Lowland Cable Yarder in Four Different Process Variants

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Outline

- Background
- Specific description of the lowland cable yarder
- Study area
- Preliminary results of field studies
  - Ergonomics
  - Productivity
  - Machine costs
  - Catenary sag
- Outlook: Possible harvesting systems
- Summary
Background

- Forest on wet (T4) or watery land (T5) account for 12% of European forest area
- Driving on those soils is not recommended due to irreversible soil disturbances or simply it’s impossible
- The importance of those problematic sites will increase with shorter freezing periods and warmer winters
- In consequence, large forest areas will be taken out of management additionally

Approach

- Felling operations might be possible by motor-manual work or mechanized work with driving only once on the sites
- Yarding operations might be possible with cable yarders
- No cable yarding technology existing for short logs
Machine Specification of Lowland Cable Yarder

- Yarding of short logs in bundles
- Hover transport of logs without touching the ground
- Acting without saddle trees up to 350 m
- Skyline up to 16.0 m height
- Mechanical dead-end tower
Machine Specification of Lowland Cable Yarder

- Mechanical dead-end tower, of 16.0 m height
- Carriage with 2 winches with synthetic fiber ropes
- Easy choker system for stacks

Picture: Engler/ Pilz, 2015
# Study Area

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Lübben 1</th>
<th>Lübben 2</th>
<th>Daubaner Wald</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brandenburg, Germany</td>
<td>Brandenburg, Germany</td>
<td>Sachsen, Germany</td>
</tr>
<tr>
<td>Pinus</td>
<td>Alnus</td>
<td>Pinus</td>
<td></td>
</tr>
<tr>
<td>Cable lines</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Max yarding distance [m]</td>
<td>( T_2 160 )</td>
<td>( T_1 180 )</td>
<td>( T_1 250 ) ( T_2 320 )</td>
</tr>
<tr>
<td>Felling operations</td>
<td>Harvester</td>
<td>Chainsaw</td>
<td>Harvester</td>
</tr>
<tr>
<td>Log distribution (stack)</td>
<td>at cable line</td>
<td>between lines</td>
<td>at cable line</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Element time study</th>
<th>Time study; day notes</th>
<th>Time study; day notes</th>
</tr>
</thead>
</table>
Methodology

- Single tree
  - Position: Distance; angle from cable line
  - DBH
  - Damage
- Traverse line of cable line
- Mean diameter and # of logs per stack
- Element time study
Pre-Results Ergonomics

- OWAS studies are currently running*
- First results tend to show short, but large stress levels
  - Approx. 80% of low degree of stresses
    1. straight back
    1. both arms below shoulder level
    2. standing on two straight legs
    1. < 10 kg load
  - Approx. 20% of high degree of stresses
    2. or 4. bent or bent and twisted back
    1. both arms below shoulder level
    4. or 6. squatting or kneeling
    2. 10 – 20 kg load

* Data from Pilz, 2015; Picture: Engler, 2015
Pre-Results Productivity, Only Yarding**

<table>
<thead>
<tr>
<th></th>
<th>Lübben 1 Brandenburg, Germany</th>
<th>Lübben 2 Brandenburg, Germany</th>
<th>Daubaner Wald Sachsen, Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td># cycles</td>
<td>61</td>
<td>68</td>
<td>63</td>
</tr>
<tr>
<td>Max yarding distance [m]</td>
<td>(T_2 \times 160)</td>
<td>(T_1 \times 180)</td>
<td>(T_1 \times 250) (T_2 \times 320)</td>
</tr>
<tr>
<td>Log diameter* [cm o.b.]</td>
<td>13.3</td>
<td>17.7</td>
<td>24.4</td>
</tr>
<tr>
<td>Log volume* [m³]</td>
<td>0.0432</td>
<td>0.0778</td>
<td>0.1871</td>
</tr>
<tr>
<td>Volume/ cycle* [m³/ cycle]</td>
<td>0.4304</td>
<td><strong>0.5347</strong></td>
<td><strong>0.7853</strong></td>
</tr>
<tr>
<td>Cycle time* [min/ cycle]</td>
<td>7.67</td>
<td>7.40</td>
<td>5.86</td>
</tr>
<tr>
<td>Productivity* [m³/ pmh₀]</td>
<td>3.35</td>
<td>4.30</td>
<td>8.32</td>
</tr>
</tbody>
</table>

