Hybridized manual transmissions for future market requirements

Drivetrain Forum 2016, Untergruppenbach
GETRAG FORD Transmissions, Frank Casimir,
Platform Director, Medium and Large Manual Transmissions
1. Why hybrid MT / AHT?
2. GETRAG Modular Hybrid Concept
3. CO₂ benefits vs. cost
4. Demonstrator project: 48V hybrid MT
5. Next integration step: AHT
6. Outlook: further technological enhancement
7. Summary
1. Why hybrid MT / AHT?

1.1 MT Advantages
1.2 Market Drivers for Change
1.3 Need for Flexibility
1.1 MT Advantages

Manual Transmissions combine the advantages of
• lowest weight,
• lowest cost and
• highest mechanical efficiency
1.2 Market Drivers for Change

**CO₂ – Regulation**
- Future emission legislation not achievable w/o hybrid elements (any transmission type)

**DAT – Driver Assistance Technologies**
- **Current Basic:**
  - Pre Collision Assist
  - Adaptive Cruise Control
  - Active Park Assist
- **Next Level:**
  - Traffic Jam Assist
  - ACC Stop&Go
  - Fully Assisted Parking
- **Final Level:**
  - Fully Autonomous Driving

Technical solutions required to keep MT compatible with future requirements
1.3 Need for Flexibility

Market Drivers

a) ICE will stay (!)
b) Development of hybrid market share difficult to predict (when, where, how)

⇒ Flexibility of technical concepts is required to
  − respond to market changes efficiently
  − avoid „dead-end“ solutions

Source: Alix Partners 2016
2. GETRAG Modular Hybrid Concept

2.1 Base Principles
2.2 Building Blocks
2.1 Base Principles

1. **Use Off-the-Shelf Technology**
   - Economies of scale
   - Minimized technical risk
   - Lower development cost

2. **Portability** between Transmission Architectures
   - Re-use of components and technical solutions
   - Economies of scale

3. **Integration** of Hybrid Technology into Transmission Unit
   - „Turn-key“ solution with integrated functions
   - Simplified interfaces to installation environment
   - Fully tested units ready for installation
2.2 Building Blocks

Step 1: Integration of e-Clutch systems, addressing:
- Convenience:
  - Stop-and-go
  - Launch assist, hill-hold
- Fuel saving:
  - Coasting (idle and start/stop)
- Driver assistance
  - Park assist, emergency brake,

Step 2: Integration of electric motor
- Fuel Saving:
  - Electric manoeuvring, boosting, active sailing
- Driver assistance
  - Autonomous parking

Step 3: Integration of Shift Actuation
- Convenience:
  - Full automatic shifting
- Driver assistance
  - Fully autonomous driving

Modular upgrade concept enables flexible response to market expectations
2.3. Step by Step: from MT to AHT

Modular upgrade concept can be used on all FWD MT product architectures
2.4 Fully integrated 48V hybrid MT

- Oil pump
- E-motor / inverter (shared with HDT)
- Clutch actuator
- Hybrid gear set
- Base: 6MTT215 (MX65)
- 3-way dog clutch with actuator
3. CO₂ Benefits vs. Cost
3.1 CO₂ Benefits in WLTP

MT + 11KW PSM + 577Wh Battery

<table>
<thead>
<tr>
<th>NEDC savings</th>
<th>WLTP savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 %</td>
<td>12 - 15 %</td>
</tr>
</tbody>
</table>

P3: E-Motor @ TM output
3.2 Cost vs. CO₂ Benefits

- DMF, Clutch, Master Cyl, Pedal
- 48V Hybrid Package
- Shift Actuation
- Clutch Actuator
- Base Transmission

**Base MT**
- MT
- MT e-clutch
- MT Hybrid 48V
- AHT 48V

**CO₂ Saving [%]**
- 4-6%
- 12 - 15%
- 12 - 15%
- 11-14%

**e-clutch**
- Shift Actuator
- e-Motor + Inverter
- e-Motor + Inverter + Reduction Drive

**e-Motor**
- Reduction Drive
- Ideal Automatic Transmission for comparison

**Automatic Transmission**
- Base AT

**Hybrid Autotrans 48V**
- Base AT

*) With S/S Coasting (Sailing)
4. GETRAG HMT Demonstrator Project
4.1 Project Description - Transmission

