Sähköiset hyötyajoneuvot
Electric Commercial Vehicles - ECV

National seminar 24.9.2014
Aalto-yliopiston Saha

Summary – wrap-up / Mikko Pihlatie

Research session 1

- Virtual battery – Ari Hentunen
  - User needs: battery performance assessment, simulation/emulation
  - Users: drive train , battery system and vehicle software developers
  - Parametrisation of an equivalent circuit model including thermal model, based on laboratory testing
  - Entropy effect taken into accout in thermal behaviour, significant in operation with wide state of charge
  - Key finding: systematic model
  - Benefits: knowledge for battery system development & assessment
  - Business: characterisation and emulation services

Research session 1

- Current trends in battery technology – Samu Kukkonen
  - Traditional technologies Pb, NiMH, Li-ion
    - 48V systems coming in vehicles
    - NiMH still suitable for certain especially mild hybrid applications
    - Li-ion is a family of batteries with different materials and constructions. Optimal choice of materials will be dependent on application
  - Standardised cell geometry (cylindrical/prismatic) vs pouch cells
    - Mass production benefits with standardised
    - Total cost for system includes packaging. Differences can arise from different geometries
  - Future technologies still a few steps away – redox flow a potential technology
  - Estimating TCO is a complex excercise and needs a combination of lab testing, modelling, simulation and field experience

Research session 1

- Electromechanical steering & actuation – Panu Sainio
  - Motivation: controllability, accuracy and sensitivity
  - Lower service requirements
  - Diagnostics and
  - Challenges: shock/impact loading lower (robustness)
  - Key findings: electromechanical steering could work
    - Has been implemented in a real machine
  - How to use the results
    - Helps to reduce energy used today for hydraulics, hydraulics only for bucket movements
  - New areas: automation and remote control. Electromechanical steering could facilitate automated working machines

Q&A session 1

- Flow battery potential: it is hard to estimate the potential for mobile applications at the moment. On the stationary side the potential is larger
- Modelling of lifetime: focus at Aalto has not been on lifetime
- Simuloinnin kaupallistaminen: palveluja syntymässä / tarjolla
- Estimating lifetime of battery / battery pack is crucial. Several parameters have big effect, such as temperature, depth of dischage (SOC window)
- Battery management (electric and thermal) is a key factor for actual battery performance and lifetime management

Session 2 industrial

- eBusSystems (electric bus system) – Veikko Karvonen
  - Electric buses as part of traffic system
  - Traffic authority (HSL) electric bus strategy is ambitious
  - Transport system view and operation concepts analysis are required for cost-efficient eBus and component design
  - Opportunity charging offers possibility for battery downsizing – at the same time suitable charging infrastructure is necessary
  - Cost – benefit analysis is necessary to estimate choices and dimensioning of charging, eBus and batteries.
  - Productivity is essential in the cost structure (labour costs)

Session 2 industrial

- Finnish electric bus – Otto Pietikäinen, Linkker Oy
  - Commercialisation of electric buses based on eBus project
  - Global need for clean and efficient urban transport
  - Expected European market size 5500 units by year 2020
  - Vision: provide the most attractive emission free bus also increasing the attractiveness of public transport
  - Recipe: opportunity charging, energy efficient powertrain, lightweight construction
    - Pantograph charging at end stops, compatibility with other modes of transport
  - Claim 10-30 % reduction to TCO though the vehicle concepts and smart integration into the transport and energy systems
  - Business model includes also retrofits of electric powertrain

Session 2 industrial

- ABB Heavy Drive – Teemu Ronkainen
  - Inverter development for HHEV (Heavy hybrid electric vehicle) applications
  - Focus: reliability, new functionalities, compact size and low cost
  - HEVI3 for reliability research. Goal to reduce design time through simulation
  - ACDC for motor models. Self-tuning generic AC drive and models, new control method
  - HEI2 (harsh environment inverter), drive technology in general. Novel converter concept study HW & SW
  - Thuja (lifetime simulation models), chip temperature measurements with fiber optics

