Machine Design in DWOC2.0

Production machine design for new cellulose-based products

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Why filaments?

• Strong form
• Building block for other shapes and structures
• Many established processes
• Filaments or fibre yarn
Raw materials

• New processes required in spinning from fibre suspensions
  – Development of sections of the spinning line required

• Established solution spinning technologies not directly applicable
  – Multiphase fibre suspension → different rheological properties
  – Forming (drawing) and axial alignment of fibres
  – Drying & dewatering
Raw materials

• Fibre properties
  • Stiffness comparable to Kevlar [1]
  • Tenacity comparable to glass fibres [2]
  • Fibre properties and yarn properties not directly comparable (fibre network)

• Native wood cellulose structure
  • Cellulose I structure is 50 % stiffer than the Cellulose II structure [1]

• Cost and raw material efficient processes
  • Development required in production of raw materials

Machine elements

Dry spinning

Dry-jet wet spinning

Wet spinning

[5] Introduction to solution spinning, http://nptel.ac.in/courses/116102010/18
Machine elements

- Wet strength
- Axial alignment of fibres
- Drawing

- Pump
- Spinneret
- Bath
- Forming
- Drying
- Spooling

- Rheology of the suspension
- Filament geometry
- Efficiency
Machine elements: Spinneret

- "Headbox" of spinning
- Iterative prototyping
- Phenomenological study of a coaxial spinneret
Process parameters

Flow rates (ml/min)
Agitation of suspension
(thermal, ultrasound, mechanical)

Pump

Spinneret

Bath

Forming

Drying

Spooling

Conductive/convective/radiation
Air flow / pressure
Drying time
Drying temperatures

Spinneret diameter (mm)
Air gap (mm)
Spinneret geometry / type
(cylindrical, conical, double conical, hyperbolical, etc.)

Bath liquid
Bath temperature
Drawing ratio
Drawing sequence
Compression / twisting
Roll / godet geometry, surface, configuration

Plying
Coating
Post-treatment
Process parameters

- Raw material properties
- Suspension parameters
  - Spinneret geometry
  - Timescales
- Forming parameters
- Drying parameters

Analysis of the effect of spinning parameters

Filament properties
- Production rates
Process parameters

- Prototype coaxial spinning line
- Different parameters measured and controlled
- Efficient testing of different spinning parameters in a fume hood with sufficient production rates
Applications

Weft-knitted sample

Sufficient production capability
Sufficient lengths of filaments
Sufficient filament properties
Applications

• Filaments are the first step…
  • Additive manufacturing
  • Combined processes
Conclusions

- New processes based on native wood fibres can be greatly improved by developing new machinery
- Effects of spinning parameters can be efficiently studied through automation and control
- Scalability can be studied through prototype spinning lines
- Development of spinning leads to different processes for new applications