XXXIV Cycle

Optimization of Electric actuation systems

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Research context and motivation

Hybrid electric vehicles (HEVs) have great potential for better fuel economy and fewer emissions. This capability basically is due to: the ability of the rechargeable storage system to recover energy during braking phases (regenerative braking), and the fact that an additional degree of freedom is available to satisfy the power demands from the driver, since power can be split between thermal and electrical paths.

ELdor IHT project introduce a new clutch-less Integrated Hybrid Transmission (IHT) configuration having three energy sources: 2 Ems and an ICE for HEV system. Which allows to operate in both PHEV and SHEV modes, and also can be driven in pure EV mode since ICE can be completely decoupled from electrical part.

This novel configuration requires investigation about:

- Sizing of the different components of the gearbox
- Stress and thermal analysis
- Control strategy optimization

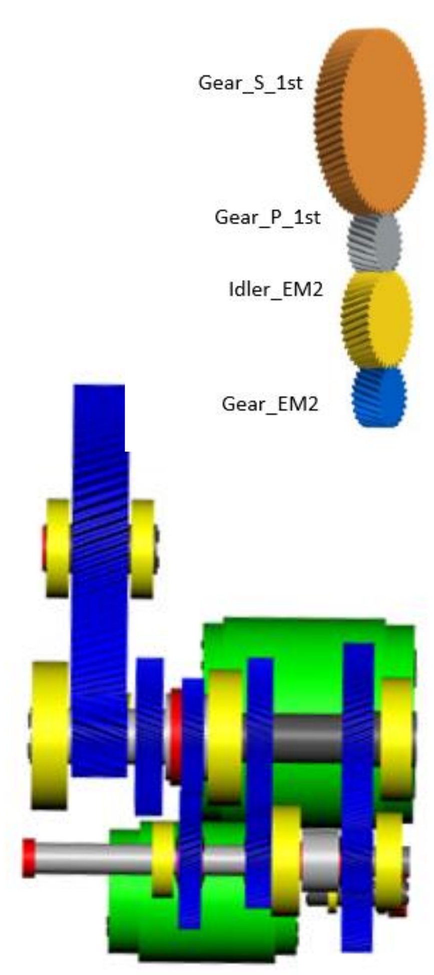
Addressed research problem

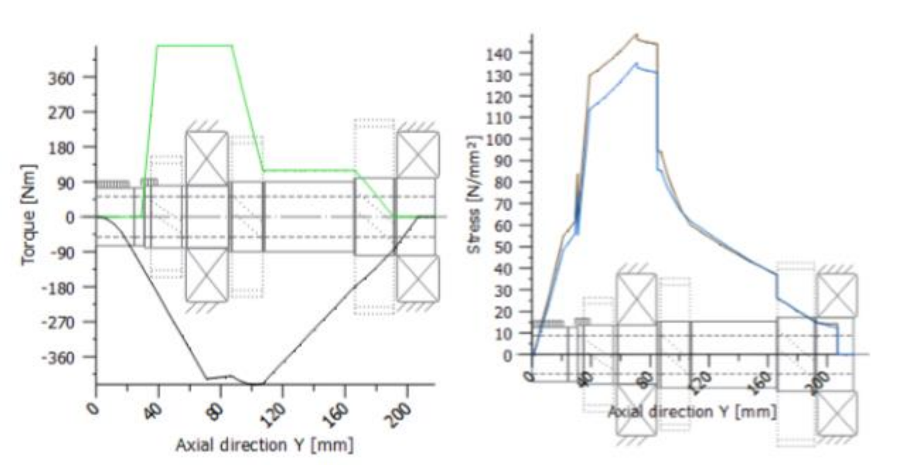
DriveTrain design of IHT

The sizes of drive train components are optimized for the desired performance of vehicle.

Stress analysis of gearbox compnents using KISSsoft software:

- shaft
- Gears (helical gears, rack and pinion gear for actuator)
- Synchronizer design
- Selection of bearing



