New concepts in drive technology - enabled by electrification

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Agenda

1. Trend of electrification in agriculture
2. Challenge of elektrifizierung
3. Short introduction of AVL and AVL CD+TE
4. Example enhancement of process by electrification + Investigation with simulation
5. Generation 0 – concept with virtual prototype using MOBEO, MOTRAN and VSM
6. Power generation in tractor
7. Integration of generator into driveline
8. Optimization of powertrain by hybridization
9. Outlook
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**AEF – Agricultural Electronics Foundation**

- Organization of tractor and implement related companies with goal of standardization
  - High-voltage-interface tractor <> implements (up to 170kW)
  - Control-interface energy flow / e-motors
- Motivation:
  - Increase of process
  - New or improved performance of implement
  - Simplification, avoid oil, etc.

AVL CD&TE is member of AEF
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Challenge

1. Reach plateau of productivity as fast as possible – example of passcar

Attention

Peak of exorbitant expectations
2011
1Mio.
E-Cars in BRD 2020

Trigger of technology
1997
SOP
Prius

Path of enlightenment
2011
Project Stops + Motorensymposium „E-Car steckt“

Valley of disappointment

Plateau of productivity

> 2013
Solutions with real customer benefit and consequently optimized systems:
1st „killer applications“

- Identification of killer applications
- Concentrate on real customer benefits
- It is not only adding electrification
- Consequently optimize complete system
- Finding Plateau may take some time
5 Element of AVL Kaleidoscope

Component configuration

IC Engine

Battery

Electric Motors

Transmission

Control Strategy

Complexity ≈ Cost, & Risk
5 Element of AVL Kaleidoscope
With Tractor to 6 Elements

Component configuration in tractor and implement – under consideration of application process

IC Engine
Transmission
Battery
Electric Motors
Control Strategy Tractor
Control Strategy Implement
Prozess
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Traction force distribution

Actual situation: Increase traction power by vehicle weight necessary (ballast)

- soil compaction due to higher weight
- wheel-soil contact area increasing
- bulldozing effect increases rolling resistance
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Traction force distribution

Countermeasure

- e-driven axle on implement (and tractor front axle)
  - increase and distribute tractive power
  - same system tractive power with lower tractor weight or higher system tractive power with same tractor weight
  - optimized vehicle slip/ fuel consumption

Benefit:
existing tractor is able to operate with lower fuel consumption or more powerful implements
Actual situation of simulation capabilities

AVL is actually capable to simulate the following effects:

- Pulling force of implements and derived power demand of engine
- Increase of traction power and ballast reduction and bulldozer effect
- Soil interaction with implement
- Fuel consumption and emission behaviour of engine
- Drivability with respect to performance and comfort related criteria

→ Tire model will be refined and adapted to embrace better agricultural tires in order to better describe slip ground contact and pulling effects in the field

=> Simulation video – tractor with plow
The Powertrain Development is organized in consecutive generations with increased maturity of the powertrain in each generation.
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Method to workout most beneficial configuration – MOBEO + MOTRAN + VSM
Involved components in power generation

- Combustion engine
- Driveline / Transmission
- E-motor / generator
- Driveline / Transmission
- Energy storage
- Power electronics
- Electrical FWD
- Exhaust aftertreatment
- Auxilaries and implements
Power Generation in tractor

Involved components in power generation

- Weight, dimensioning and product price
- Parameters
  - High Speed instead of high torque
  - High power density
  - Optimized sheet metal geometries
  - Housing, cooling, etc.

Power: 50 kW

- Weight: 30 kg
  - Diameter: 150 mm
  - rpm: 15,000

- Weight: 44 kg
  - Diameter: 300 mm
  - rpm: 7,000

- Weight: 50 kg
  - Diameter: 350 mm
  - rpm: 2,000

Source: Bosch
Source: Bosch
Source: HermeticDrive
1st rough investigation of tractor hybridization

1. Base
2. Increase load to 200Nm to charge the battery
3. Cut the Peak torque
4. Limit the torque gradient during acceleration (Ramp Torque)
5. Combination of cutting the peak torque and limit the gradient (each is compensated by 50% of work available)
### Tractor and Implement Optimization by hybridization

#### 1st rough investigation of tractor hybridization – results NRTC

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Outlook

- Process improvements applying electrification are visible creating real customer benefit
- Optimization potential of tractor applying electrification and hybridization is visible
  - Dynamic of combustion engine may be reduced resulting in lower emissions
  - Efficiency of exhaust aftertreatment is increased due to more efficient thermomanagement
  - Overall fuel consumption reduction – depending on application battery size, engine and exhaust gas after treatment concept
- Generator integration in existing tractor driveline architecture enables mid-term solutions
- MOBEO, MOTRAN and VSM is detailed simulation method to workout optimum topology, functionality and configuration for tractor, implement and its process