Chapter

Introductory Chapter: The Challenges of Future Internal Combustion Engines

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1. Introduction

Based on previsions, reciprocating internal combustion engine (ICE) will continue to be widely used in all sectors: transportation (land, sea, and sky), industrial, and energy production. For example, despite the significant electrification of powertrains based on light and heavy duty ICE for land transportation—the sector with the highest penetration of electrification—thermal engine will remain the prime mover. In fact, a majority of the scenarios investigated consider that various types of powertrains using liquid or gaseous carbon-based fuels would still cover up to 80% of the world fleet in 2050 (even if the major part of these powertrains will certainly be hybridized and partly electrified) [1, 2]. Therefore, the ICE development, finalized—based on the application field—at complying with limitations of pollutants as well as CO2 emission levels while maintaining or increasing performance, will for sure continue for the next decades.

In the last three decades, a significant effort has been done finalized at reducing pollutant emission levels emitted by ICE: this research and development activity has led to a wide portfolio of technological solutions like improved injection systems and air management, more accurate design of the whole combustion system, aftertreatment devices, and so on [1].

More recently, attention has been addressed to CO2 emission levels too, due to well-known problems concerning global warming and oil depletion. Dealing with CO2 reduction requires a systemic approach for the following reason: nowadays, the concept of fuel for reciprocating internal combustion engines must be expanded, given that the electrification of powertrain is leading the engines to use electricity, besides conventionals (fossil, bio, and alternative), as fuels. Therefore, CO2 is emitted not only during the engine operation but also when the *fuel* (then including the electricity) is produced. As a consequence, CO2 reduction is currently pursued not only during the engine operation, but also at fuel and electricity production levels. Moreover, the overall result of CO2 reduction is expected to be reached in a contest where the energy demand is significantly increasing.

It is widely recognized that one single technology will not solve completely the problem of CO2 emissions in the atmosphere. Rather, the different technologies already available will have to be integrated in order to solve this global problem. In the following, the technologies already available will be analyzed, at fuel production, electricity production, and engine design levels.

At **fuel production level**, biofuels—gaseous or liquid—represent a prosecutable solution in terms of CO2 reduction, given the “virtually zero” CO2 cycle characterizing them. A biofuel is a fuel produced through contemporary biological processes, such as agriculture and anaerobic digestion, while geological processes from prehistoric biological matter produce fossil fuels, such as coal and petroleum. If CO2 emissions can be lowered by biofuels, pollution problems remain substantially unchanged. However, respecting sustainability criteria for biofuels limits the exploitation of biomasses for biofuel production.

Other investigated solutions are synthetic fuels, as hydrogen, syngas, and the so-called e-fuels. Their production, which can contribute at recycling the CO2 released in the atmosphere during combustion, requires in several cases a significant energy amount. Therefore, synthetic fuels make sense only if the energy required to produce them is obtained from renewable sources.

A good midterm solution is recognized to be the utilization of alternative fossil fuels already available in nature like methane, main constituent of natural gas. In this way, the impact of the production phase of fuels is mitigated. The utilization of methane leads to the reduction, but does not avoid the emission of both CO2 and pollutants.

At **electricity production level**, a big contribution to CO2 reduction has been provided in the last years by the significant spreading of renewable energy source exploitations. Photovoltaic plants, wind farms, geothermal and hydro power plants, currently account for more than 20% of global energy demand. The big problem of these technologies is represented by their availability, intrinsically limited in time and space, as well as their reliability. It is evident, then, that currently they are considered as integrative—rather than substitutive—energy sources. A possible solution to the problems mentioned above would be to develop technologies able to store the electricity produced in excess during the periods of high availability (as already done nowadays in several hydroelectric power plants were electricity in excess, produced during night hours by thermal power plants, is used to pump water at high altitude, so recharging the hydroelectric power plants for the following day). In this view, the exploitation of the electricity produced in excess when available could be used to produce the abovementioned synthetic fuels, both gaseous and liquid.

Finally, at **engine design level**, a substantial contribution to CO2 reduction can derive from the abatement of auxiliary power losses, but also recovering the thermal power usually wasted at the exhaust, for example, through technologies like turbocharging and turbocompounding, organic Rankine cycles, and thermoelectric generators. Moreover, for several applications, like transportation sector, engine lightweighting as well as downsizing lead to the reduction of overall weight of the transportation vector. In the first case, the engine weight reduction is obtained using lighter materials, while in the second case, the goal is to reduce the engine displacement keeping unchanged the engine performance. Hybrid powertrains—where multiple forms of motive power are available—also lead to the reduction of CO2 levels, because they allow to operate the thermal engines in the areas of the characteristic map with the highest values of fuel conversion efficiency. If a storage system is integrated in the powertrain, then other technologies leading to CO2 reduction can be also applied, like kinetic energy recovery systems.

As previously said, all the above technologies cannot be considered as isolated, but they will all contribute to CO2 abatement. In order to reach this result, they will require an always increasing level of integration in the future. ICE development will be then finalized at providing a machine suitable to exploit all the opportunities for reducing CO2 emissions while satisfying the energy demand.

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References

[1] Ertrac. Future Light and Heavy Duty ICE Powertrain Technologies [Internet]. 2016. Available from: https://www.ertrac.org/uploads/documentsearch/id42/2016-06-09_Future%20ICE_Powertrain_Technologies_final.pdf

[2] Magna. The Road to Electrification—The Magna Powertrain Approach [Internet]. Available from: http://www.drivetrainforum.com/media/departments/communications/events_1/dtf/2018/vortraege_1/DTF2018_Lecture_MPT_Stephan_Weng.pdf