METU EE 7566

Spring 2019

Homework 1: Vehicle Dynamics and Electrified Vehicle Powertrains

This is the first part of your HW1 that will have in total 5 parts. I expect you to develop a Matlab script with the parts explained below. Homework 1 will be collected once all parts are completed, but I highly recommend you to start working on it as the assignments are posted.

Part 1: Week 2 → Speed and torque calculations + maximum power required (EM and Battery)

Part 2: Week 3 → Acceleration Performance

Part 3: Week 4 → Drive Cycle Calculation

Part 4: Week 6 → Matlab Assignment EV

Part 5: Week 7 → Matlab Assignment Range Extender

Part 1: You are asked to redesign a midsize internal combustion engine vehicle (characteristics of the car is given below) as a battery electric vehicle with following requirements:

- Max vehicle speed 150 km/h and acceleration capability at maximum speed 0.05g

Find the following quantities:

a. Electric machine maximum speed and torque at maximum speed (so required power)
b. Power capacity of the battery

Assume following constant efficiency values for the energy converters.

Efficiency of electric machine + inverter	*92%*
Efficiency of gearbox + differential	*97%*
Efficiency of battery pack	*95%*

Vehicle and component characteristics:

Mass of body without powertrain	1000 kg
Increase in mass due to acceleration of rotating masses	1.05
Gravitational acceleration	9.8 m/s^2
Frontal area	2.57 m^2
Aerodynamic drag coefficient	0.26
Density of air	1.25 kg/m^3
Friction coefficient of tires	0.006
Radius of wheels	0.3 m
Gear ratio (electric motor to wheels	9.0478
Accessories consumption (fixed)	750 W
Adhesive coefficient of tires to ground surface	0.9
Front wheel drive with equally distributed load on wheels	0.5 (Acceleration)
Load distribution during braking, W_{front}/W_{total}	0.65 (Braking)
Specific cost of electric machine + inverter	$30/kWh
Specific mass of electric machine + inverter	1.1 kW/kg
Specific volume of electric machine + inverter	2.6 kW/l
Battery pack specific cost, P_{batt}/E_{batt}: power-to-energy ratio	**$(200 + 13 x P_{batt}/E_{batt})/kWh**
Battery pack specific mass	**(200 - 3 x P_{batt}/E_{batt}) Wh/kg +120 kg**
Specific cost of internal combustion engine	$50/kW
Specific mass of internal combustion engine	0.55 kW/kg
Charger mass and cost (fixed)	10 kg and $300
Fuel tank mass and cost (fixed)	5 kg and $150