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Author(s) Heikkilä, Pirjo; Jetsu, Petri; Pöhler, Tiina; Ketoja, Jukka; Tanaka, Atsushi; Lehmonen, Jani; Kinnunen-Raudaskoski; Hjelt, Tuomo; Koskela, Hanna; Forsström, Ulla; Harlin, Ali
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Foam Technologies in Production and Finishing of Nonwoven Materials

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Pirjo Heikkilä, Petri Jetsu, Tiina Pöhler, Jukka Ketoja, Atsushi Tanaka, Jani Lehmonen, Karita Kinnunen-Raudaskoski, Tuomo Hjelt, Hanna Koskela, Ulla Forsström, Ali Harlin

VTT Technical Research Centre of Finland Ltd
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VTT and Our Foam Technologies
VTT Technical Research Centre of Finland Ltd.

- The biggest multi-technological applied research organisation in Northern Europe

Resources
- Turnover 308 M€ (2013)
- personnel 2,600 (2015)
- Unique research and testing infrastructure
- Wide national and international cooperation network

Foam Technologies
Foam as Transport Media Instead of Water

An aqueous foam is an excellent suspending medium:

- Material is located in “bubble pockets” (vertex)
- Pseudoplastic nature allows for the dispersion of relative long fibers under high shear conditions at consistencies of 0.5 to 1.5 w-w-%

Air content 66%
Foam Technologies
Foam as Transport Media Instead of Water

1. **Foam laying** for production of nonwovens
   - Method comparable to wet-laying
   - Wet foam – air content <70%
   - Air bubbles in foam prevent flocculation of fibres → good formation
   - Currently used mostly for rigid fibres such as glass and carbon fibres

2. **Foam coating** for functionalization of nonwovens
   - Dry foam – air content 70-95 %
   - Allows very thin contour coatings, from almost 0 to a few grams per m²
     - Less coating penetration into the structure
     - Even application of small quantities on large areas: for 1 µm coating amount we make layer of 10 µm (air content 90 %)
   - Common technology used in textile industry for over 20 years, typically low speeds and narrow machines
Foam Laying
Benefits... Over Traditional Forming & Other Textile Methods

Material properties
- Possibility to adjust porosity and bulkiness in forming
- Possibility to use longer fibres compared to wet- and air-laying
- Good formation: more homogeneous compared to other nonwovens and textiles
- Easily adaptable to hydrophilic fibres such as cellulosics, but possibility to use synthetic fibres also
- Extended raw material combinations → tailored product properties

Process
- Higher forming consistency compared to wet-laying → possibility to modify current dilute processes
- Less water → less energy in drying and transport
- Better productivity compared to most other textile processes
Foam Coating

Benefits

Coating properties
- Thin homogeneous coatings
- Coatings from wide range of materials
- Simple ‘coating recipes’ with foaming chemistry, e.g. for nanomaterials no binders required since surface forces enough

Process
- Versatility
  - Non-contact/contact method
  - Higher concentrations possible compared e.g. to spraying
  - Enables application of high viscous and gel like material, e.g. NFC, MFC
- Simple in use
  - Savings in drying energy
  - No side streams, no recirculation, less maintenance
  - Easy to install into the existing machines
  - Low space demand compared with spray or film transfer
  - Occupationally safe method, no airborne particles
Foam Coating
Research Environments at VTT

- Wet web application
  SUORA (see next slide)
- Dry web application
  SUTCO and KCL pilot coater)

→ Contact application, foam killing with the nip, especially for dense surface layers and nonwovens

← Non-contact application with curtain coating, foam killing by absorption, especially for small application amounts
Foam Laying  
Research Environments at VTT

VTT paper making research environment

SUORA
Foam generation
Fourdrinier hybrid and gap former
Pressing with shoe press up to 2000 kN/m
Speed up to 2000 m/min

2011

- Foam laid tissue and nonwovens in laboratory scale
- Foam laid tissue and nonwovens in semi-pilot scale at speed of 210 m/min
- Pilot-scale foam forming facilities tissue and nonwovens

2016

- Next generation fibre foam research environment for special grades and long fibre usage
Nonwoven Materials from Cellulose Fibres by Foam Laying
Foam Laid Nonwovens from Cellulosic Fibres
Lab Scale - Different Fibre Compositions

Sheet (60 g/m²)
• 9 mm viscose fibres
• Viscose mixture with
  • cellulose pulp (pine kraft)
  • binder fibres (bi-component PES/PE)

Formation
→ Excellent, very homogeneous
Chemical (latex) or thermal bonding
→ Stiff, paper like products

“Novel Emerging of Fibre Web Products (Neoweb)”
2012-2013
VTT internal project
Foam Laid Nonwovens from Cellulosic Fibres
Lab Scale - Different Fibre Compositions