* arithmetic mean
** logs were piled at cable line; lateral yarding was excluded from calculations

Data Lübben 1: Engler, 2015
Data Lübben 2 and Daubaner Wald: Pilz, 2015
Time Demand for Elements

- Empty run shares 7.8 – 10.5 %, and load run shares 9.5 – 12.7 % of total productive time.
- Spooling-out and chokering is time demanding, 40.7 – 43.6 %, – adequate stacks required.
- Influence of driving distance on system productivity seems to be minor.

**Time consumption per work elements**

(T1: Stack vol. 0.40 m³ o.b.; mass 352.1 kg; T2: stack vol. 0.67 m³ o.b.; mass 590.9 kg)

Data Lübben 1: Engler, 2015
Cycle Volume and Productivity

- Carried volume per cycle is strongly correlated with productivity
- It seems to be a larger influence factor than yarding distance
- Max carrying capacity is 1 t, about 1 m³

Data Lübben 1: Engler, 2015  Data Lübben 2 and Daubaner Wald: Pilz, 2015
Pre-Cost Calculation

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition costs</td>
<td>230,000 Euro</td>
</tr>
<tr>
<td>Amortization</td>
<td>17,000 pmh$_{15}$/ 15 years</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>5 l/ pmh$_{15}$</td>
</tr>
<tr>
<td>Fuel costs</td>
<td>1.4 Euro/l</td>
</tr>
<tr>
<td>Interest rate</td>
<td>8.0 %</td>
</tr>
<tr>
<td>Operator costs per person</td>
<td>31.0 Euro/pmh$_{15}$</td>
</tr>
<tr>
<td>∑ Material costs</td>
<td>82.1 Euro/pmh$_{15}$</td>
</tr>
<tr>
<td>∑ Personnel costs</td>
<td>62.0 Euro/pmh$_{15}$</td>
</tr>
<tr>
<td>∑ Operation costs</td>
<td>144.1 Euro/pmh$_{15}$</td>
</tr>
</tbody>
</table>

Cost calculation according to KWF
Pre-Cost Calculation

- System costs vary depending on
  - The productivity and cost of the harvester (188.1 EUR/ pmh_{15})
  - The productivity of the cable yarder itself
  - Volume of harvested biomass per running meter
- Costs in a range between 50.0 to 75.0 EUR/ m^3 o.b. seems to be realistic
Catenary Sag

- At the maximum catenary sag the distance to the ground was still approx. 15 m at a yarding distance of 180 m.

Diagramm: Knobloch, 2015
Outlook: Possible harvesting systems

Stand characteristics

good for harvester

not for harvester

1. Processing: harvester
   Hauling: harvester
   Yarding: flat lift

2. Processing: Chainsaw
   Hauling: tractor
   Yarding: flat lift

3. Processing: Chainsaw
   Hauling: portal harvester
   Yarding: flat lift

4. Processing: portal harvester
   Hauling: portal harvester
   Yarding: flat lift

Soil characteristics

T3: sensible, but in limits trafficable

T4 or T5: not trafficable

Diagramm: Erler, 2015
Outlook

T4 or T5: not trafficable

T3: sensible, but in limits trafficable

soil characteristics

Processing:
- 4: portal harvester
- 3: Chainsaw

Hauling:
- 4: portal harvester
- 3: flat lift

Yarding:
- 4: flat lift
- 3: flat lift

Diagramm: Erler, 2015
Summary

- The lowland cable yarder ‘flat lift‘ works fine (!)

- Technology enables forest work on forest land where access was prior impossible (or only with irreversible damage)

- Soil damages are limited to a minimum

- Avoiding of tree damages by short logs

- Yarding can be combined with standard harvester processing, due to short logs

- Short log yarding is in line with forest certification schemes

- Productivity is in range of 5 – 8 m³/ pmh₀

- Costs range about 50.0 to 75.0 EUR/ pmh₁₅ incl. setting up and dismounting the towers and the skyline
References