



**6th INTERNATIONAL CONFERENCE IN MEMORY OF
PROFESSOR VALERY KOMAROV**

**THE ISSUES IN MECHANICS
OF PULP-AND-PAPER MATERIALS**







**Improving recycled material fines retention using bio-based
materials and advanced process solutions for board
manufacturing**

Prof. Dr. Klaus Dölle
State University of New York (SUNY)
College of Environmental Science & Forestry (ESF)
Department of Chemical Engineering (CHE)

Today's Topics

- Introduction SUNY-ESF & Project
- Materials
- Paper Testing
- Testing Results
- Conclusion
- Next Steps
- References, Contacts, etc.
- Q&A

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The State University of New York (SUNY)



Source: <http://www.suny.edu>¹

The State University of New York (SUNY)

SUNY in Numbers (2020):

Founded: 1816 in Potsdam New York (officially 1948)

Students: approx. 394,220 from all 50 US States and 180 nations

Locations: 64 of which 14 are doctoral granting Universities

Employees: 91,961

Programs: over 4,352 UG majors

Target US University System

Research & Development:

Research Foundation:

Budget: ca. \$1005 million

R&D Projects: 7,689

Economic Impact:

\$8.17 ROI on every \$1 of

NYS funding



Source: <http://www.suny.edu/about/fast-facts?>

The State University of New York (SUNY) College of Environmental Science and Forestry (ESF) Department of Chemical Engineering (CHE)

Founded: 1920 , oldest US paper program

Programs:

- Paper Engineering (127 credit hours)**
 - ABET Accredited – Engineering 100%
- Bioprocess Engineering (127 credit hours)**
 - ABET Accredited - Chemical Engineering
- Renewable Materials (127 credit hours)**
- Chemical Engineering (127 credit hours)**

Enrolled Studentes: 90 undergraduate & 35 graduate

Faculty: 10 Faculty & 2 Lecturers

Studenten Faculty Ratio: 9:1

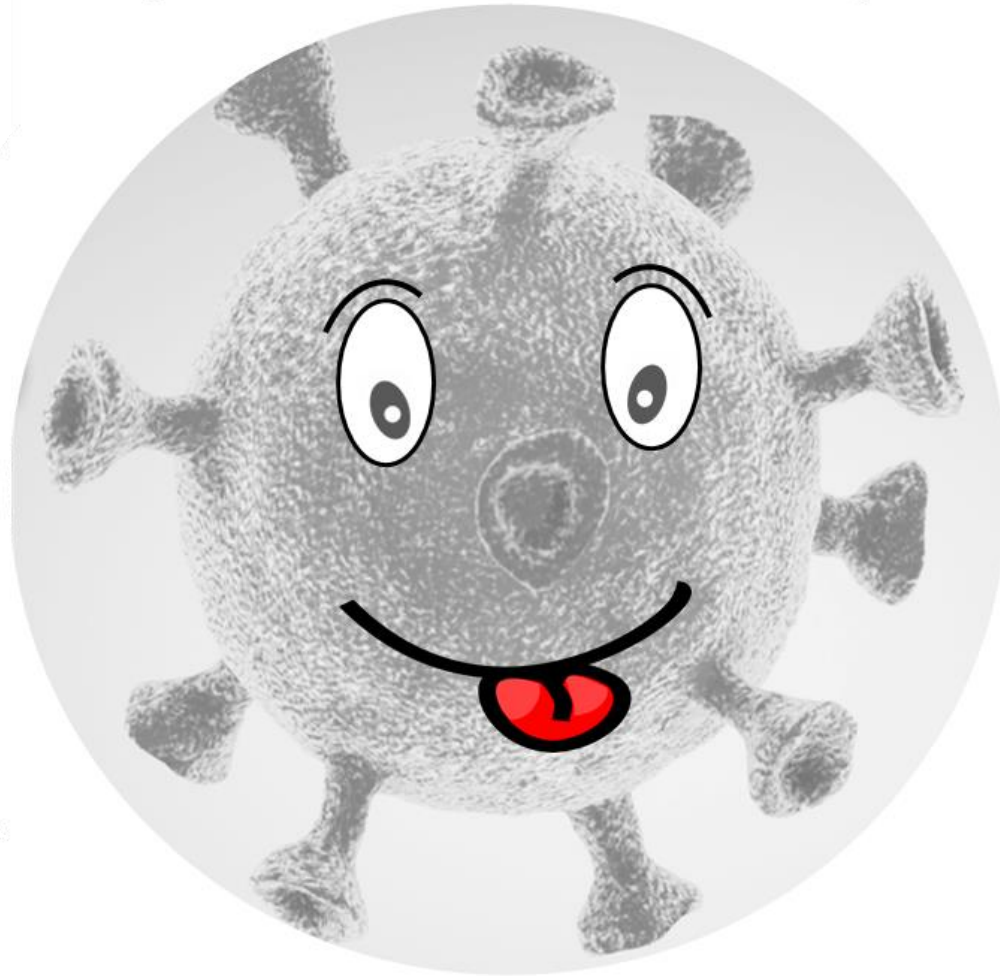
Institut/Foundation: ESPRA / ESPRI & SPPF / TRINITY



The Research Project – work in progress

- Driven by the need of the paper industry to become more sustainable and eco-friendly by implementing bio-based products in the manufacturing process.
- Paper materials are known for their sustainability, biodegradability, and its eco-efficiency.
- On-line retailing is revolutionizing shopping behaviors all over the world³.
- Paper and cardboard production reached nearly 78 million metric tons in the U.S. and about 420 million metric tons worldwide in 2019³.
- U.S. Consumers spent \$861 billion on the web for retail purchases in 2020, a 44.0% increase compared to \$598 billion in 2019³. Forecasts for 2021 are above 930 billion⁴.
- Students and personal interest.