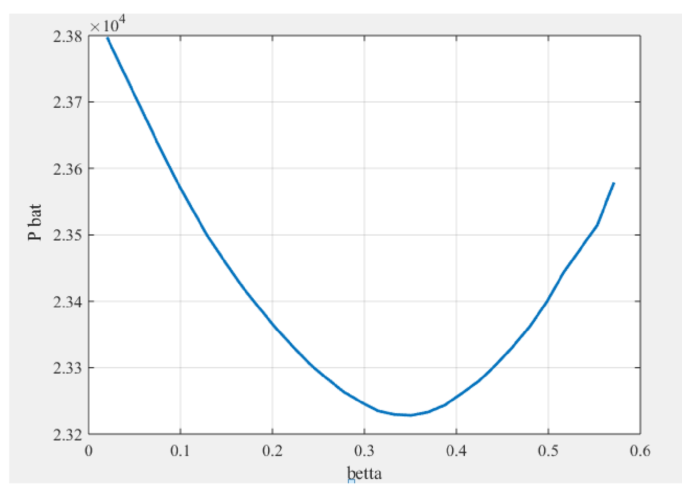


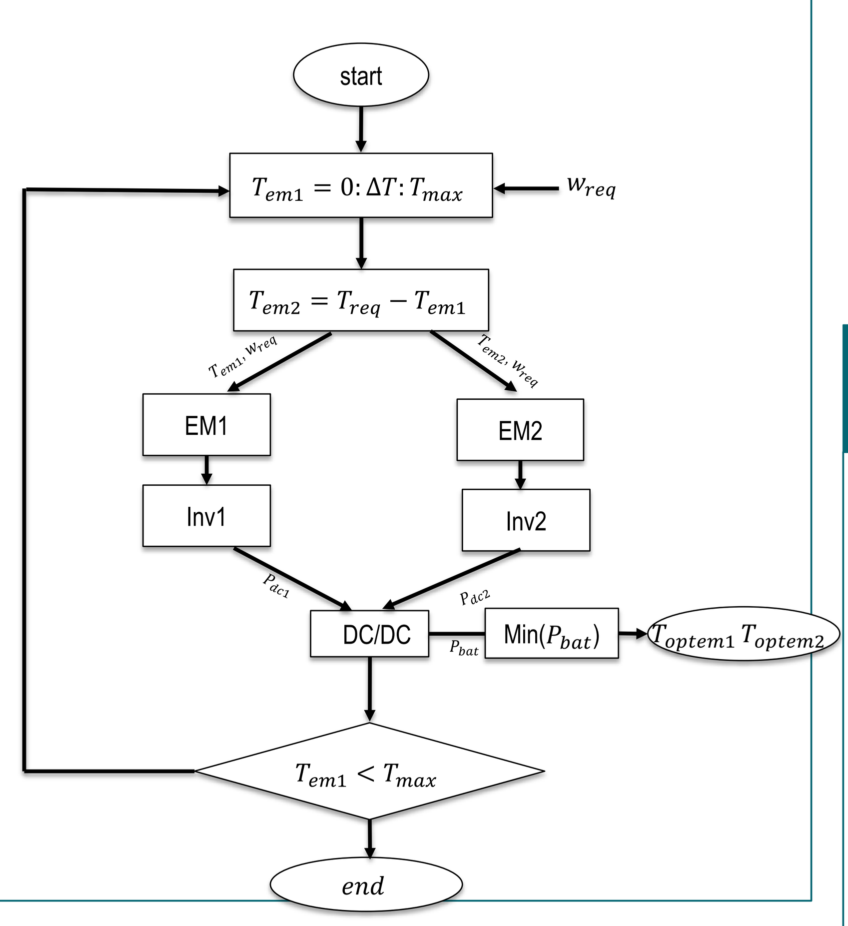
Torque profile on the shaft

Nominal equivalent Stress distribution on the shaft

Optimization of Energy Menagement system

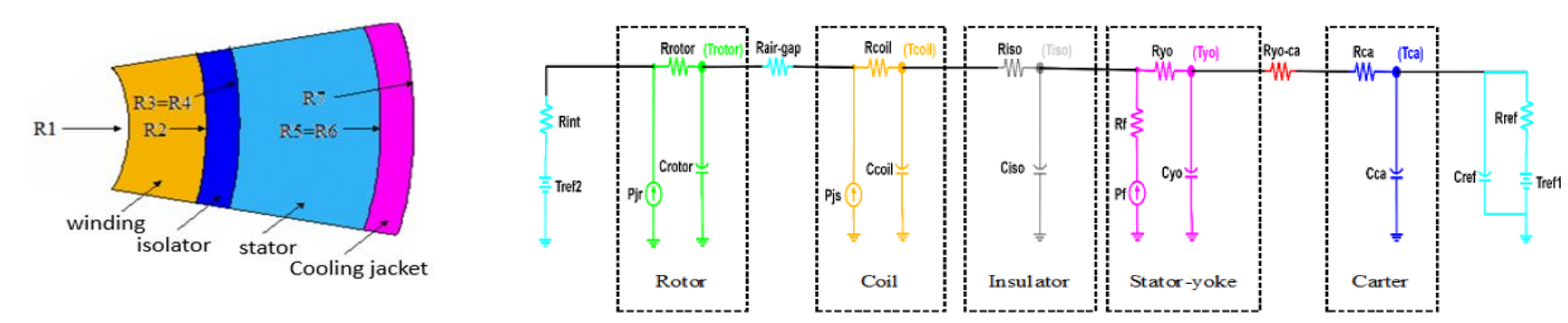
TCU that coordinates the output power from an internal combustion engine (ICE) and electric motors simultaneously is important for a HEV because EMSs affect fuel economy and battery state of charge (SOC) directly.





