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Editorial: New developments in vehicle thermal management

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Editorial on the Research Topic
New developments in vehicle thermal management

The role of transportation is essential in meeting international targets for increasing energy efficiency and reducing fossil fuel consumption. Thermal engines still dominate the propulsion systems of vehicles, making it imperative to improve their efficiency during the transition to more sustainable systems powered by green electricity and hydrogen.

Among the various technologies being developed to achieve these goals, thermal management stands out as a cost-effective option. It proves to be appealing not only for traditional vehicles with thermal engines but also for hybrid and electric vehicles. This Research Topic aims to showcase the latest innovations in technologies, components, layouts, control management, and vehicle cabin conditioning. Thermal management options also encompass opportunities for energy recovery, which can significantly enhance the overall efficiency of vehicles. Furthermore, the integration of cabin conditioning and auxiliary systems into the vehicle's thermal management is relevant not only for traditional vehicles but also for hybrid, electric, and hydrogen-fueled vehicles and transportation means.

In particular, this Research Topic in Frontiers of Mechanical Engineering contains 4 papers, including 1 review and 3 research articles, supplied by researchers from 6 countries. These papers cover broad areas, including recent advances in hybrid and electric vehicles lubrication and thermal management, waste heat recovery, thermal energy storages and the estimation of power demand of auxiliaries.

Indeed, auxiliary engine loads have become a critical factor affecting powertrain performance and fuel economy. This is true both for thermal engines and for hybrid and electrified ones. In this regard, air conditioning, alternators, water pump and steering pump are the components that cannot be neglected. For a medium car (about 100 hp power), the contribution of the auxiliary loads can be more than 17% of the brake power (Gajanayake et al.), and it depends significantly on the operating and environmental conditions. Air conditioning systems usually consist of refrigerating units, where the compressor is driven by a belt linked to the engine crankshaft. During summer, the power absorbed can be significantly high when the cabin temperature approaches 40°C or at low vehicle speeds, reducing the cooling of the condenser placed in the front end of the vehicle (Askar et al., 2023). Even the alternator is an energy-consuming component, and the progressive electrification of the vehicles claims for even more efficient electrical machines. The coolant pump is usually always active during the vehicle run since it has the fundamental role of delivering the coolant fluid to the engine and the other components of the powertrain, such as batteries, electronics and heater cores. The temperature control of these auxiliary components, which play a crucial role in the proper functioning of the vehicle, requires the coolant pump to be highly reliable, usually resulting in a general overdesign of this component. Hence, its optimization in terms of sizing and control strategy could reduce the final fuel consumption and produce benefits during the warm-up phase and thermal optimization of the engine, also reducing pollutant emissions (Di Bartolomeo et al., 2023). An electric control strategy of the pump would be beneficial in this regard despite increasing the battery and alternator load. Steering pump often has a lower impact on the overall energy consumption on board (1% or less), but not negligible in particular for electric drivetrains (Römer et al., 2018).

Moreover, in hybrid and electric vehicles, the estimation of the thermal needs is a crucial issue. Power batteries should be cooled to keep them at a suitable temperature, but the heat rejected by the small and micro components of the electronics for powertrain control is challenging to evaluate and is located in a very high-density space. Even fast-charging cables could need a refrigeration medium (Tung et al.). Hence, technological innovations in cooling and thermal management systems should be developed. Advanced thermal fluids with nano-particles, two-phase fluids, circuits with micro-channels and flooded systems are on the frontiers of research and development in this sector. Heating and cooling needs during summer and winter suggest the use of heat pumps, whose thermal sinks should be reversible and adequately included in the cooling system and auxiliary load estimation (Liu et al., 2018). Therefore, the thermal management of a hybrid, electric or fuel cell-based vehicle can be even more complex than that of a thermal engine. The lubrication of electric vehicle components is often neglected, but they must also achieve low electrical conductivity and good thermal properties (Yan et al., 2020).

