Multi-layer drum winches within subsea hoisting cranes

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Fibre rope in multi-layer winding

A good idea?

No

Yes
**Contents**

- Introduction
- Important rope properties for multi-layer winding
- Rope elasticity's
- Rope deformation and winding pack
- Selection of rope diameter
- Conclusion

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FörderTechnik
Lippmann German Ropes
Dyneema® HAMPI-DJAN

on the basis of a decision by the German Bundestag

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Introduction

- Trends in the use of running ropes
  - Demand for large rope length
  - Lightweight design
- Implications form these trends
  - Use of high performance fibre (HPF) ropes in running rope applications
  - Lightweight drum design
  - Design a safe system of fibre rope and drum

**Design strategies for fibre rope application**

- **Option 1:** Design a system of HPF rope and drum
  - HPF rope selection suitable to the application
  - Drum adjustment referring to HPF rope
  - Optimised system – more expensive option

- **Option 2:** Replacement of wire ropes with HPF ropes (on wire rope drum)
  - HPF rope selection suitable to the application
  - HPF rope selection suitable to the drum
  - Cheaper option – more difficult rope selection
# Rope properties and their influence on the drum

<table>
<thead>
<tr>
<th></th>
<th>Wire rope</th>
<th>Fibre rope</th>
<th>Influence on the drum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lateral stiffness</strong></td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Influence" /></td>
</tr>
<tr>
<td><strong>Friction</strong></td>
<td><img src="image4.png" alt="Friction" /></td>
<td><img src="image5.png" alt="Friction" /></td>
<td><img src="image3.png" alt="Influence" /></td>
</tr>
<tr>
<td><strong>Deformation</strong></td>
<td><img src="image6.png" alt="Deformation" /></td>
<td><img src="image7.png" alt="Deformation" /></td>
<td><img src="image3.png" alt="Influence" /></td>
</tr>
</tbody>
</table>
Load reducing effect in multilayer winding

$$\Delta F_{sk} = p_r \cdot \frac{\sqrt{\frac{\pi}{4} \cdot d_{max} \cdot d_{min} \cdot f_{tex}}}{2 \cdot r_m} \cdot \frac{E_{SL}}{E_{SQ}} \cdot A_{tex}$$

- Rope deformation
- Winding radius
- Rope elasticity
## Ropes

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>d in mm</th>
<th>Material</th>
<th>Construction</th>
<th>Core</th>
<th>Cover-braid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DynIce Warp</td>
<td>22</td>
<td>Dyneema SK 75</td>
<td>12 strand braided, heat stretched</td>
<td>Polyethylene</td>
<td>Dyneema</td>
</tr>
<tr>
<td>2</td>
<td>DynIce Dux</td>
<td>23</td>
<td>Dyneema</td>
<td>12 strand braided, heat stretched</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Eurolift²</td>
<td>23</td>
<td>wire</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


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Rope elasticity's

Lateral elasticity $E_{SQ}$

![Graph showing lateral elasticity $E_{SQ}$ with values 640, 231, and 1577 for rope numbers 1, 2, and 3, respectively.]

Longitudinal elasticity $E_{SL}$

![Graph showing longitudinal elasticity $E_{SL}$ with values 39, 54, and 112 for rope numbers 1, 2, and 3, respectively.]

Ratio longitudinal to lateral elasticity

$$\Delta F_{sk} = \frac{p_r \cdot \sqrt{\frac{\pi}{4} \cdot d_{\text{max}} \cdot d_{\text{min}} \cdot f_{\text{tex}}}}{2 \cdot r_m} \cdot \frac{E_{SL}}{E_{SQ}} \cdot A_{\text{tex}}$$

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Multi-layer drum

- Drum
- Grooving system (Lebus-grooving)

Flanges
Drum barrel
Coil

Parallel section 1  CS 1  PS 2  Cross section 2

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Rope deformation

- Scanner configuration
- Compiled rope cross section
- Measurement
  - Find $d_{\text{min}}$ and $d_{\text{max}}$
  - Related circularity

\[ R_{rel} = \frac{d_{\text{min}}}{d_{\text{max}}} \]
Rope deformation

- Cross section rope 1
- Cross section rope 2

Core and cover-braid: $R_{rel} = 0.93$

No core and cover-braid: $R_{rel} = 0.81$
Winding pack

- Scanner configuration
- Compiled winding pack
Winding pack

- Winding pack rope 1
- Winding pack rope 2

Core and cover-braid: $R_{rel} = 0.93$

No core and cover-braid: $R_{rel} = 0.81$
Winding pack

- Winding pack rope 1
- Winding pack rope 2

Core and cover-braid: $R_{rel} = 0.93$

No core and cover-braid: $R_{rel} = 0.81$
**Selection of rope diameter**

- Minimum breaking load
- Rope fits best into groove \( (e = 1.05 \cdot d_{\text{nom}}) \)

<table>
<thead>
<tr>
<th>( R_{\text{rel}} )</th>
<th>( R_{\text{rel}} = 1 )</th>
<th>( R_{\text{rel}} = 0.9 )</th>
<th>( R_{\text{rel}} = 0.8 )</th>
<th>( R_{\text{rel}} = 0.7 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( d_{\text{nom}} ) (mm)</td>
<td>23.00</td>
<td>23.00</td>
<td>23.00</td>
<td>23.00</td>
</tr>
<tr>
<td>( d_{\text{nom}} ) (mm)</td>
<td>23.00</td>
<td>22.69</td>
<td>21.39</td>
<td>20.01</td>
</tr>
<tr>
<td>( R_{\text{rel}} )</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
</tr>
</tbody>
</table>

\[ R_{\text{rel}} = \frac{d_{\text{min}}}{d_{\text{max}}} \]
Selection of rope diameter

- Simplified test to determine the deformation:
  \[ R_{rel} = \frac{d_{\text{min}}}{d_{\text{max}}} \]
  
  - Relevant longitudinal force
  - Lateral force as on rope drum
  - Measure rope deformation

![Diagram of rope deformation and forces](image-url)
Option 1: Design a system of HPF rope and drum

Adjust the drum surface to the deformed HPF rope

- Shape of grooving
- Filling bars at the flanges
- Leave some space in the cross section area
Comparison of design options

Option?

Option 2:
- Rope 1
- Rope 2

Option 1:
Conclusion

- Ratio of elasticity’s of HPF rope can be similar to wire rope
- Deformation of rope cross section must be taken into account for options 1 and 2
  - perform a simplified test or a spooling test
- The goal should be option 1: Design a system of HPF rope and drum

Wire rope like HPF rope

Adjusted drum surface