MODELLING WEFT KNITTING FOR COMPOSITE PRE-FORMS

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Content

- Introduction
- Objective
- Experiments
- Model
- Results and discussion
- Future steps
- Summary and Conclusion

Introduction

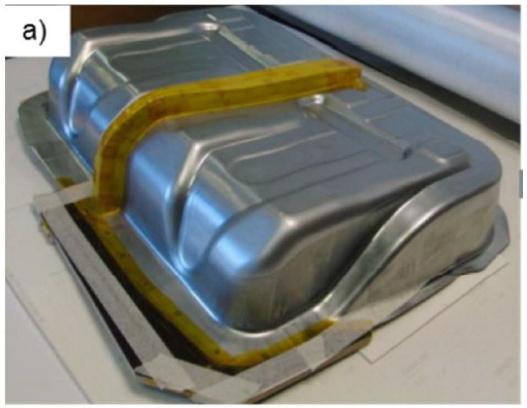
MapicC 3D (FP7)

- Accurately model the performance of a composite structure (Seatplate)
- Fibres are used for a knitted structure

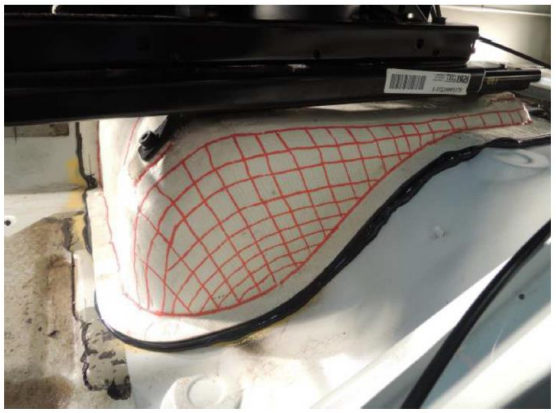
Example:

Replace existing metallic junction system by lighter composite material with same or better mechanical performance, using weft knitted textiles

Volvo truck cabin



metal



weft knitted thermoplastic composite

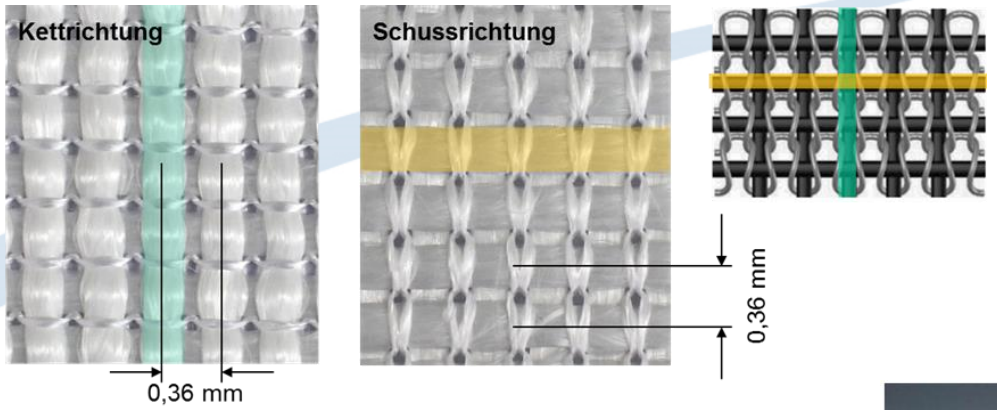
© Volvo truck

Introduction

production of structures

automated process,
Steiger „Aries 3D“
flat bed knitting machine

Reinforcement yarns in knitted strucures



5 Lagen

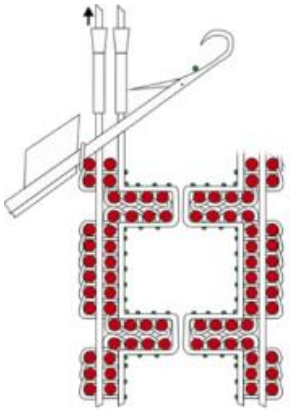
Multiple layers
combined in process

9 Lagen

Introduction

production of structures

Multi-layer
weft knitted fabrics



Un-expanded
product

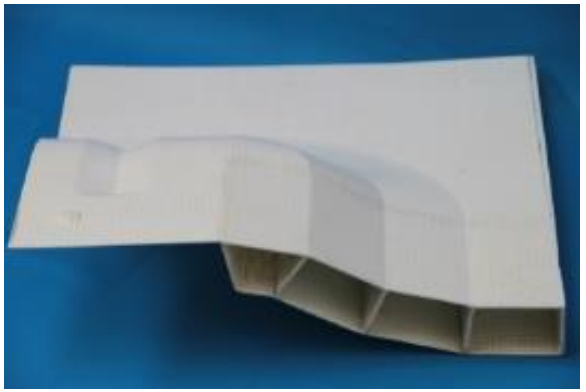
Application of inserts

Introduction

composites from knitted structure

knitted pre-form
(comingled yarns)

pre-form in mould



product

Objective

Development of a weft knitting process simulation model, which includes the relevant kinematics of the process, and should be able to predict the resulting textile structure. Relevant required variational parameters include:

- yarn characterisation
- machine settings
- friction
- yarn tension
- pull off tension

Starting point is a basic simple loop structure, produced on a hand knitting machine (which is still widely used in production (Asia) of clothing, but more important, easy accessible and well controllable)

Experiments

flat bed machine

overview

Experiments

flat bed machine

knitting

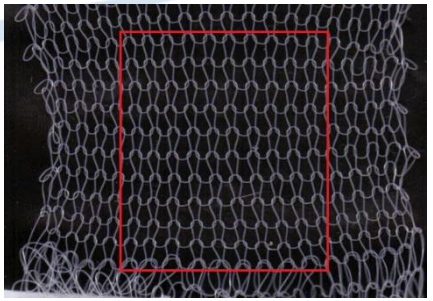
Experiments

flat bed machine

Parameter settings for the knitting experiments

flat bed machine

Parameter	S1	S2	S3
Yarn tension (g)	10	5	2
pull-off tension (g)	607	1087	1567
stitch cam depth (mm)	3.80	4.92	6.50



basic loop structure

Full factorial DoE, 3^3 experiments

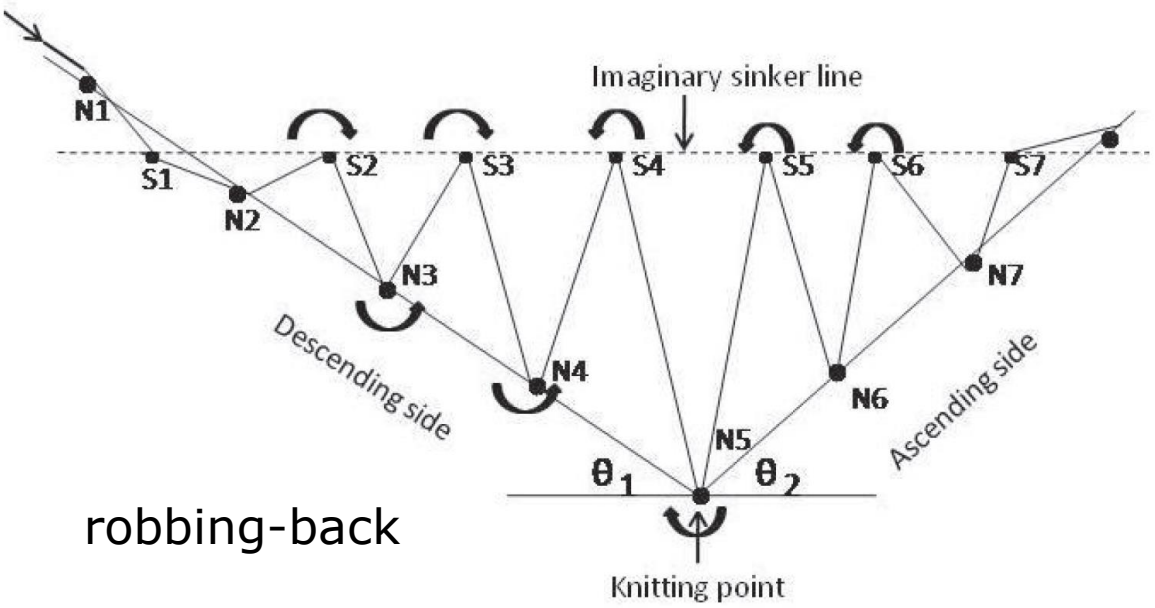
Results:
loop-lengths were measured and evaluated as a effect of parameter settings

