

Potentials of Thermosetting for Increasing the Strength of HMPE Fiber ropes

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Outline:

1. Motivation
2. Samples and testing parameters
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1. Motivation

- Thermosetting is well known in modern rope making for increasing strength of Dyneema® ropes
- Parameters for thermosetting of ropes made from Dyneema® fibers known and published
- Parameters for thermosetting of other HMPE fiber (e.g. Spectra® or Asian types) NOT published
- Several requests on parameters for thermosetting of 'non-European HMPE' ropes

→ comparative investigations on thermosetting of various HMPE fibers

2. Samples and testing parameters

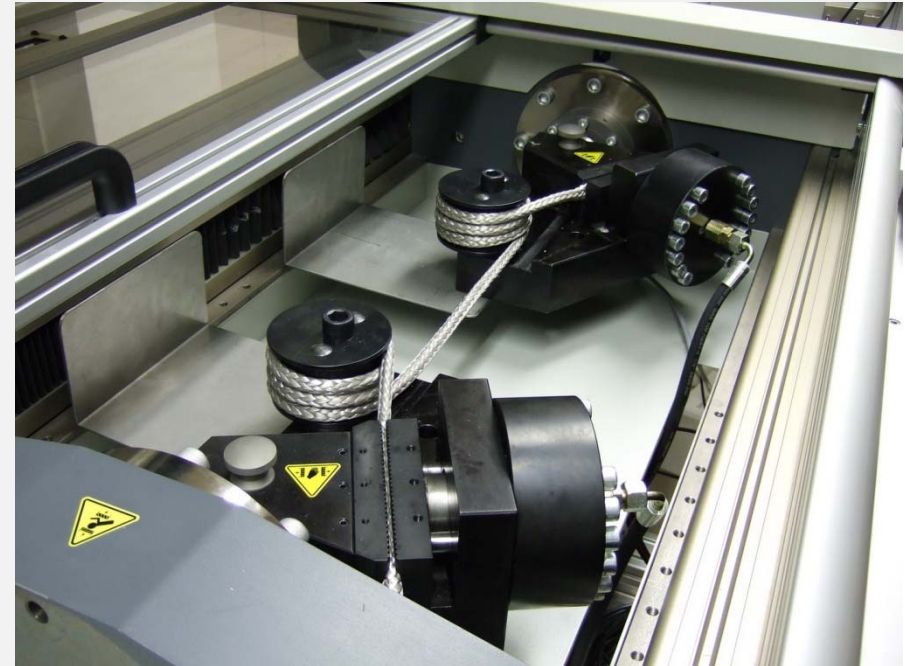
Rope samples

- Four different HMPE fibers:
 - Dyneema[®] SK75 by DSM Dyneema; 1760 dtex
 - Spectra[®] S1000 by Honeywell; 1778 dtex
 - TNX[®] by unknown Chinese manufacturer; 1780 dtex
 - Eosten[®] FT093 by EOS 3 s.r.l., Italy / Beijing Tongyizhong, China; 1760 dtex
- Rope design:
 - 7 yarns twisted at 25/m to form 1 strand
 - 12-strand braided rope with braid length of 39 mm
 - nominal rope diameter: 6 mm