Ongoing Work

1. Thermal modeling EM, INV, Battery 1D thermal lumped model



2. Equivalent fuel consumption minimization strategy

Objective is to minimize equivalent fuel consumption rate which is sum fuel consumption rate by ICE ($\dot{m}_{ice}$) and equivalent fuel consumption rate of battery ($\dot{m}_{equ}$):

$$J_{ECMS} = \dot{m}_{ice} + P(t) * \dot{m}_{equ}$$

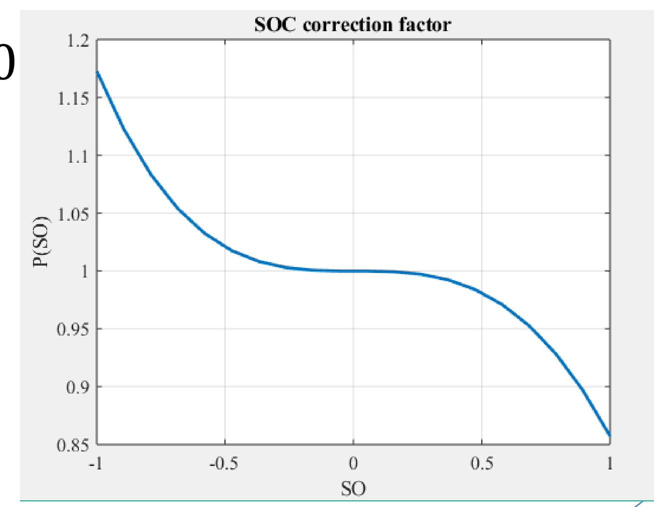
where,

$$\dot{m}_{equ} = \begin{cases} P_b(t)/(\eta_{dis} * Q_f) & \text{if } P_b(t) > 0 \\ P_b(t) * \eta_{ch}/Q_f & \text{if } P_b(t) < 0 \end{cases}$$

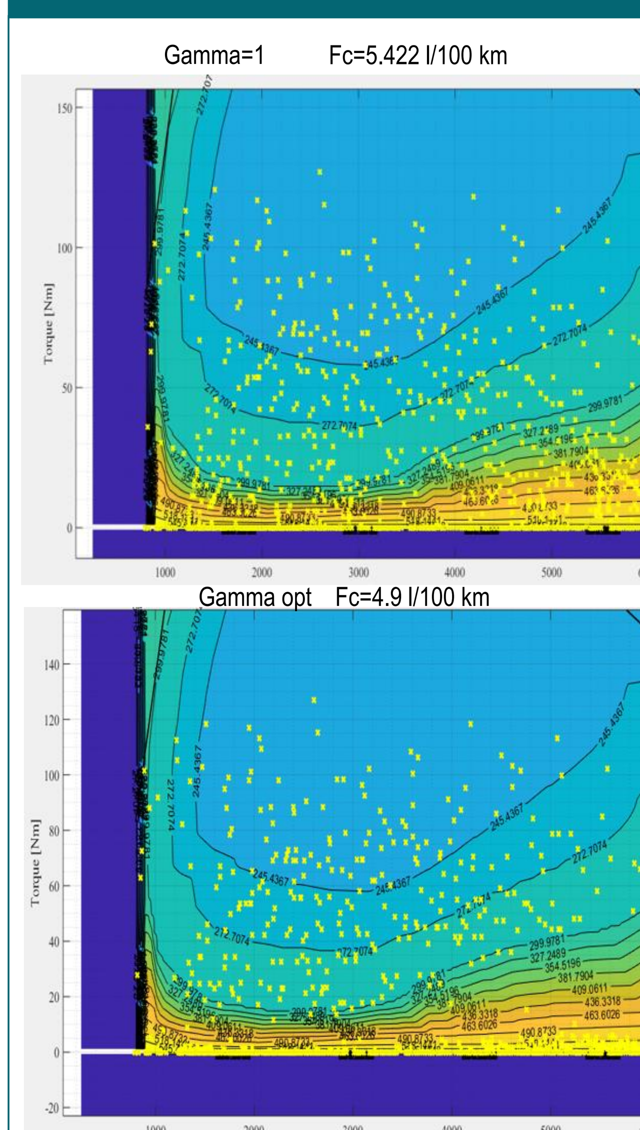
Correction function: $P(t) = 1 - \varepsilon * SO^3 + \sigma * SO^4$

Factor P is used to penalize $\dot{m}_{equ}$ when SOC is out of SOC threshold limits.

