Vectron’s extra mile
Contents

- From the wording "extra mile" to the definition of the input variables
- From the basic design to its technological implementation
- Verification under real operating conditions
- News
What is the "extra mile"?

1. Moving whole trains at intermodal terminals
What is the "extra mile"?

Hamburg Billwerder (western end) intermodal terminal
What is the "extra mile"?

1. Moving whole trains at intermodal terminals
2. Moving locomotives at system-switching stations
3. Driving on non-electrified track sections as part of transfer or shunting operations
Example of a transfer operation
Parameters for driving the "extra mile"

Infrastructure parameters:
1. Intermodal terminals: max. gradient 1.5 - 2.5‰.
2. Railway sidings: short sections with max. gradient 40‰.

Operating parameters:
1. Max. permissible train length 700 m (max. track length 750 m)
2. Max. permissible shunting speed 25 km/h (if "route clear" announced, then 40 km/h)
3. Minimum speed is not defined, but appropriate clearance times must be observed
Design requirements

1. Maximum possible tractive effort at wheel rim required only in lower speed range (on start-up)

2. Max. speed of 40 km/h with sufficient tractive effort at wheel rim for light hauled loads

3. Retention of the Vectron platform concept with full modularity and retrofitting capability

Efficient utilization of available engine power
Principles of drive dynamics

Influencing factors for optimum implementation of the equation of motion:

\[ P = F \times v \]

\[ P = (F_w + F_h) \times \frac{s}{t} \]

- Train resistance force
- Downhill-slope force

Is determined by:

- Operating requirements
- Appropriate clearance time
Verification of "train resistance" in the lower speed range

Task:
1. Determination of breakaway behaviour
2. Behaviour at points
3. Driving on curves and reverse curves

Procedure:
1. Measurements in a station with suitable station gridiron and departure tracks with subsequent curves
2. Software-based adjustment of the power of a ES64U4 to 60 kW and 120 kW at the wheel rim
3. Variation of hauled loads with 26 open Eaos freight cars (Total load in increments from 350 t up to 1,415 t)
Result of verification of "train resistance" in the lower speed range

Results: Train resistance - speed curve
Influencing variables for the design of the DPM

Integration of the DPM in the modular locomotive concept

Vectron AC

Vectron DC
Input variables for the design

- Integration of max. possible output power
- Autonomous frame with all components needed for operation
- Supply air / exhaust air and exhaust gas routing via the roof
- Electrical connections and fuel supply from below
- Maintenance from machine room aisle
- Weight max. 1,400 kg.
- Retrofitting capability
Thermal analysis

\[ P_{\text{therm.}} = P_{\text{combustion engine}} + P_{\text{exhaust gas}} + P_{\text{cooling}} \]

\[ P_{\text{elec.}} = P_{\text{combustion engine}} - P_{\text{power take-off (fans, etc.)}} - P_{\text{elec. loss}} \]

→ \( P_{\text{therm.}} \approx 3.4 \times P_{\text{elec.}} \)

→ **540 kW** has to be processed thermally for 160 kW electric power

→ **180 kW** combustion-engine power produces 160 kW electric power
Modular basic engine as starting point

Modular basic engine concept + High packaging density of special applications =

Integrated engine-alternator unit for stage IIIB with cooled high-pressure EGR and DPF

© Siemens AG 2016 All rights reserved.
Result and key data

- **Power:** 180 kW
- Two output voltages from the same hardware:
  - 1.8 / 3.6 kV DC
- Integrated preheating concept:
  - Maximization of availability
  - Minimization of time to full load acceptance
- Exhaust gas requirements:
  - Stage IIIB (EGR, DPF)
- Power density:
  - 86.54 kW/m³
- Power-to-weight ratio
  - 7.77 kg/kW

Steyr Motors test facility
Theoretical review of performance

- High surplus of tractive effort in the start-up range
- Rapid achievement of shunting speed when moving the locomotive alone
- Appropriate clearance time with normal hauled loads

Complete tractive effort - speed curve with one DPM

<table>
<thead>
<tr>
<th>Tractive effort [kN]</th>
<th>Speed [km/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x Vectron + mixed freight trains, container trains, 400 t, 0 ‰</td>
<td></td>
</tr>
<tr>
<td>1 x Vectron + mixed freight trains, container trains, 1000 t, 0 ‰</td>
<td></td>
</tr>
<tr>
<td>1 x Vectron + mixed freight trains, container trains, 1400 t, 0 ‰</td>
<td></td>
</tr>
<tr>
<td>1 x Vectron + mixed freight trains, container trains, 1200 t, 2 ‰</td>
<td></td>
</tr>
</tbody>
</table>
Practical review of performance

Transfer operation with fully laden tank-car train

Shunting operation with heavy iron-ore train for voestalpine Stahl GmbH

Test runs with 1,000 t coal train
Thanks to its modularity, Vectron provides the option of integrating an additional DPM in AC locomotives

- Based on the design of locomotives for VR in Finland

- Power cascading, i.e. 0 / 1 / 2 DPM possible

=> Maximum flexibility and long-term adaptability for current and future transport tasks!
News
Integration of two DPM in the Vectron AC

Technical data:
• Diesel engine power: 2 x 180 kW
• Power at wheel rim: up to 260 kW
• One or two DPM with almost exactly the same locomotive weight (active ballasting)
Rent a DPM: … Modularity taken to the next logical level
The innovative "Rent a DPM" concept offers numerous benefits

**Maximal flexibility - Changes in general conditions**
- Short-term servicing of new / temporary transport orders which require operation on non-electrified sections of track
- Termination of shunting activity by existing service provider

**Minimal investment - cost optimization**
- Reduced investment in purchase of locomotives
- Financing of functionality from current operations possible

**Optimal reliability -**
- Full-service package: Preventive and corrective maintenance included
- Benefits due to optimum maintenance intervals, expert maintenance personnel and central Siemens spare parts stock
Rent a DPM includes:

- 1 or 2 diesel power module(s) including tank
- Installation and removal, including commissioning
- Preventive and corrective maintenance

⇒ Full service
Thank you for your attention