1) Yarn tension inversely proportional with loop-length
2) Pull-off tension and stich-cam settings are proportional with loop-length
3) Only yarn and pull-off tension affect robbing back effect

observations agree well with reported results from literature

Experiments

robbing back

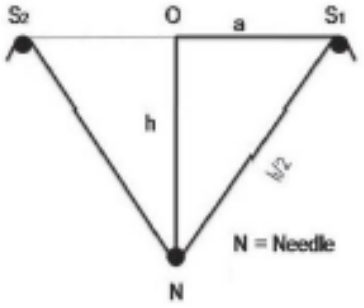


robbing-back

$$RB\% = \frac{l_t - l_a}{l_t} \times 100$$

mit
RB%:Robbing-back Größe
l_t: echte Maschenlaenge
l_a: theoretische Maschenlaenge

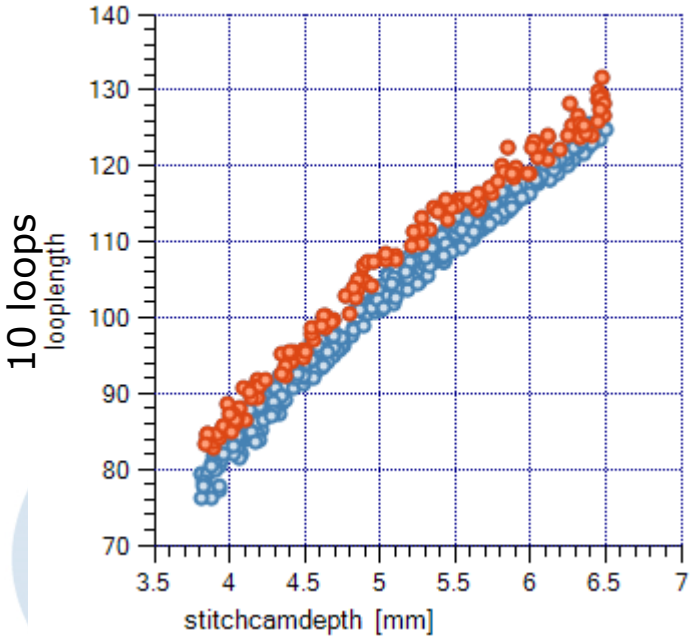
$$l_t = 2\sqrt{a^2 + h^2}$$



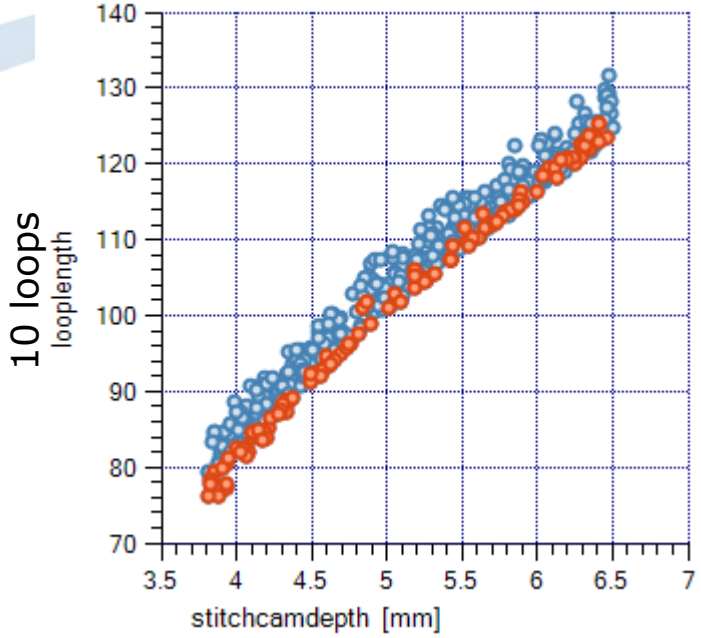
Experiments

flat bed machine

Implementation of DoE into MrReves (Design Exploration Software developed at Reden)
clear effect of yarn tension



Low yarn tension

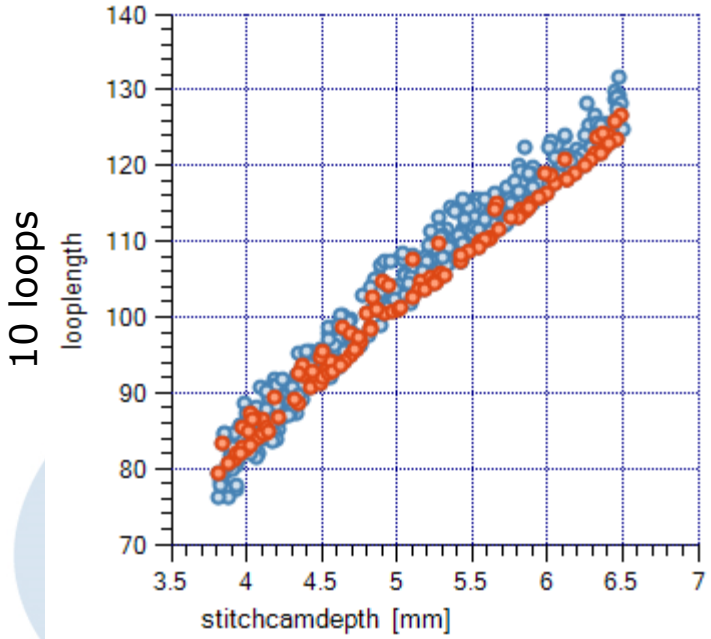


High yarn tension

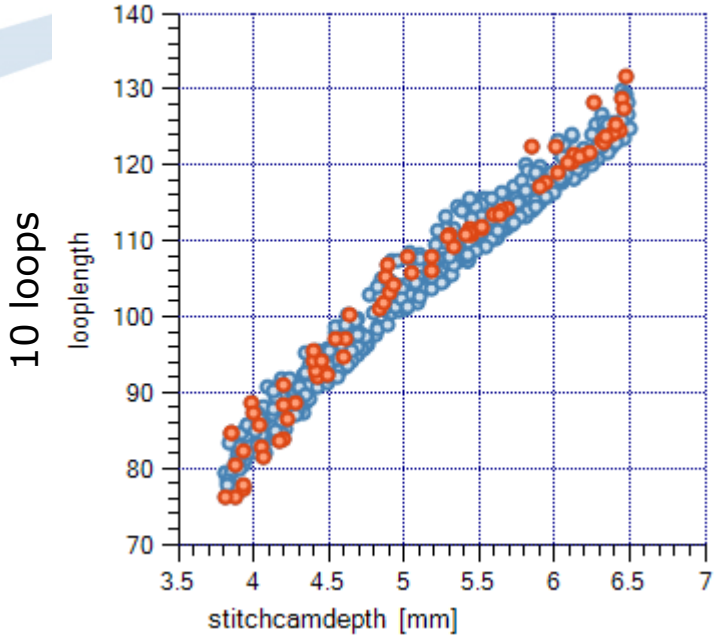
Experiments

flat bed machine

Implementation of DoE into MrReves (Design Exploration Software developed at Reden)
effect of takedown tension less pronousced