**Features**

**Package**  
B-car-compatible (e.g. Ford Fiesta)

**CO2 savings**  
Simulation for Fiesta & Fox engine:  
NEDC: ~22%  
WLTP: 12%

**DAT features**  
electric parking (auto FWD/REV with up to 1500Nm)

electric maneuvering, stop&go driving

---

<table>
<thead>
<tr>
<th></th>
<th>HMT65 - design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base TM</td>
<td>GFT MX65, 6-speed</td>
</tr>
<tr>
<td>Electric machine</td>
<td>48V, 13.5kW, c/o 7DHT300</td>
</tr>
<tr>
<td>Inverter</td>
<td>48V, 13.5kW, c/o 7DHT300</td>
</tr>
<tr>
<td>EM coupling</td>
<td>P3; ratios 10, 26 or decoupled</td>
</tr>
<tr>
<td>EM cooling</td>
<td>Electric oil pump</td>
</tr>
<tr>
<td>Clutch actuator</td>
<td>eHCC</td>
</tr>
</tbody>
</table>
4.2 Kinematic Arrangement
4.3 System Configuration
5. Next Integration Step: AHT
(Automated Hybrid Transmission)
5.1 Next Step: Adding Shift Actuation

- **Description**
  - Eliminate internal shifter and replace by electromagnetically actuated *shift drum*.
  - Modularity principle: Use of platform *part modules* from 3rd generation DCT platform.

Step from HMT to AHT supports market trend to autonomous driving.
5.2 Gear Shift Quality of AHT

Required:
No torque interruption during shifting!
5.2 Gear Shift Quality of AHT

**Required:**
No torque interruption during shifting!

**Solution:**
E-motor provides torque support during gear shift.

**Result:**
Good shift quality
6. Outlook:
Future Technical Enhancement
6. High Voltage Hybrid

<table>
<thead>
<tr>
<th>Machine Type</th>
<th>48V</th>
<th>320V DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Operational Speed</td>
<td>18,000 rpm</td>
<td>18,000 rpm</td>
</tr>
<tr>
<td>Edge Speed</td>
<td>3,000 rpm</td>
<td>6,000 rpm</td>
</tr>
<tr>
<td>Peak Torque @ Edge Speed</td>
<td>55 Nm</td>
<td>101 Nm</td>
</tr>
<tr>
<td>Cont. Torque @ Edge Speed</td>
<td>36 Nm</td>
<td>--</td>
</tr>
<tr>
<td>Peak Power (motoring)</td>
<td>12.6 kW</td>
<td>65 kW</td>
</tr>
<tr>
<td>Peak Power (generating)</td>
<td>13.5 kW</td>
<td>--</td>
</tr>
<tr>
<td>Peak Power @ Maximum Speed</td>
<td>11 kW</td>
<td>62 kW</td>
</tr>
<tr>
<td>Continuous Power</td>
<td>8 kW</td>
<td>&gt; 40kW</td>
</tr>
<tr>
<td>Length/Diameter (active) [mm]</td>
<td>67 / 150</td>
<td>Stator: 65 / 155</td>
</tr>
<tr>
<td>Inertia</td>
<td>5630 kgmm²</td>
<td>5100 kgmm²</td>
</tr>
<tr>
<td>Weight</td>
<td>12.5 kg</td>
<td>--</td>
</tr>
</tbody>
</table>

Package compatible e-motor options for 48V and 320V – modularity also for Voltage upgrade
7. Summary
Hybrid MT with integrated e-motor

- maintain weight and cost advantage of manual transmissions
- offer significant CO₂ benefits
- secure compatibility with current and future driver assistance functions

Utilizing the GETRAG Modular Hybrid Concept offers

- early technical maturity
- economies of scale through combined volumes
- a flexible platform for enhancing the scope of hybridization and driver assistance

The first GETRAG demonstrator with 48V hybrid MT is planned for Q3 2017
THANK YOU FOR YOUR ATTENTION
DRIVETRAIN FORUM 2016