also has safety advantages, since it does not require the contact protection as is the case when the voltage exceeds 60V.

for the estimation of the battery pack cost [12], we can compare the costs from retail for the components needed in the 48V architecture with an estimate of the Renault Zoe's costs.

The contact protection and wiring costs are not readily available in literature. However, given the order of magnitude of at least 3000 EUR in differences for the battery pack costs, it is fair to assume that the wiring needed for high currents wouldn't be enough to compensate those differences in the case of a small car (< 800kg). As shown before in Fig. 13, when the vehicle mass goes over this limit, the currents increase much more sharply and past that point, our assumptions for the costs may no longer hold true.

It is also likely that in large scale production, the battery pack costs would be lower than the ones found on retail, making the 48V configuration more appealing.

Conclusions

The 48V architecture is gaining in popularity in the context of electrification and urban mobility alternative solutions. It is not only adapted to the trend of reducing emissions, but the occupancy rates justify the usage of smaller cars in dense urban areas. The safety advantages of not needing the same protections as the high voltage counterparts are also another aspect that could make it more appealing in the future.

Given the requirements established in Section 3, it has been shown that the LV architecture can attend those expectations, as well as the homologation requirements related to the WLTC, making it possible to perform in their intended applications on cities.

The best architecture would include 2 EMs on a 50/50 current and torque split between the two, as shown in Fig. 18, Fig. 19 and Tables 6, 7 and 8. The maximum current reduction has a strong positive impact in reducing the costs, while the performance is nearly identical.

It is also imperative to implement regenerative braking of some sort. This allows the vehicle to have more range, extending the battery life duration and mitigating one of the concerns related to electric cars (the range anxiety). The assumptions made of 100% regen would not be achieved in real conditions, rendering our comparisons in cases with regeneration against cases with no regeneration more accentuated than reality, but the gains still justify the usage of this function.

Overall, the 48V solution presents itself as a possible cost-alternative solution for urban mobility, despite its limitations and the constraints of being implemented on smaller cars, and more development is expected on those systems as the electric vehicles trend is more dominant on the market.

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