2. Samples and testing parameters

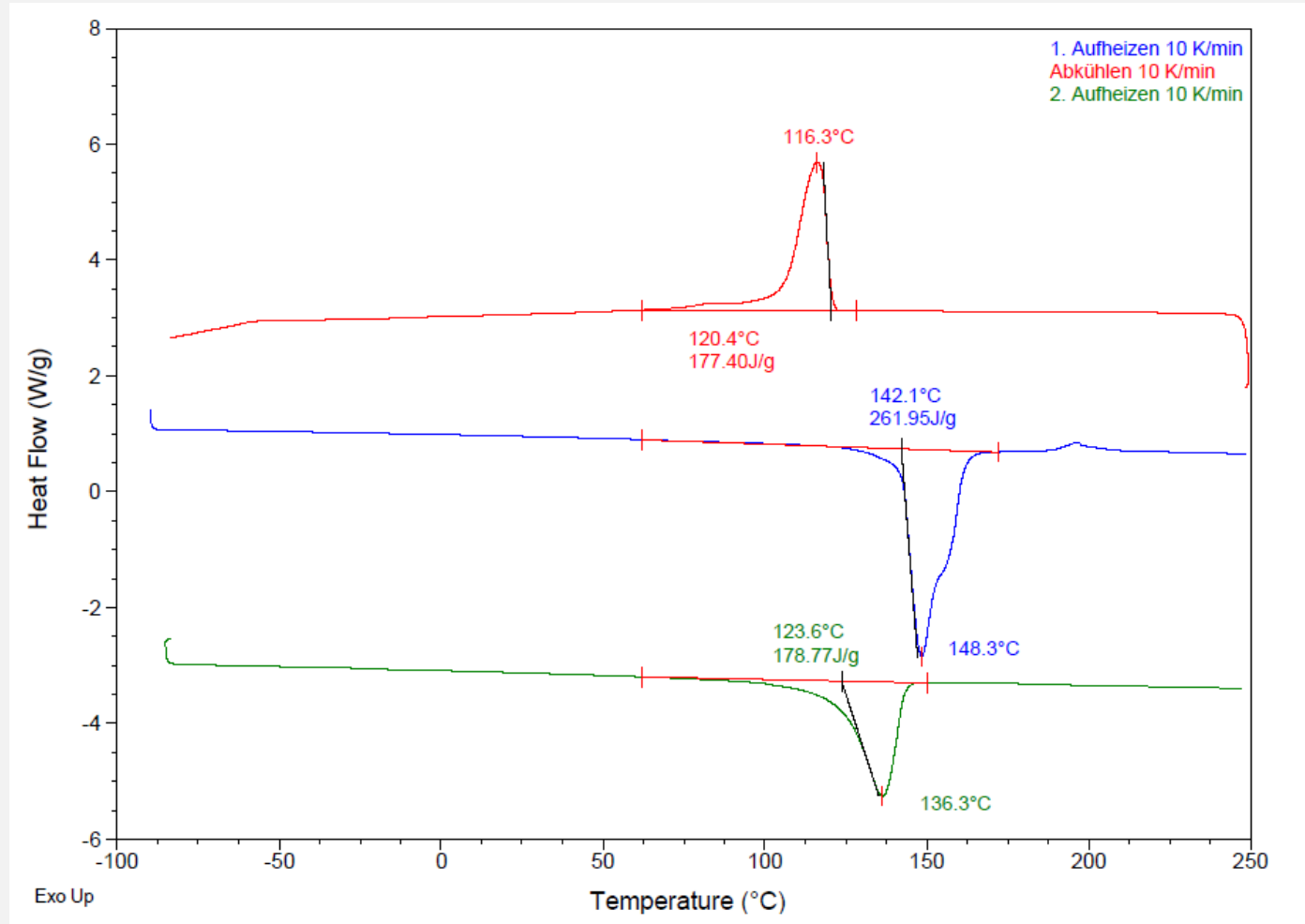
Rope samples

- Mean Break Load of the rope samples:
 - Dyneema[®] SK75: 28700 N (2926 kg)
 - Spectra[®] S1000: 31100 N (3170 kg)
 - TNX[®] : 27800 N (2834 kg)
 - Eosten[®] FT093 : 29100 N (2966 kg)
- Melting Peak (yarns) at DSC analysis:
 - Dyneema[®] SK75: 148.3°C
 - Spectra[®] S1000: 147.7°C, smaller second peak at about 157°C
 - TNX[®] : 146.8°C, second peak at 156.3°C, third peak at 160°C
 - Eosten[®] FT093 : 149.5°C