The use of thermal storage is more than an option in the optimization of a so-complex cooling system. It can be used in thermal engines to store the excess energy when the vehicle is running to use it during the warm-up phase, accelerating the heating of the engine or the lubricating oil and reducing fuel consumption and pollutants emissions due to quenching phenomena, low combustion efficiencies and catalyst light-off during the cold phase (Broatch et al., 2022; Vittorini et al., 2022). It can also be helpful in hybrid and electric vehicles to have a reliable thermal source for critical conditions. The simplest technological solution uses a liquid storage system, but phase-change materials using latent heat at different specific temperatures are under development (Sevilla and Radulovic).

Finally, energy recovery in thermal engines or integrating cooling systems represents a very interesting opportunity to reduce final fuel consumption. Several options of waste heat recovery systems are more suitable for heavy-duty vehicles than smaller ones. Organic Rankine Cycle units represent the most investigated technology, which recovers the thermal energy wasted by exhaust gases, cooling and lubricant circuit, or other components (charge air cooler, EGR, *etc.*,—Di Battista D. and Cipollone R., 2023). A thermodynamic cycle is realized through an evaporator, an expander/turbine, a condenser and a pump. The recovery opportunity is significant considering the high temperature of the exhaust gases, but advancements are needed to improve the recovery efficiency. The frequent variations of the hot source require the development of suitable control strategies and the optimization of the unit's components. In particular, the choice and the design of the expander is a crucial and open issue (Soldado et al.; Fatigati et al., 2022), which stimulated the creativity and innovative thinking of the engineers.

In closing, the guest editors hope that the readers will find a clear vision of the opportunities related to thermal management systems and their importance in the present and future trends of vehicles. They would like to appreciate the valuable contributions of all the authors sincerely. Acknowledgment is due to all reviewers' service and commitment which played a significant role in enhancing the overall quality and integrity of the published articles on this Research Topic.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Askar, A. H., Kovács, E., and Bolló, B. (2023). *Lecture notes in mechanical engineering*. Cham: Springer. doi:10.1007/978-3-031-15211-5_31

Broatch, A., Olmeda, P., Martín, J., and Amin, D. (2022). Improvement in engine thermal management by changing coolant and oil mass. *Appl. Therm. Eng.* 212, 118513. ISSN 1359-4311. doi:10.1016/j.applthermaleng.2022.118513

Di Bartolomeo, M., Di Battista, D., and Cipollone, R. (2023). Experimentally based methodology to evaluate fuel saving and CO₂ reduction of electrical engine cooling pump during real driving. *SAE Int. J. Engines* 16 (5), 693–707. doi:10.4271/03-16-05-0041

Di Battista, D., and Cipollone, R. (2023). Waste energy recovery and valorization in internal combustion engines for transportation. *Energies* 16 (8), 3503. doi:10.3390/en16083503

Fatigati, F., Vittorini, D., Coletta, A., and Cipollone, R. (2022). Assessment of the differential impact of scroll and sliding vane rotary expander permeability on the energy performance of a small-scale solar-ORC unit. *Energy Convers. Manag.* 269, 116169. ISSN 0196-8904. doi:10.1016/j.enconman.2022.116169

Liu, K., Wang, J., Yamamoto, T., and Morikawa, T. (2018). Exploring the interactive effects of ambient temperature and vehicle auxiliary loads on electric vehicle energy consumption. *Appl. Energy* 227, 324–331. ISSN 0306-2619. doi:10.1016/j.apenergy.2017.08.074

Römer, J., Kautzmann, P., Frey, M., and Gauterin, F. (2018). Reducing energy demand using wheel-individual electric drives to substitute EPS-systems. *Energies* 11 (1), 247. doi:10.3390/en11010247

Vittorini, D., Diomede, D. D., Battista, D. D., Carapellucci, R., and Cipollone, R. (2022). Model parameterized assessment of a thermal storage unit for engine oil warm-up improvement. *J. Phys. Conf. Ser.* 2385, 012077. doi:10.1088/1742-6596/2385/1/012077

Yan, C., Jha, S., Raut, A., Zhang, W., and Hong, L. (2020). Performance characteristics of lubricants in electric and hybrid vehicles: A review of current and future needs. *Front. Mech. Eng.* 6. doi:10.3389/fmech.2020.571464