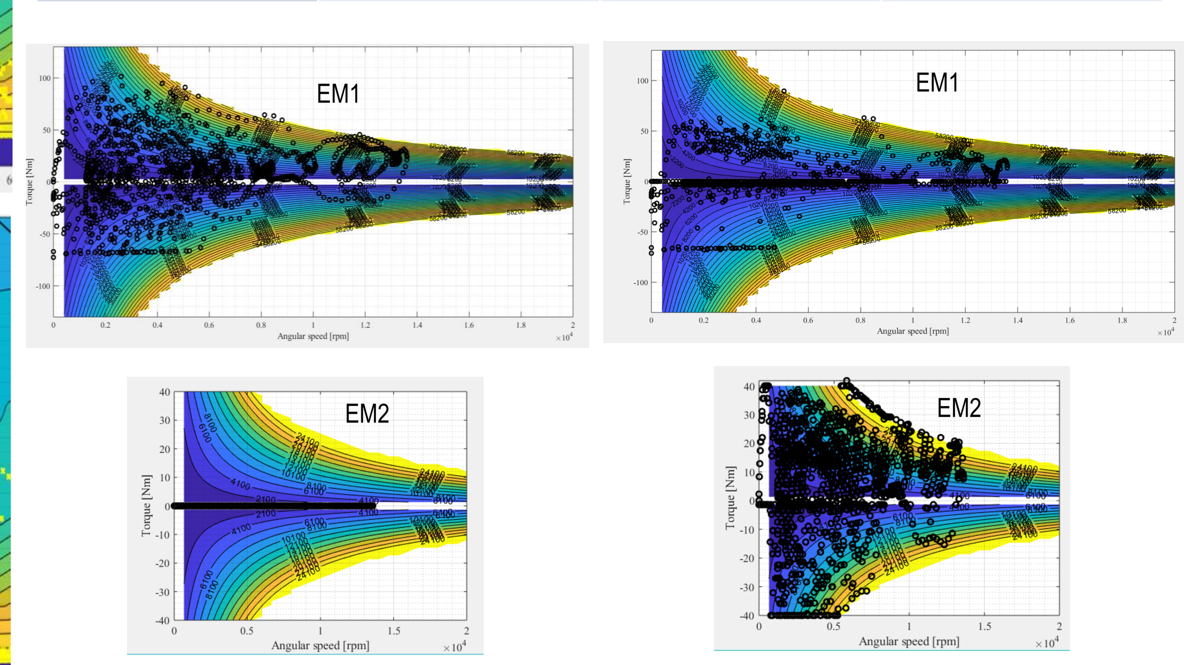
Normalized SOC: $SO(t) = \frac{2*SOC(t) - (SOC_u + SOC_l)}{SOC_u - SOC_l}$



Simulation results



	Mode	SOCf alfa=1, betta=0;	SOCf alfa & beta optimum
NEDC	Mode 5	0.739	0.747
	Mode 6	0.718	0.731
	Mode 7	0.694	0.702
	Mode 8	0.674	0.687



Future work

1. Design of Cooling system for IHT HEV system

2. Implementation of energy management system integrated with thermal model

Paper for submission

Preparing 2 paper for publication:

Optimization of electric motors usage in HEV system

Powertrain Configuration: Novel Integrated Hybrid Transmission for Power split

List of attended classes

- 01TBARO– Fundamentals of fluid film lubrication: models and applications(20/05/2019, 2 CFU)
- 01RYZRO – Advanced finite element models for mechanical and multi problems(14/01/2019, 6 CFU)
- 01TAKRO - System health Management (02/05/2019, 4 CFU)
- 01QORRO – Writing Scientific Papers in English(06/06/2019, 3 CFU)
- 01SWPRO - Time management (27/02/2019, 1CFU)
- 01TAMRO - Structural mechatronics: systems and technologies (18/09/2019, 4CFU)
- Siemens PLM Software - Digital Signal Processing in Simcenter Testlab (3CFU, hard skill 3rd level) In Politecnico di Torino on 25th and 27th of March