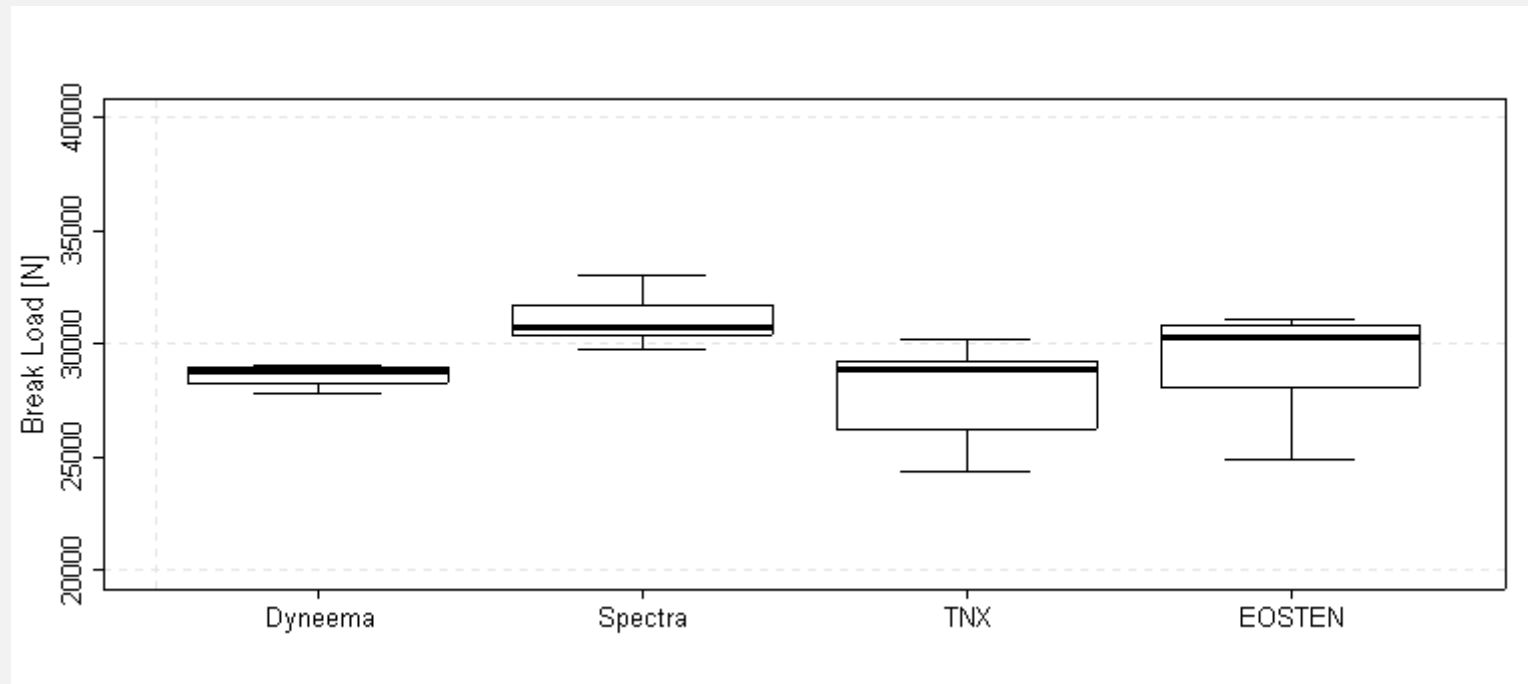
2. Samples and testing parameters

Rope samples



2. Samples and testing parameters

Rope samples



2. Samples and testing parameters

Thermosetting process

- Thermosetting of fiber ropes is simple process:
 - rope loaded with tensile load
 - rope heated up to a material-dependent temperature, while kept under load
 - rope kept under load and temperature for a special time
 - rope cooled down below critical temperature (material-dependent)
 - tensile load released
- Parameters with influence on results:
 - Tensile load (%MBL) during thermosetting
 - Temperature
 - Dwell time

2. Samples and testing parameters

Thermosetting machinery

- Rope Liner I by MAGEBA Textilmaschinen GmbH & Co. KG, Germany
- Machinery for coating and thermosetting of fiber ropes
- Customized machine for laboratory used at Chemnitz University
- Max. thermosetting load: 3000 kg
- Max. temperature: 250°C
- Max. rope speed: 5 m/min

2. Samples and testing parameters

Thermosetting machinery



2. Samples and testing parameters

Thermosetting parameters

- Thermosetting temperatures varied between 130°C and 150°C in steps of 5 Kelvin
- Thermosetting load at 12% of the ropes' mean break load:
 - Dyneema[®] SK75: 350 kg
 - Spectra[®] S1000: 380 kg
 - TNX[®]: 340 kg
 - Eosten FT093[®]: 370 kg
- Thermosetting speed: 2.5 m/min → dwell time: 3 min after heating rope through to core