Session 2 industrial

- Next generation straddle and shuttle carriers – Juho Leskinen Cargotec
  - Straddle and shuttle carried portfolio: classic/electric/hybrid straddle carried, automated operation
  - Modular powertrain in the hybrid carrier: big downsizing of diesel (11 l → 4.4 l)
    - Li-ion based battery solution, several options are still open
  - Customer case analysis
    - straddle carried: 30% decrease in fuel consumption & emission, engine running time 70% (utilisation increased), lower noise, higher machine availability
    - Shuttle case: 40% fuel savings, 60% machine operation time, lower noise, higher machine availability

Session 2 Q&A

- Comment: service cost of electric buses is not necessarily lower than for diesel buses. Less service but maybe more difficult to identify
  - How experienced is the service personnel
- Role of big companies such as ABB
  - Publication of results, doctoral thesis
- Kalmar:
  - Payback time for hybrid carriers? About 2 years. Machine life cycle is about 10 years.
  - powertrain is developed in-house
  - Machine design and dimensioning is based in duty cycle analysis → very big variations in requirements by customer
  - Kalmar – tailored solutions available for customers, especially in control and fleet management
  - Market demand is high, largest market share expected for hybrids

Session 3 Vehicle, machines, systems and modelling

- Future hybrid work machine components and tools – Lasse Laurila
  - Questions: lifetime – is the lifetime different from conventional machines, Integrated or discrete components
  - Vision: local hydraulic circuits and actuators
  - New components: integrated electro-hydraulic energy converter (IEHEC), with direct-immersion oil cooling
  - Integrated two-speed gearbox and electric motor (In-Hugor): integration of gearbox and PMSM
  - Tools for developers: virtual simulation test bench utilised in all stages, HIL, load/duty cycle analysis from simulator

Session 3 Vehicle, machines, systems and modelling

- Modelling energy management in eBus – Teemu Halmeaho
- Motivation: lack of public research results on HVAC systems in buses – passenger e-cars shown big drop in range due to heating/cooling
- Aims: powertrain efficiency, effect of heating/cooling on overall vehicle efficiency, potential for new solutions, intelligent control: system-level simulation, CFD, validation
- Heat flows and management at vehicle level
- Key findings: selected modelling approach suits well for energy management,
- Benefit for companies: improving overall efficiency of vehicles, design support for vehicles & components, improved passenger comfort

Session 3 Vehicle, machines, systems and modelling

- eBus fleet and lab tests on commercial buses
  - Field tests – datalogging (to be further improved) with eMule
  - Chassis dynamometer measurements: Caetano, Ebusco, BYD, VDL (scheduled), eMule prototype
  - Lab measurement programme for total energy consumption plus division between different systems
  - Key findings:
    - battery operating T is a key parameter for efficiency and lifetime
    - Regeneration is a crucial element for high efficiency
    - Low vehicle mass is beneficial
    - Comprehensive R&D has been built up for electric buses with field testing, chassis dynamometer testing, and simulation

Session 3 Vehicle, machines, systems and modelling

- Power system vs eMobility- Joni Markkula
- Standardisation of car – charger – power grid connection plays a major role
- Electric vehicles as part of the power system
  - Intelligent charging a rising trend
  - For heavy duty / commercial vehicles charging infrastructure, coordination, business models and interoperability are still unresolved
  - Optimising charging system, vehicle and battery needs to be done together
- BMS is a key component for battery system performance and lifetime
- Power grid simulations important when intoducing larger number of high power charging points

Session 3 Q&A

- Regeneration a key aspect for energy efficiency.
- Regeneration in winter conditions is a challenge due to low friction

General observations

- Clear steps forward have been made
- New industrial projects in the network
- Active participation and discussions
- Many issues need still attention
  - Understanding batteries is critical
  - Reliability, lifetime and safety are still not
  - Technoeconomic evaluations (TCO) needed to support decisions

Summary

- What are the critical issues? Why?
  - Battery system and its performance – most uncertain single component needing development
  - Modelling and simulation tools at different levels are needed to assess dynamic performance (from early engineering phase to piloting)
  - Simulation with fleet experiments are needed (combination of theory with practice)
- Rising trends with related business
  - New electric components with higher integration level
  - Virtual design and analysis by simulation tools
  - Concepts and design based on duty cycle and requirements analysis (measurements & simulation)
  - Definition of total cost of ownership for the end user/customer
  - Intelligent charging and energy management will be needed

Next steps?

- The work continues…
- Next ECV national seminar: spring 2015 at TUT

→ **Tentative date: Tuesday 10.3.2015**