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Background information

Green sustainable mobility solutions are the future. Both electric and hybrid vehicles and drive systems will play a crucial part in this.

Today already, European regulations stimulate the use of electric vehicles on the road. By 2020, more than five million of these vehicles driving on our European roads. This will most definitely be the case if our batteries will become sufficiently efficient and budget-friendly to be able to compete with fossil fuels from an economic point of view as well.

Also in industry, we move towards cleaner drive systems. The industry is responsible for almost one third of the global energy consumption and the corresponding CO_2 emission. So it makes absolute sense that energy efficiency will become a crucial criterion and all components in conventional drive systems are becoming more efficient: electromagnetic actuators, batteries, supercapacitors, etc. But also in the integration of these separate components there is still significant room for further progress.

Virtual design: Today, measuring the energy loss in drive systems is almost impossible in the design phase, whereas at this stage it is particularly crucial. Virtual models for drive systems that map their functional behavior in full detail will allow to measure the efficiency of all individual components but also the way in which they work together – or not. While creating these virtual models, particular attention is paid to new components such as elastic elements as a substitute for conventional bearings.

Energy management systems: Drive systems are becoming increasingly redundant. This evolution allows to develop systems that optimise the energy flows in the system and recover excess energy.

Hybrid energy storage: There are already several systems for storing energy produced by vehicles when braking: batteries, supercapacitors, flywheels, springs, etc. Also the combination of these systems offers considerable potential. But there is also room for research into new designs.

Active mechatronic subsystems: Today, most mechanical components of drive systems are not part of an active control circuit. By replacing these passive components by active mechatronic solutions, considerable energy gains can be generated: less friction, reduced electricity consumption, less vibration...

Production cells and machines must be increasingly able to operate autonomously. This allows to use them more efficiently and to create more robust, high-quality processes that consume but a minimum of energy. Finally, safety is increased as human errors are excluded.

Self-driving vehicles are coming our way as well. These are not only able to drive autonomously, they also use cloud data to communicate with the world on road conditions, other vehicles and own performances. This way, self-driving vehicles will make traffic safer and more energy-efficient.

Awaiting full autonomy, maximum support to the operator and driver obviously remains a very important objective. Besides, all autonomous systems benefit from access to databases and real-time information.

To be able to realise autonomous vehicles, machines and production cells, major breakthroughs are needed in the following research domains:

Model-based optimal control: In a system that has disposal of a physical model, it is perfectly possible to design a supervisory controller that always ensures the optimal configuration of the system, whatever the operational conditions. Still, designing such controller is not at all easy. It requires complex, linked mechatronic systems and is faced with the limitations of existing models and the stochastic nature of many processes. In addition, such controller works best on the basis of efficient, non-complex algorithms.

Self-learning control system: In complex processes, realistic modelling is impossible. In these situations, a self-learning controller is an attractive option. Extensive theoretical basis for these controllers already exist but their integration in vehicles and production systems still needs further development.

Situation modelling: A supervisory controller will always be connected to external information sources: other vehicles, smart grids, traffic systems, etc. The information from these external sources is so fragmented and uncertain that information fusion in the controller is crucial for its optimal functioning. At the same time, research into the protection of such communication links is absolutely necessary.

Shared human/machine control: Fully autonomous systems will be developed gradually. Meanwhile, an optimal and safe cooperation with human operators and drivers is a top priority. Controllers must learn preferences, know how to deal with changing behavior, etc. On the other hand, operators can learn from the machine as well.