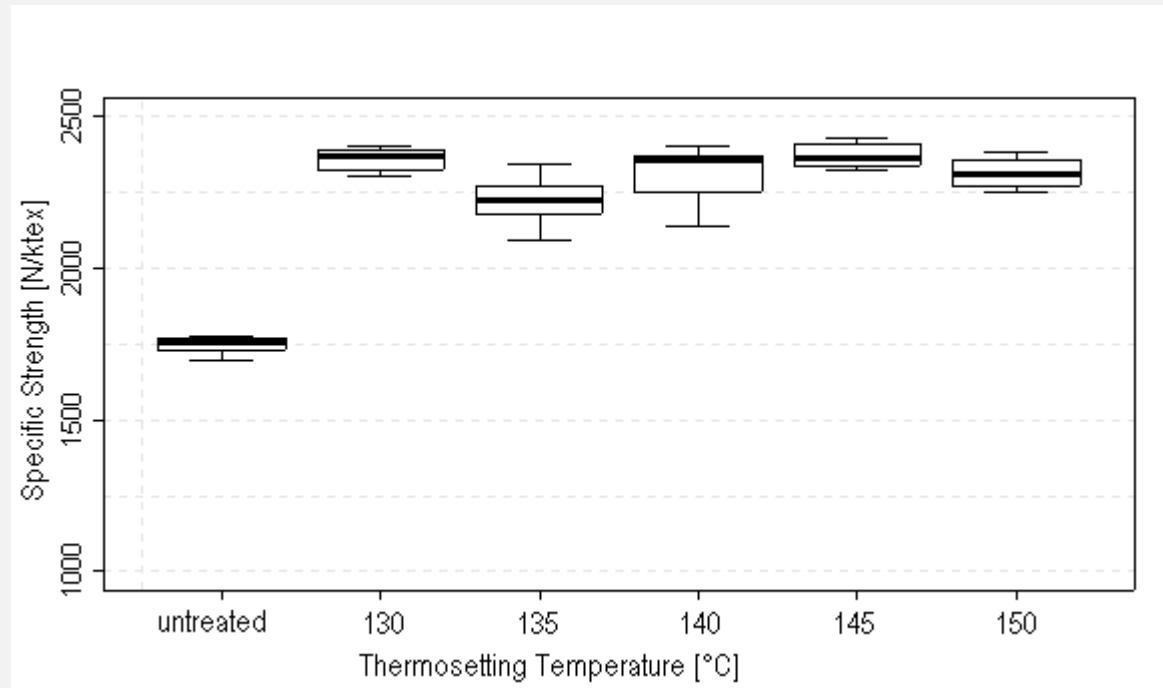
3. Results

Dyneema® SK75:

- Highest specific strength (N/ktex) after thermosetting at 130°C and 145°C
- Increase of specific strength is about 35% compared to untreated state
- Decrease of diameter (about 10%) and increase of braid pitch (about 15%) after thermosetting at 145°C

3. Results

Dyneema® SK75:



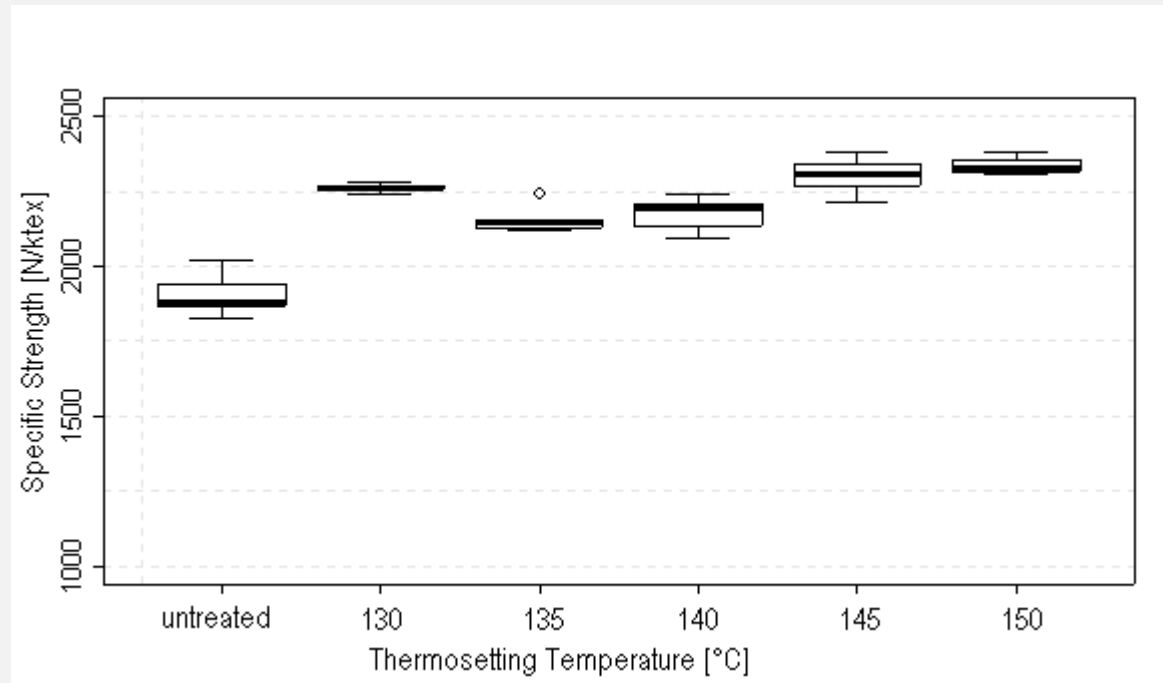
3. Results

Spectra[®] S1000:

- Highest specific strength after thermosetting at 150°C
- Increase of specific strength is about 25% compared to untreated state
- Decrease of diameter and increase of braid pitch
- Ropes made from Dyneema[®] SK75 and Spectra[®] S1000 at same level after thermosetting

3. Results

Spectra® S1000:



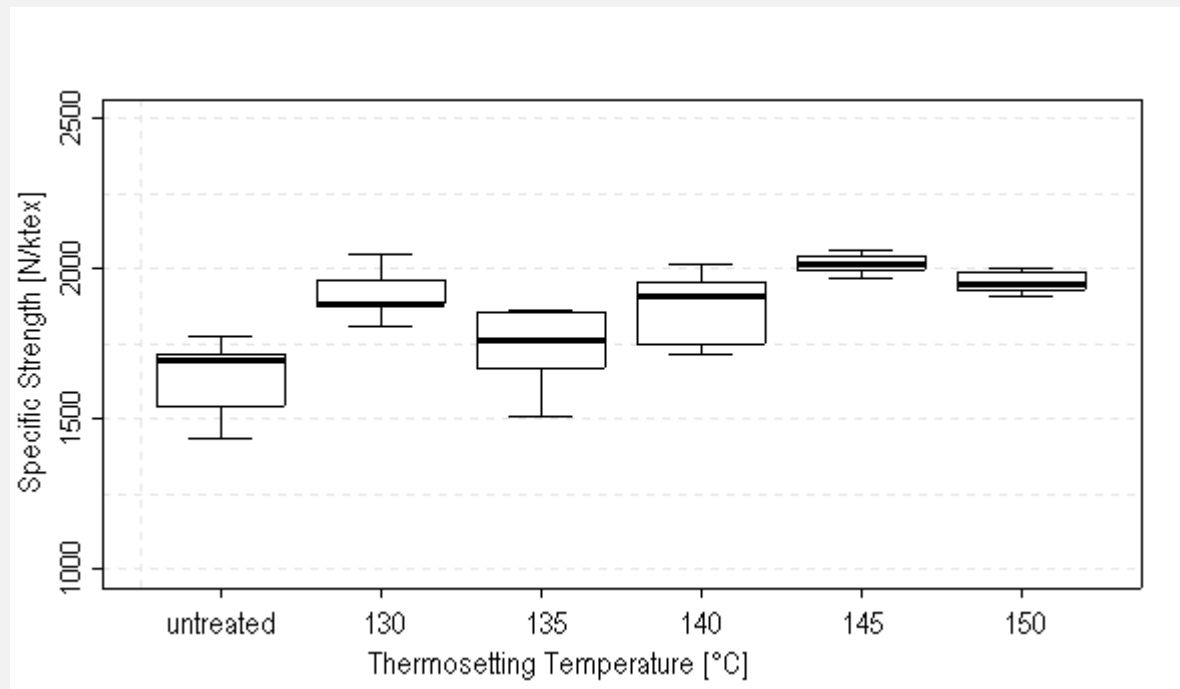
3. Results

TNX[®]:

- Highest specific strength after thermosetting at 145°C
- Increase of specific strength is about 23% compared to untreated state
- Decrease of diameter and increase of braid pitch
- After thermosetting just slightly better than untreated Spectra[®] S1000

3. Results

TNX®:



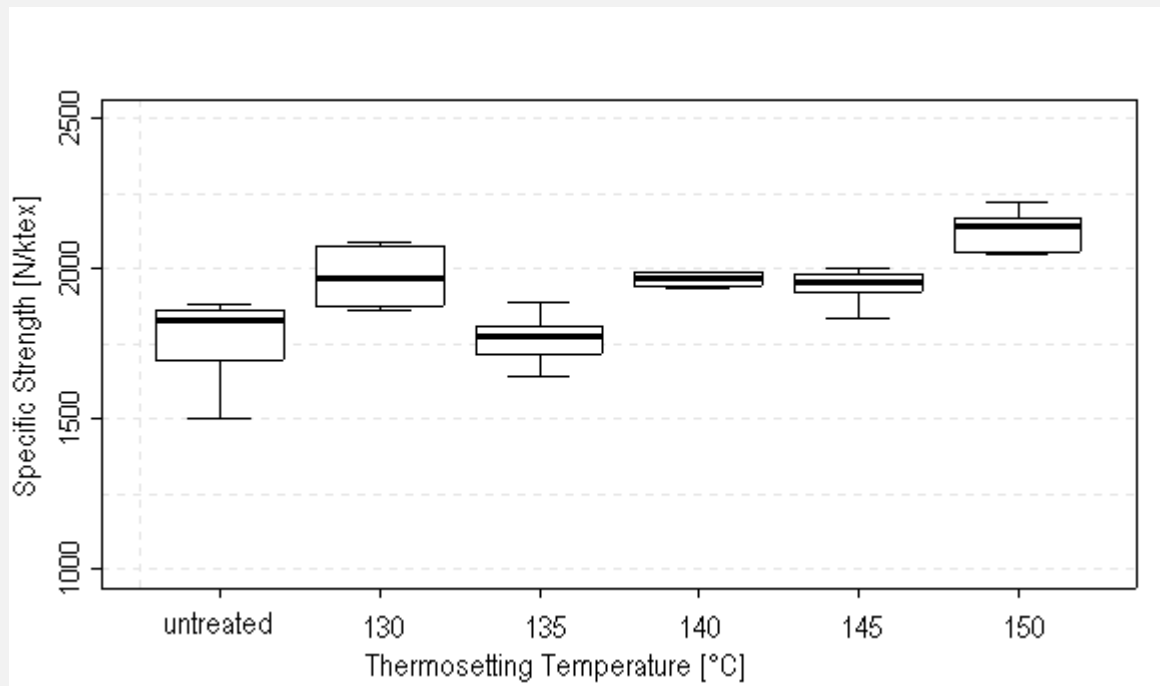
3. Results

Eosten[®] FT093:

- Highest specific strength after thermosetting at 150°C
- Increase of specific strength is about 25% compared to untreated state
- Decrease of diameter and increase of braid pitch
- After thermosetting better than TNX[®] but not as good as Dyneema[®] Sk75 and Spectra[®] S1000