Foam laid sheets from cellulose carbamate (CCA)
• Fibres made from recycled fibre at VTT
• Fibres were cut to 13 mm or 25 mm length
• Bundles opened using laboratory scale carding device
• The quality of the sheets formation depends on how well the opening i.e. carding was done

Foam Laid Nonwovens from Cellulosic Fibres
Lab Scale - Different Fibre Lengths

- Visually 6 mm web most homogeneous, 12 mm sheet had real differences in homogeneity and 24 mm sheet has more fibre bundling

- Optical formation slightly weakened with fibre lengths 12 mm and 24 mm
- Floc size remained constant

Lehmonen et al. Foam forming for Tissue and Nonwovens” PaperCon 2015 April 19 – 22, 2015, Atlanta
Design Driven Value Chain in the World of Cellulose (DWoC), Finnish national project funded by TEKES, 2013-2015
Mechanical bonding of foam laid nonwovens (MECBO), VTT internal project, 2014
Foam Laid Nonwovens from Cellulosic Fibres
Semi Pilot Scale - Hydroentanglement

- Brilliant formation in the case of long fibres, even though high forming consistency applied
- Mechanical bonding instead of chemical bonding → aspect for sustainability
- Widening of raw material combinations → process simplifying

After drying

Hydroentangled
Foam Laid Nonwovens from Cellulosic Fibres
Semi Pilot Scale - Hydroentanglement

→ Clear increase in strain after hydroentanglement leading to more textile-like structures

→ Tensile strength was also improved after hydroentanglement

Mechanical bonding of foam laid nonwovens (MECBO), VTT internal project, 2014
Foam Laid Nonwovens from Cellulosic Fibres
Hydroentangled Textile-Like Nonwovens

100% 24 mm viscose fibres
150 g/m²
Tensile strength 128 N/m
Strain at max force 10%

70% 12 mm viscose fibres,
30% softwood kraft pulp
50 g/m²
Tensile strength 207 N/m
Strain at max force 26%

100% 12 mm viscose fibres
100 g/m²
Tensile strength* 834 N/m
Strain at max force 36%

Mechanical bonding of foam laid nonwovens (MECBO), VTT internal project, 2014
Foam Laid Nonwovens from Cellulosic Fibres
Summary of Experimental Results

- Foam laid nonwovens with good formation were obtained
- Formation dependent of many factors e.g.:
  - Fibre length: Shorter fibres easier; currently good formation obtained with fibre lengths up to 24 mm
  - Adding fibre:
    - Opening of fibres (in lab scale done with carding)
    - Mixing fibres into foam
  - Foam characteristics
- Foam laying suitable for paper-like products, but also textile-like products possible especially when using mechanical bonding
Functionalization of Nonwoven with Nanofibrillated Cellulose Utilizing Foam Coating
Foam Coated Nonwoven
Surface Properties and Wetting

• Materials
  • Base mixture of cellulosic and synthetics, chemically bonded
  • Coating with CNF (< 0.4 g/m²) with PVA as foaming agent

• Effects of coating
  • Closing the surface
  • Increased hydrophilicity (WCA measurement not possible for coated) and faster wetting

03/07/2015

Surface treatment with Foam application (SurfFoam), VTT internal project, 2014
Foam Coated Nonwoven Surface Properties and Wetting

PVA and CNF both hydrophilic by nature, but wetting also affected by capillary structure
Foam Coated Nonwoven
Bending Stiffness and Air Permeability

Surface treatment with Foam application (SurfFoam), VTT internal project, 2014
Foam Coated Nonwoven Functionalization Option

- TiO₂ and ZnO have photo-oxidative and antimicrobial activities
  - Inhibition to grow (bacteriostatic)
  - Killing (bactericidal)

- Functionalization of CNF by the addition of inorganic TiO₂ and ZnO nanoparticles and then application with foam technology

- We have done such coatings on paper, similar approach suitable for nonwoven
Foam Coated Nonwoven

Summary of Experimental Results

- Thin coatings with CNF and its compounds
  - More hydrophilic nature and changed capillary structure speed up the wetting of the sample
  - A very small amount of pure CNF (0.4 g/m²) and increased CNF amount of PVA+CNF-coatings promote faster wetting compared to the original base material.
  - Possibility to achieve functionalities such as antimicrobial activity
Summary and Conclusions
Summary and Conclusions

- Foam laying
  - Excellent formation
  - Development work on-going to enable use of longer fibres → More textile like structures possible, especially hand and drapability
  - Next generation fibre foam research environment under development for special grades and long fibre usage

- Foam coating
  - Thin layers coated evenly
  - Adjustment of properties with very small amount of functional material

- Foam technologies beneficial not only for product, but also from processing point of view due to reduced water use!
Thank you for your attention, and meet me after this session to see the samples!

For more information contact: pirjo.heikkila@vtt.fi