Low takedown tension

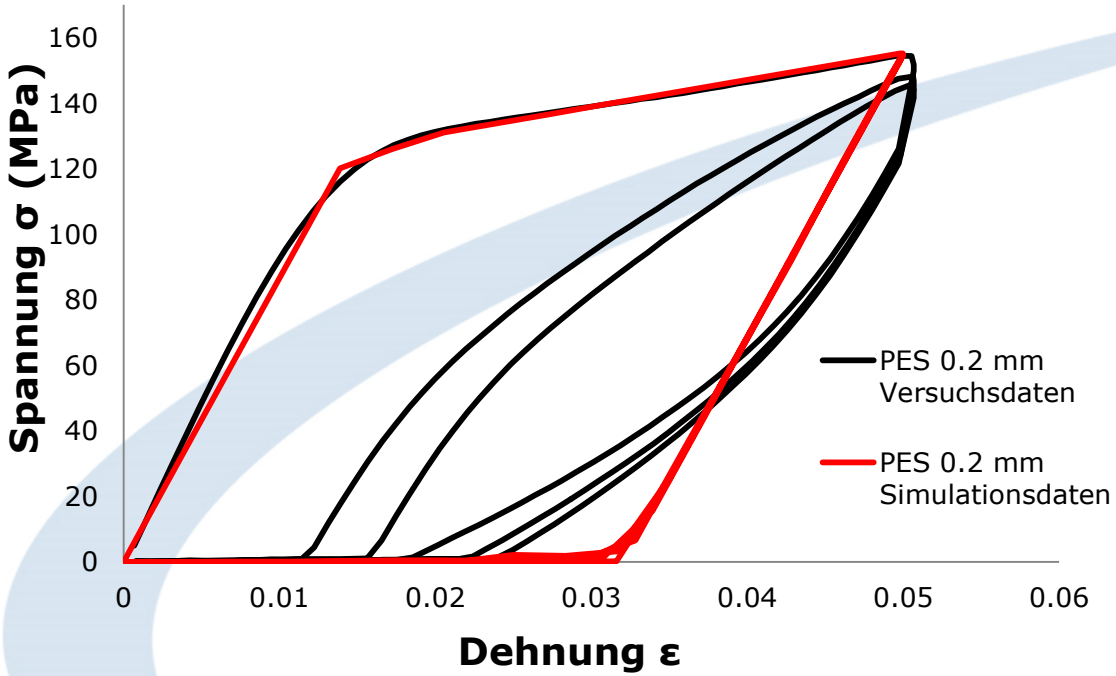


High takedown tension

Experiments

model input material

Yarn material



elasto-plastic material behaviour implemented in FEM

Viscoelasticity neglected

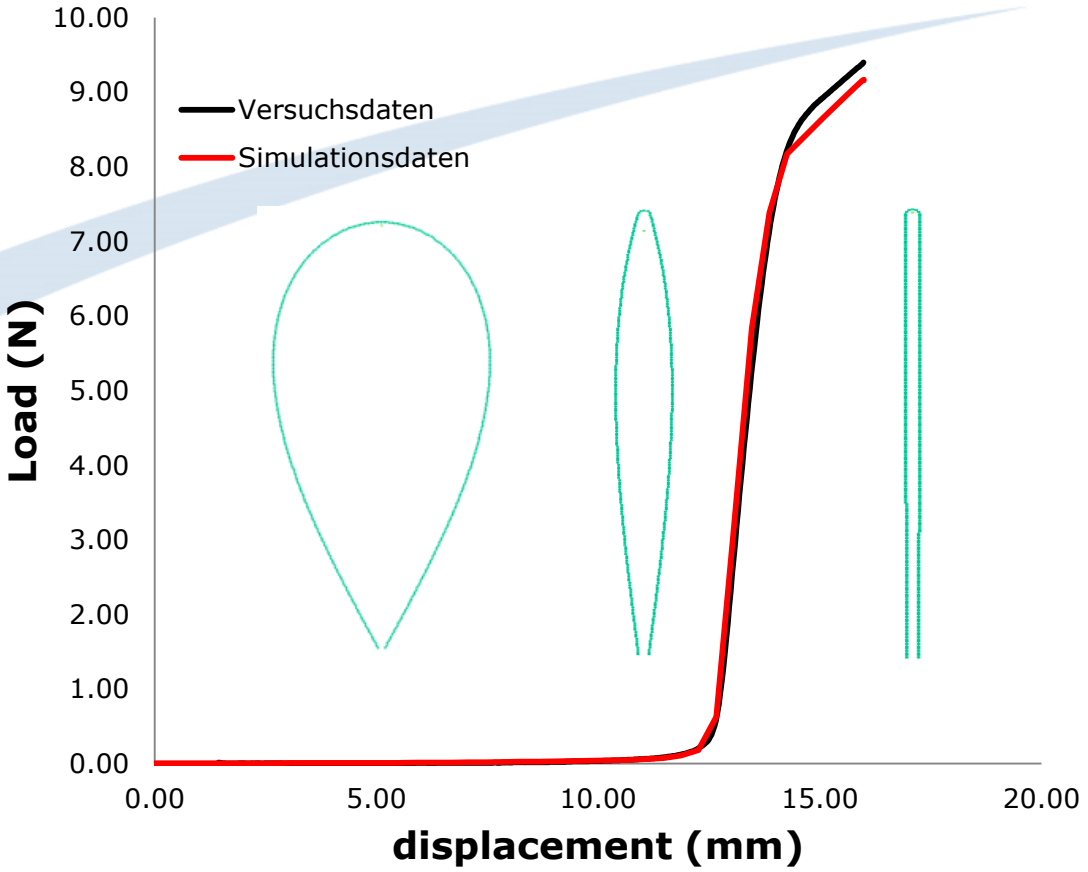
repetitive stress-strain curve from 900S monofilament