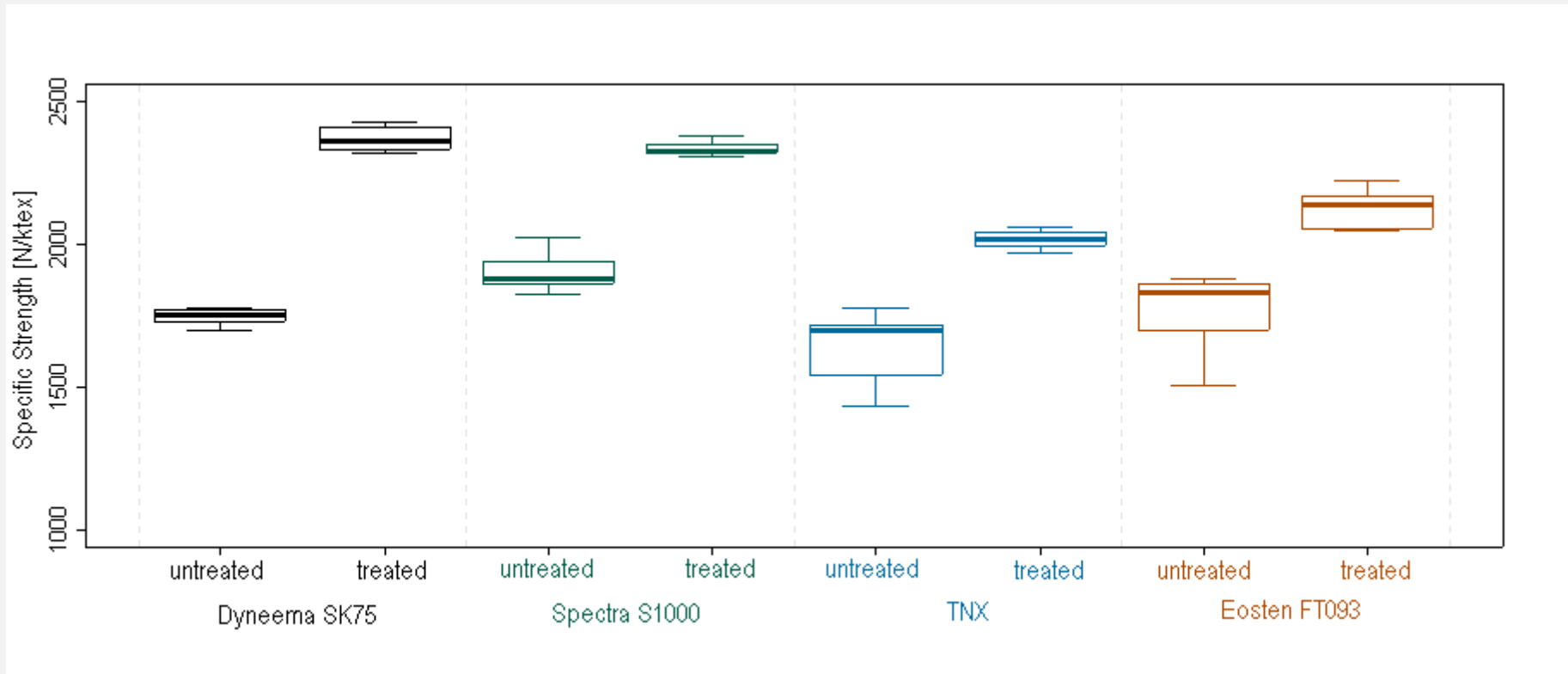
3. Results

Eosten® FT093:



3. Results

Overview on all fibers:



4. Conclusions

- Thermosetting at 130°C provides good results in increasing the strength of HMPE fiber ropes
- Optimal temperatures are varying within the HMPE fibers
- Max. increase in strength is varying within the HMPE fibers
- Investigating the optimal temperature for a special HMPE fiber is recommended

5. Outlook

- Further tests on other HMPE fibers (e.g. MirAcle[®] /Korea, Trevo[®] 70 by ICD/China, ...)
- Investigation on varying thermosetting loads for all the fibers (already published for Dyneema[®] SK75)
- Investigation on varying dwell time for all the fibers (already known for Dyneema[®] SK75)
- Investigation on CBOS performance of ropes after thermosetting (partly known for Dyneema[®] SK75)

Thank you very much for your attention.

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special thanks to:

