Vehicle Modelling

By

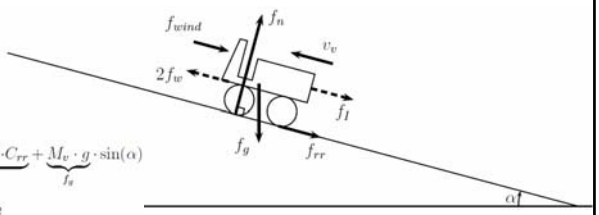
Erik Schaltz
Department of Energy Technology, Aalborg University

Outline

- Modelling
  - Battery
  - Ultracapacitor
  - Fuel cell
  - Power electronics
  - Electric machine
- Drive cycle
  - Performance investigation of electric vehicle

Modelling

Forces acting on a vehicle

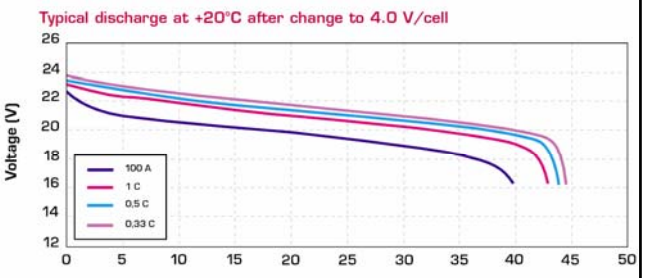


$$f_{traction} = 2f_w = \underbrace{M_v \frac{dv_v}{dt}}_{f_l} + \underbrace{\overbrace{M_w \cdot g \cdot \cos(\alpha)}^{f_n} \cdot C_{rr}}_{f_{rr}} + \underbrace{M_v \cdot g \cdot \sin(\alpha)}_{f_g} + \underbrace{\frac{1}{2}\rho_{air} C_{drag} A_{front} (v_v + v_{wind})^2}_{f_{wind}}$$

- Two solutions for equation
  - Traction force is known => vehicle speed can be calculated
  - A given vehicle speed is desired => calculate required traction force
- Problem
  - Must model power flow from (to) source to (from) traction force
  - The power flow depend on the internal conditions / states of the vehicle

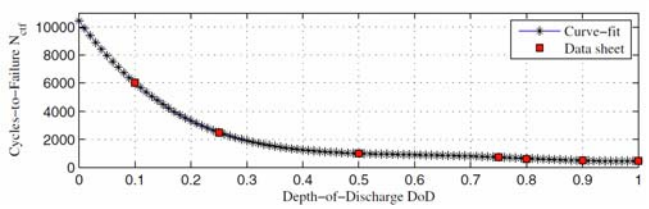
Battery

Capacity depend on the charge/ discharge current



Source:

Life time depend on how deep and often it is discharged



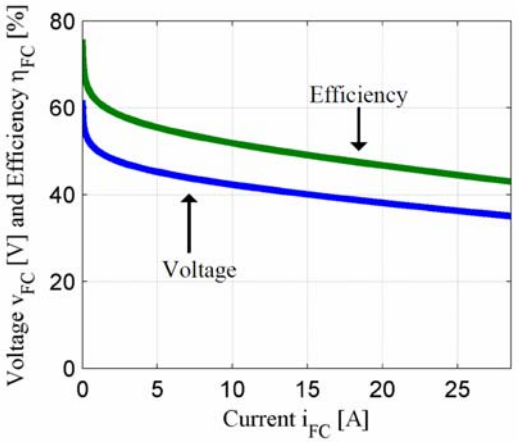
Ultracapacitor

- Relatively high self discharge when fully charged, e.g. energy loss from 100% to 90% in 4 hours
- Capacitance depend on the charge level

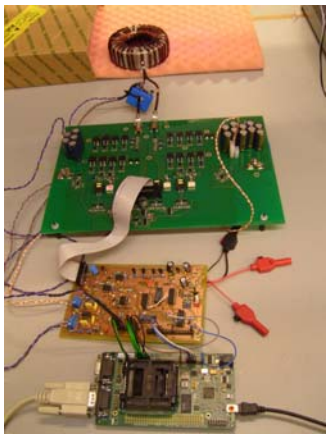
Source: www.maxwell.com

Fuel cell

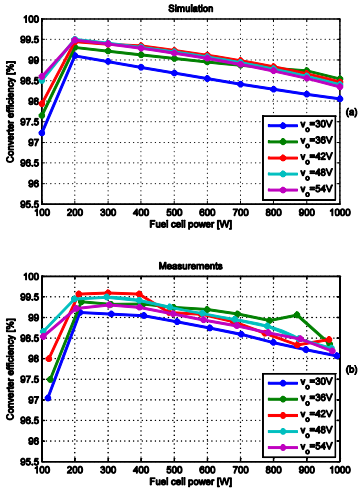
- Voltage and efficiency depend on the current level
- Huge advantage if heat (loss) can be used for heating



Power electronics



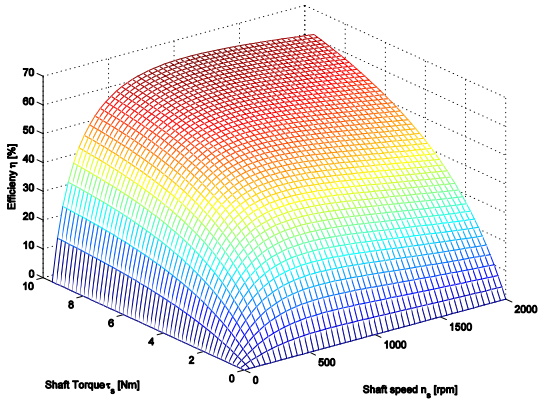
Efficiency depend on the power and voltage level



Electric machines

Efficiency depend on the speed and torque

Efficiency map of a DC-motor



Drive cycle

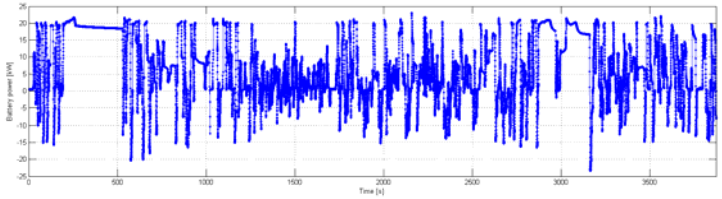
Field test of an electric Renault Kangoo, performed 28/5-2009

- **EV Kangoo**
  - **22 kW motor**
  - **90 km city driving**
  - **100 km/h max speed**

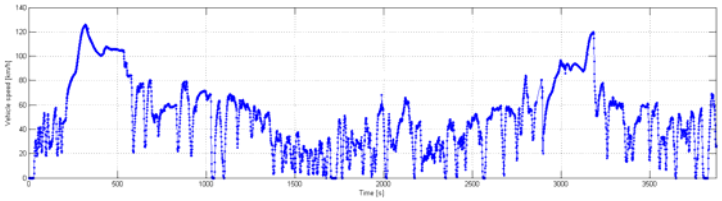
Route

Measurements

Battery power [kW]



Vehicle speed [km/h]



Time [s]