Experiments

model input material

Yarn material

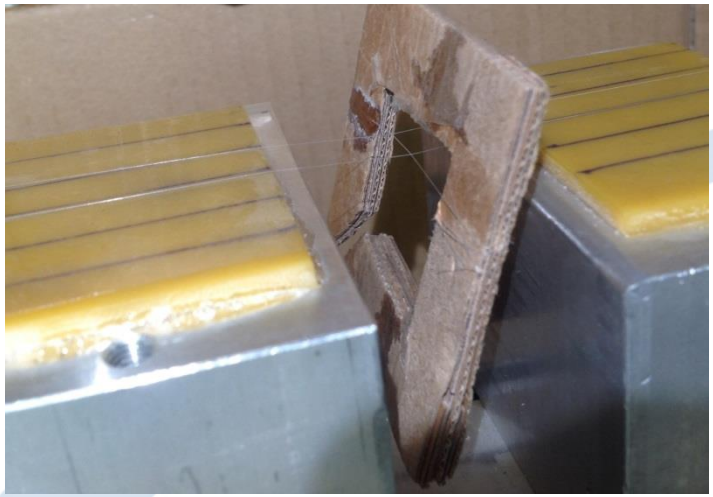
- tensile behaviour in loop-test



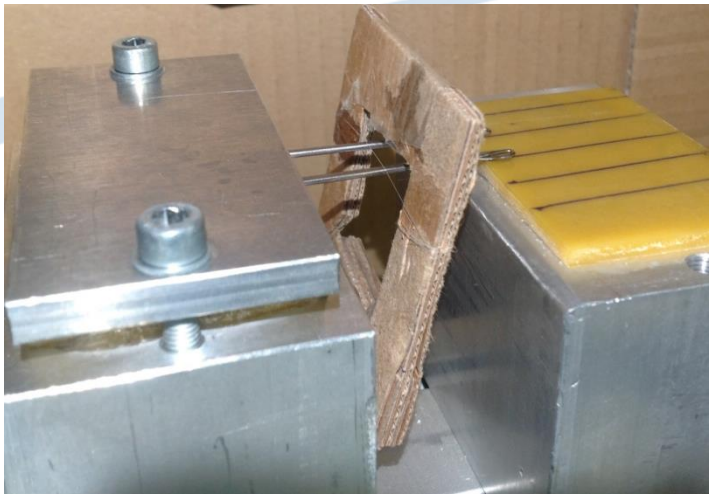
Experiments

model input friction

Yarn-yarn, yarn-needle friction



Yarn-Yarn μ = 0.06

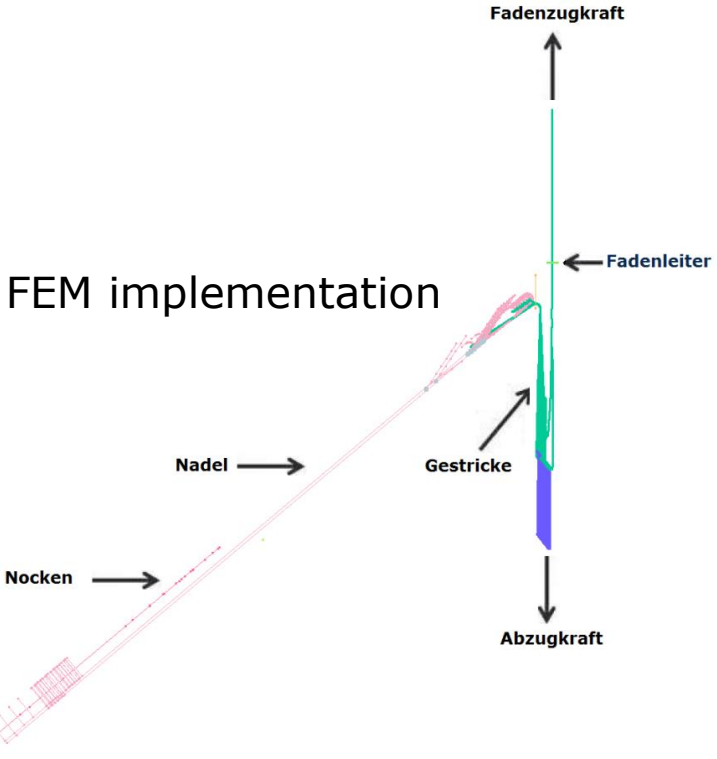


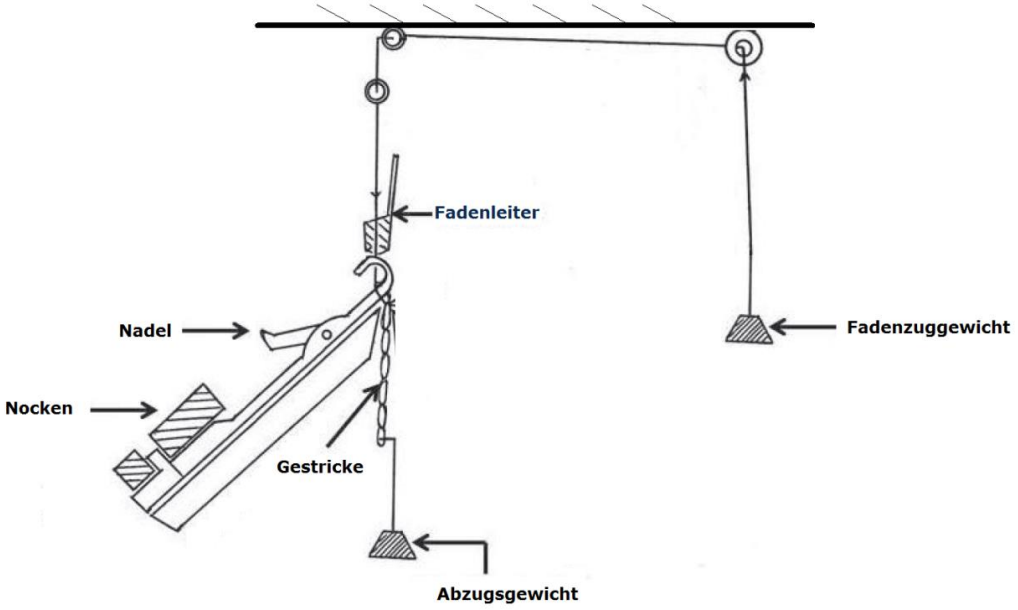
Yarn-Needle μ = 0.27

Model

flat bed machine

FEM implementation



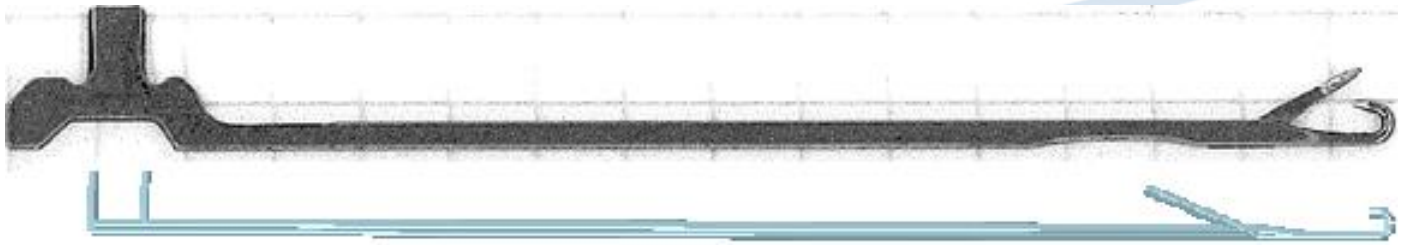


differences between model and “real” flat bed knitting machine

Model

Needle

Needle made from beam elements

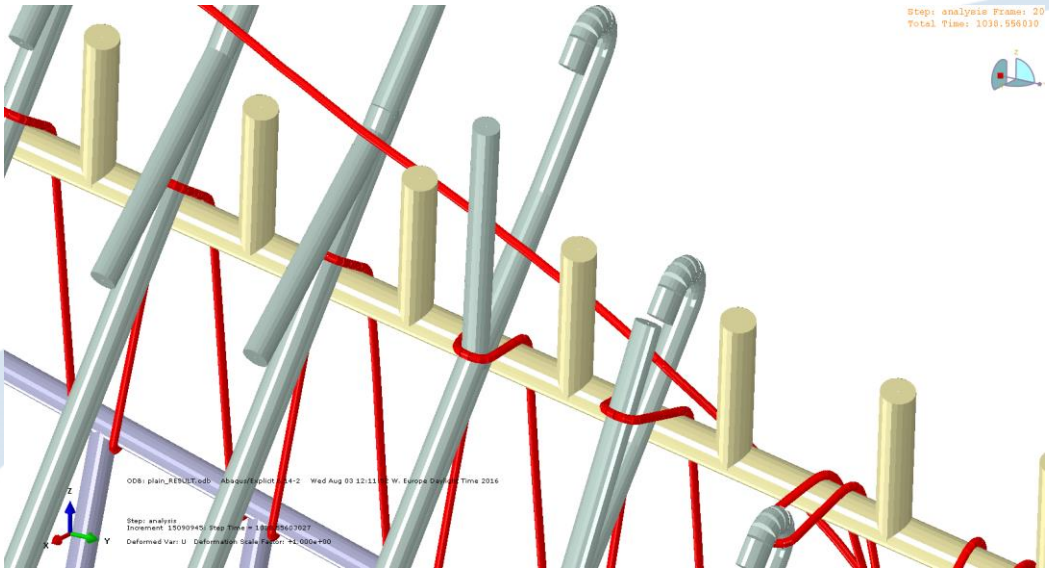


- edge-to-edge contact between needle and yarn
- latch opens or closes by yarns contact, rotation of latch allowed around the “out-of-plane” direction

Model

takedown

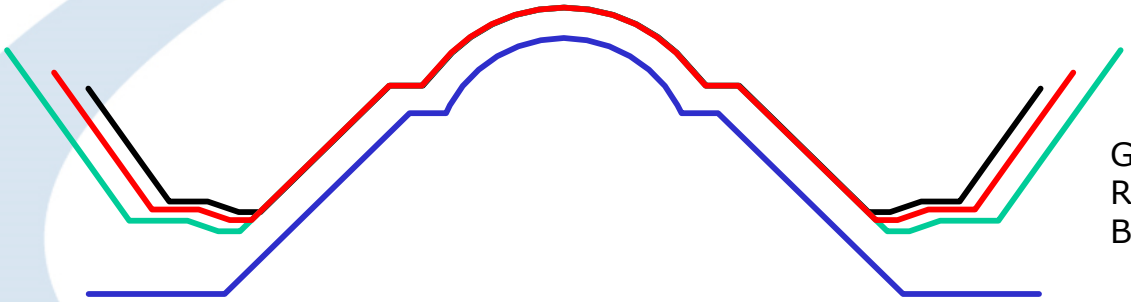
takedown modelled as a rake, edge-to-edge contact with yarn



Model

stitch cam

Stitchcam is moved up and down, manipulating the loop length

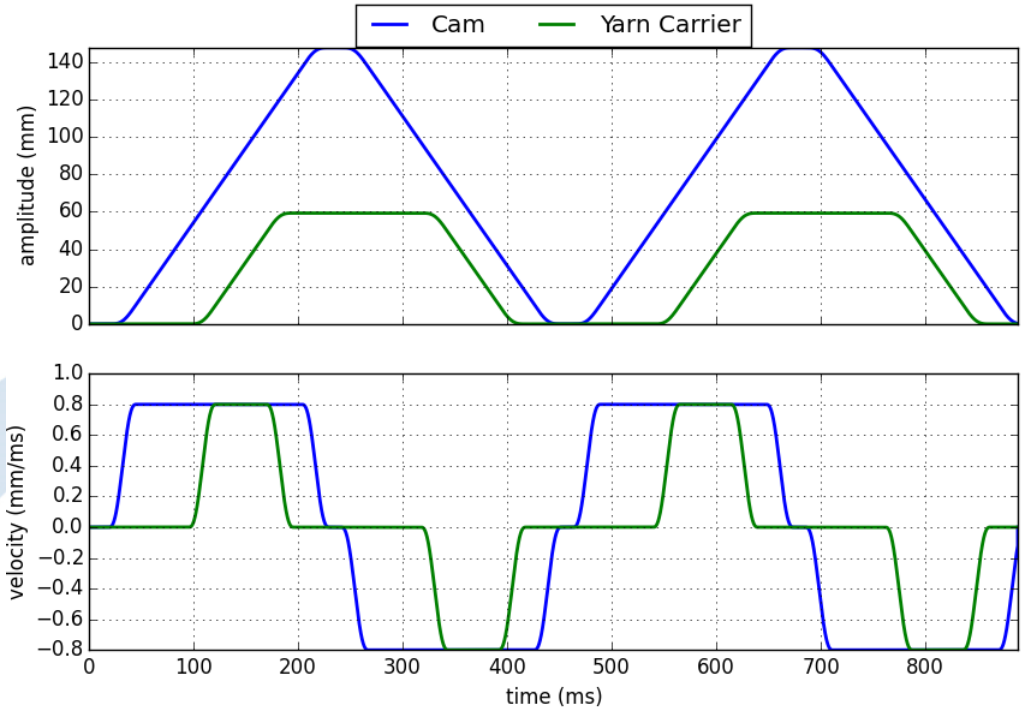


Green = stitchcam 4= 6.5 mm
Red = stitchcam 3 = 4.92 mm
Black = stitchcam 2 = 3.8 mm

Stitch cam in reality and in model

Model

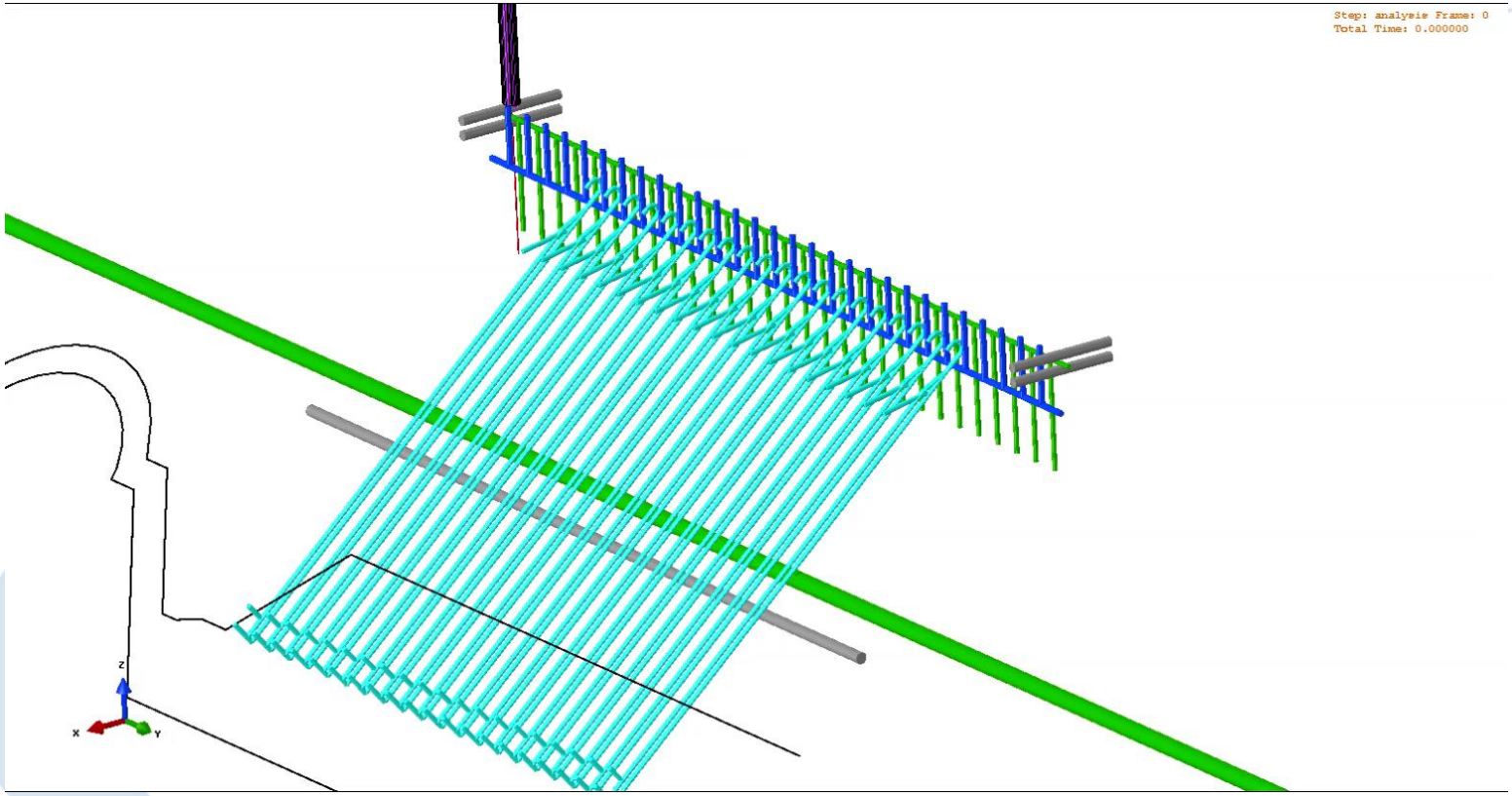
cam and yarn carrier



velocity profiles of cam and yarn carrier

Model

flat bed machine

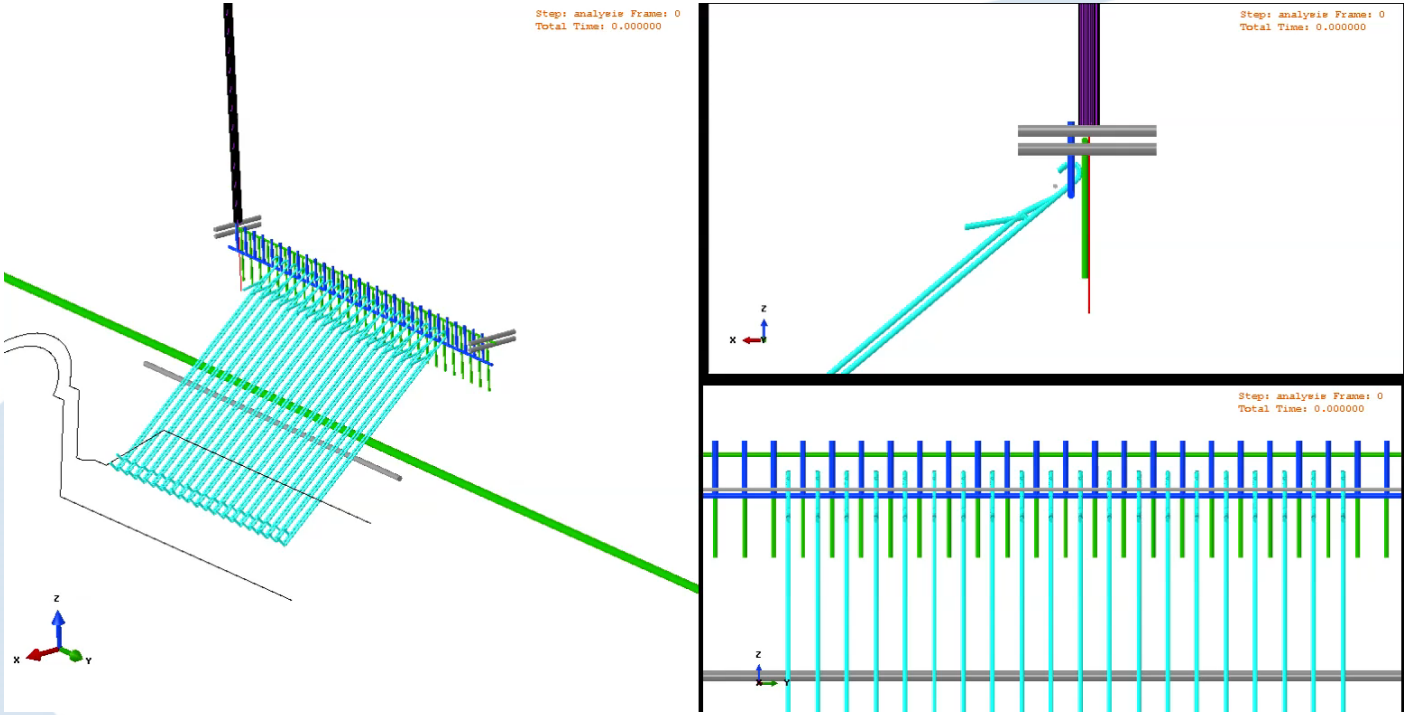


Iso-metric view

Model

flat bed machine

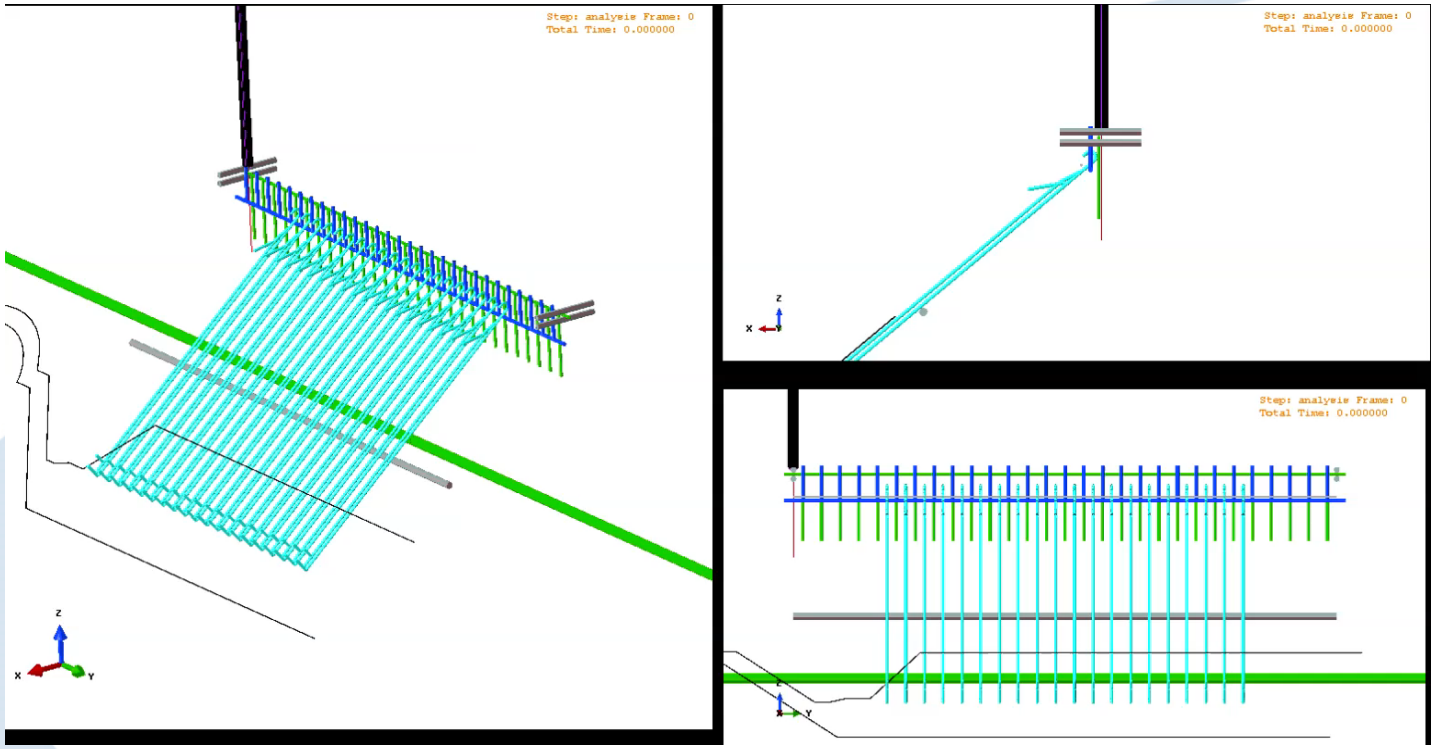
high yarn tension, low pull-off force, stitchcam 2



Model

flat bed machine

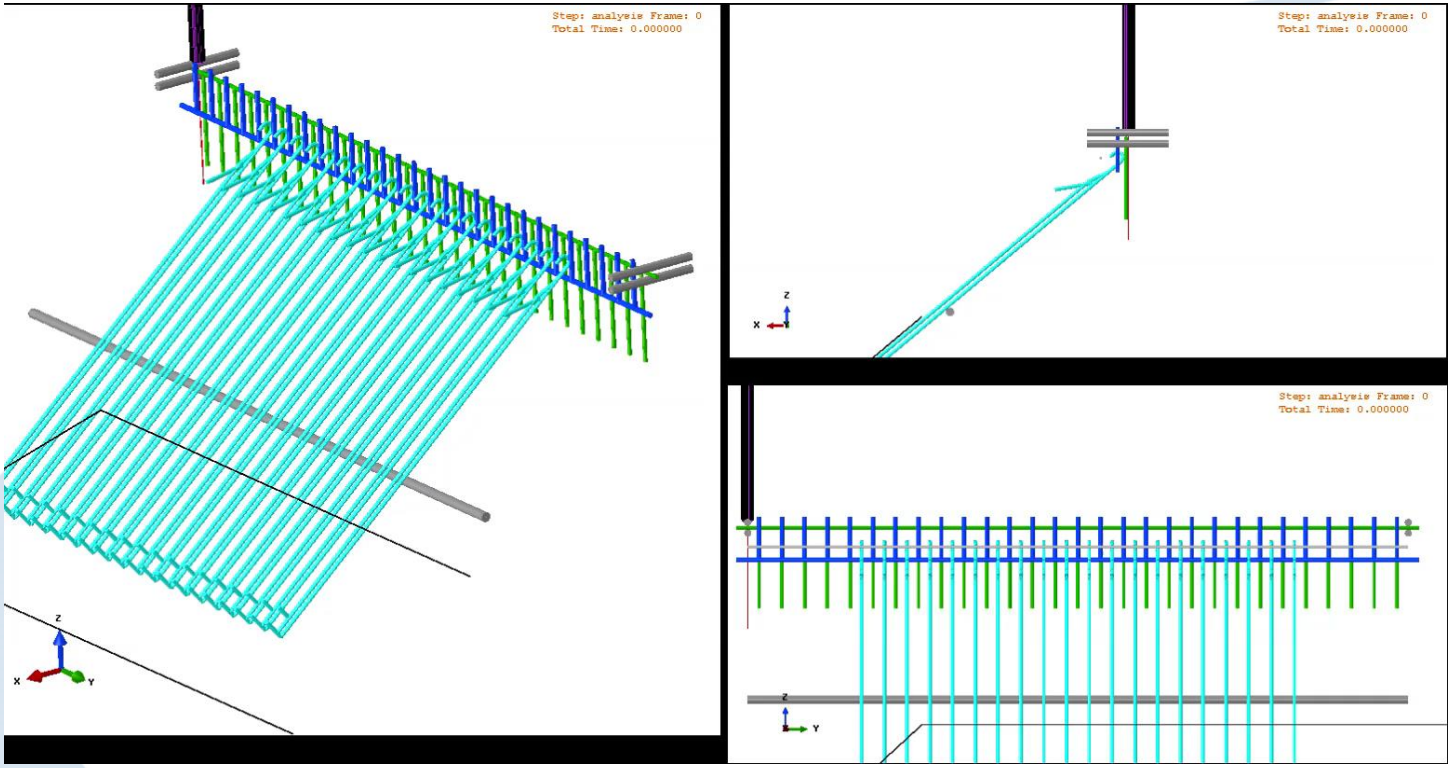
middle yarn tension, middle pull-off force, stitchcam 2



Model

flat bed machine

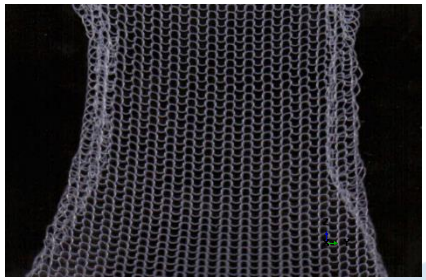
low yarn tension, high pull-off force, stitchcam 4

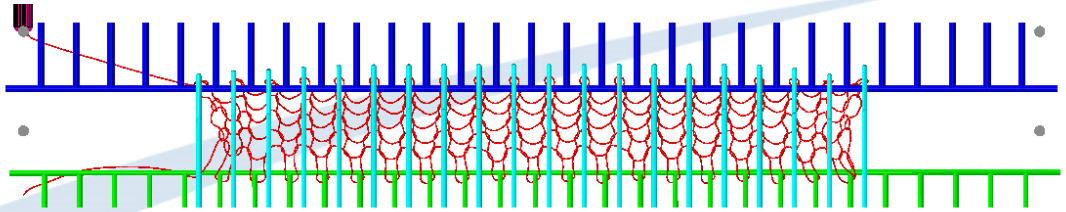


Results and discussion

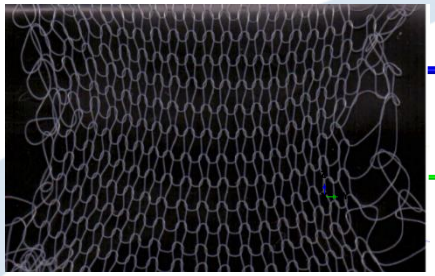
shape after knitting

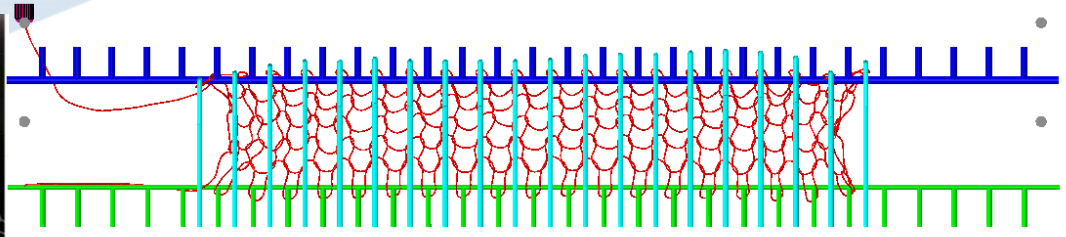
Stitchcam 2



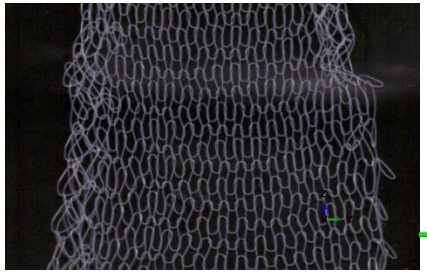


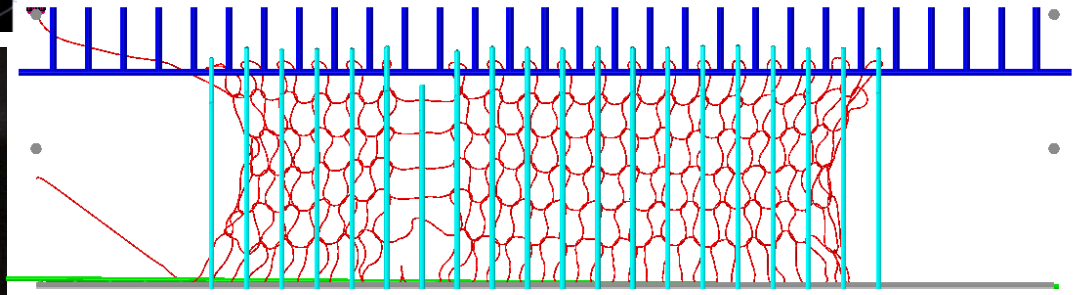
Stitchcam 3





Stitchcam 4

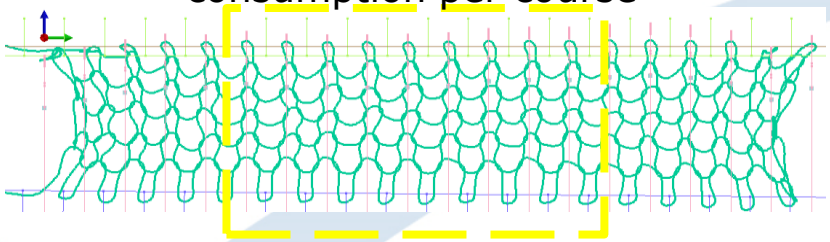




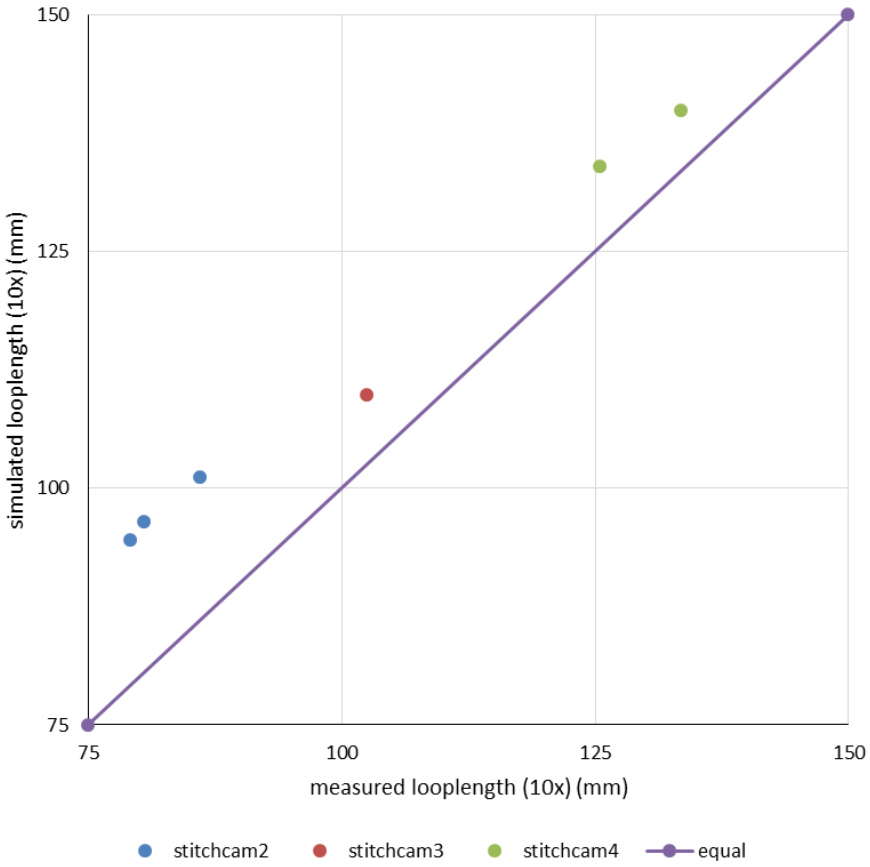
Results and discussion

knitting

- Measured
  - Looplength over 10 loops
- Simulation
  - Looplength based on yarn consumption per course

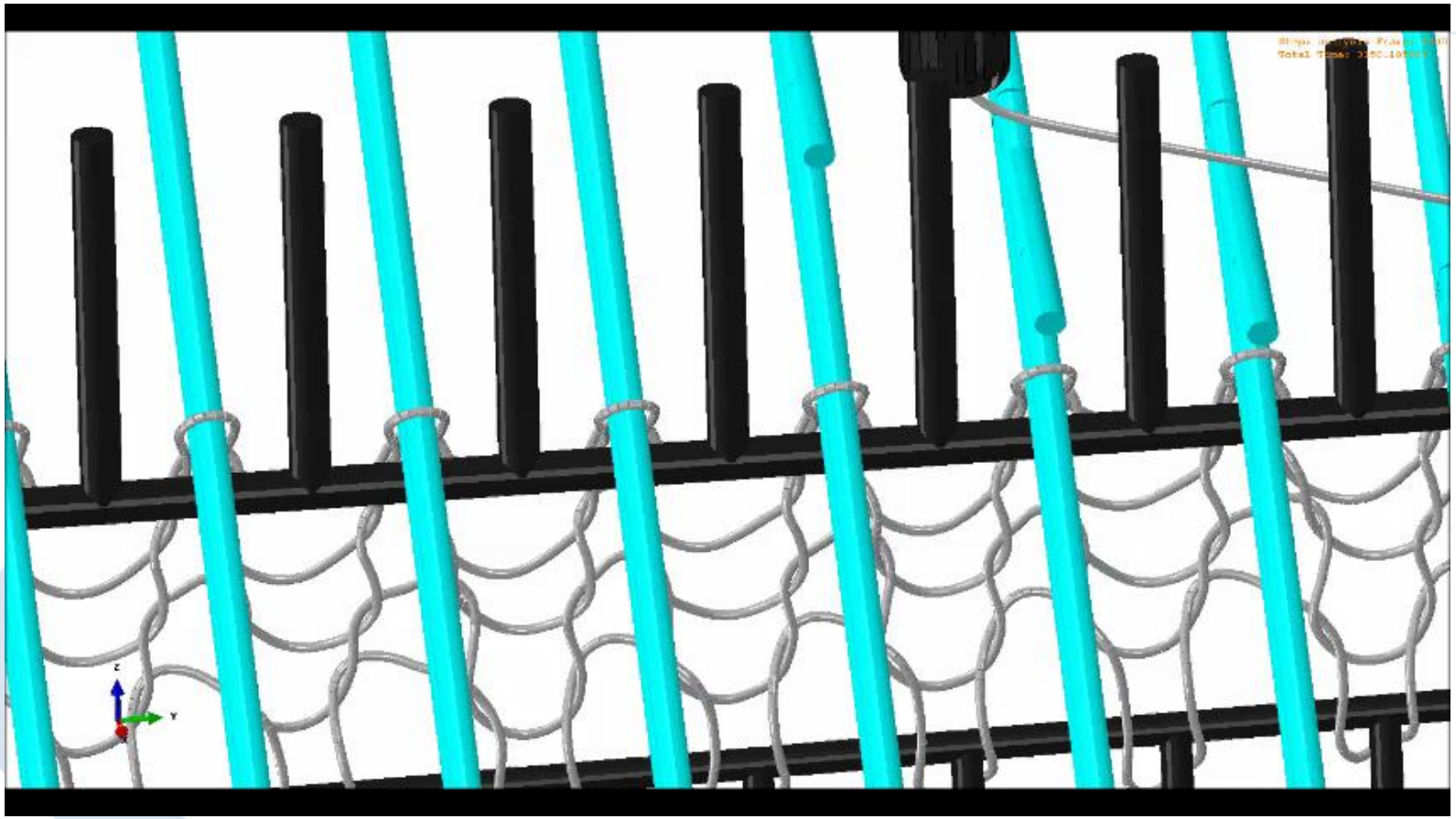


variant	measured	simulation	difference	
1	79.1	94.5	19.47%	stitchcam2
11	80.5	96.5	19.88%	
21	86	101.15	17.62%	
14	102.5	109.9	7.22%	stitchcam3
17	125.5	134	6.77%	stitchcam4
27	133.4	140	4.95%	



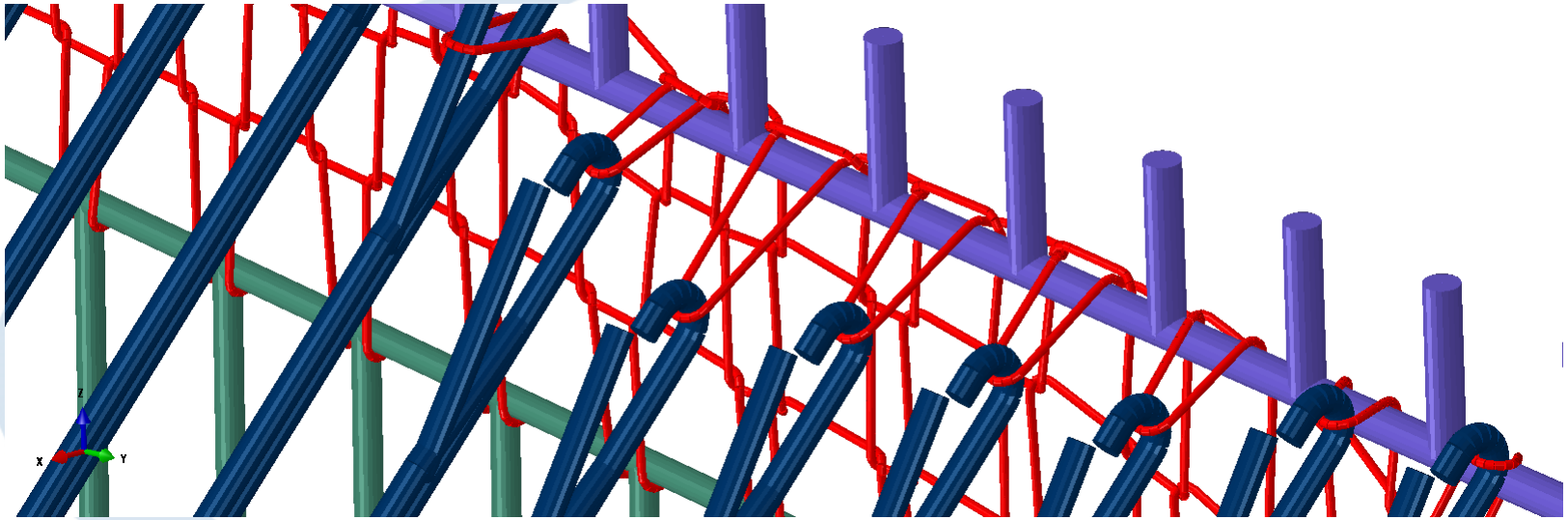
Results and discussion

robbing back



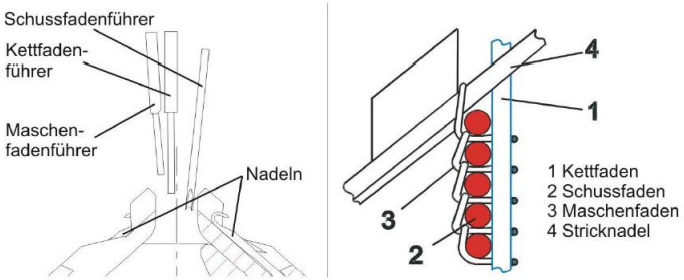
Summary and conclusion

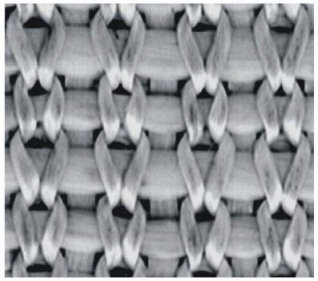
- Finite Element knitting model created, successfully applied to knitting process
- Material and process properties successfully measured and implemented
- Good correlation between modelled yarn consumption and experimentally measured yarn consumption
- Plasticity in yarn observed and important for successful implementation



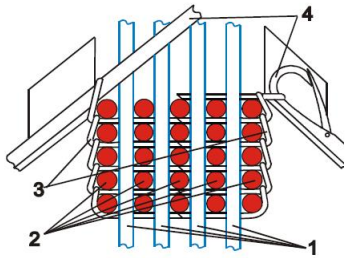
Future steps

a) Biaxiale Verstärkung





b) Biaxial verstärkte Mehrlagengestricke (MLG)



Stricken mit biaxialen Verstärkungsfäden
Quelle: CHERIF (2015)

Komplex geformtes
Motorradschutzblech aus
CF-Mehrlagengestrick

Quellen: Korropol, IMA, ITB

5 Lagen

9 Lagen

Drapierte Glas-Mehrlagengestrickte
Quelle: CHERIF (2015)

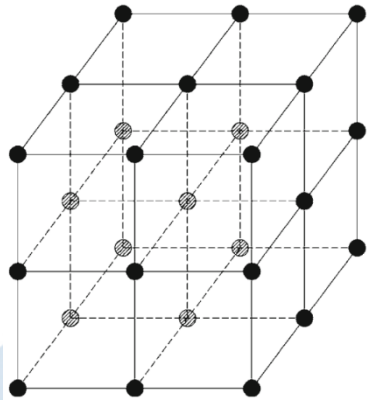
Acknowledgements

Thank you for your attention!

- Thanks to:
- Lambert, Martijn, Lisa, and our Phos Istos and MapicC 3D partners

Experiments

Simulationplannung



3^3 Voll-faktorielles Design
Quelle: CAVAZZUTI (2013)

Simulation Nr.	Fadenzugkraft [g] (nominaler Wert)	Abzugskraft [g]	Kuliertief [mm]
1	10	607	3.80
2	10	1087	3.80
3	10	1567	3.80
4	10	607	4.92
5	10	1087	4.92
6	10	1567	4.92
7	10	607	6.50
8	10	1087	6.50
9	10	1567	6.50
10	5	607	3.80
11	5	1087	3.80
12	5	1567	3.80
13	5	607	4.92
14	5	1087	4.92
15	5	1567	4.92
16	5	607	6.50
17	5	1087	6.50
18	5	1567	6.50
19	2	607	3.80
20	2	1087	3.80
21	2	1567	3.80
22	2	607	4.92
23	2	1087	4.92
24	2	1567	4.92
25	2	607	6.50
26	2	1087	6.50
27	2	1567	6.50