And then there was this Guy.....



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Materials

Fiber Material:

- OCC fiber material from headbox and or from disk filter, collected or sent to ESF
- Woodmeal/woodflour particle size $20\mu\text{m}$ to $50\mu\text{m}$ and $40\mu\text{m}$ to $70\mu\text{m}$

Starch:

- Cationic starch a modified corn starch with a positive charge, tapioca starch
- Applied uncooked and cooked⁴

Hydrated Lime:

- Dolomitic hydrated lime in powder form for in-situ PCC production^{6,7}.

Filler:

- Commercial available PCC and GCC product in powder form.
- All refining done according to TAPPI T200 sp-06 (Valley beater method)

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Paper Testing



Some Testing Methods

- TAPPI T205 sp-12:** “Forming handsheets for physical tests of pulp”
- TAPPI T211 om-02:** “Ash in wood, pulp, paper and paperboard: Combustion at 525°C”
- TAPPI T220 sp-10:** “Physical testing of pulp handsheets”
- TAPPI T227 om-09:** “Freeness of pulp (Canadian standard method)”
- TAPPI T240 om-07:** “Consistency (concentration) of pulp suspensions”
- TAPPI T261 cm-00:** “Fines fraction by weight of paper stock by wet screening” *Britt Jar Method*
- TAPPI T402 sp-13:** “Standard conditioning and testing atmospheres for paper, board, pulp handsheets”
- TAPPI T403 om-02:** “Bursting strength of paper”
- TAPPI T410 om-08:** “Grammage of Paper and Paperboard (weight per unit area)”
- TAPPI T411 om-10:** “Thickness (caliper) of paper, paperboard, and combined board”
- TAPPI T412 om-06:** “Moisture in pulp, paper and paperboard”
- TAPPI T414 om-12:** “Internal tearing resistance of paper (Elmendorf-type method)”
- TAPPI T425 om-06:** “Opacity of paper (15/d geometry, illuminant A/2°, 89% reflectance)”
- TAPPI T494 om-06:** “Tensile properties of paper and paperboard (const. rate of elong. Appar.)”
- TAPPI T538 om-08:** “Roughness of paper and paperboard (Sheffield method)” - *Smoothness*
- TAPPI T547 om-07:** “Air permeance of paper and paperboard (Sheffield method)” - *Porosity*

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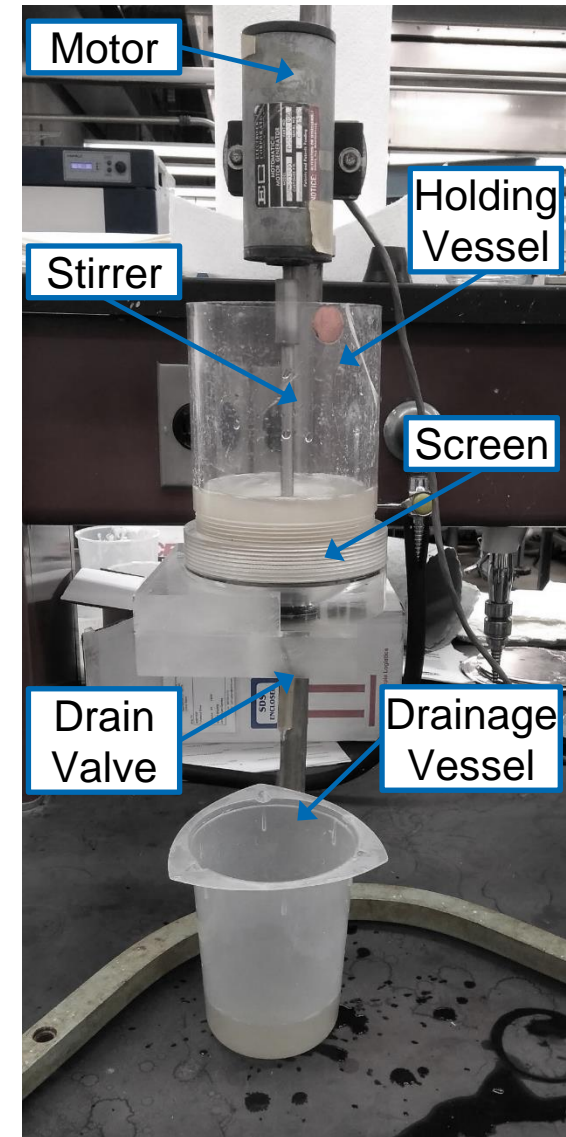
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T261- Britt Jar Method

- Prepare a master batch of 4 to 10 L at 0.5% consistency
- Set stirrer to 750 rpm or desired speed and locate propeller 1/8" or 3.2 mm above the 200 mesh/ 75 μm screen
- Fill 500 ml of suspension in holding vessel and start stirring
- Open drain valve
- After liquid level is 5 mm add 500 ml of wash water
- After filtrate is clear (5 washing cycles), remaining material is screen over a weighted ashless filter paper 30 μm using a Büchner funnel



- Conduct analyses



T205 – Forming Handsheets



a



b



c

a) TAPPI Handsheet forming , b) Handsheet pressing, c) Handsheet drying

100 g/m² Handsheets were formed at a temperature of 45°C to simulate papermaking process

T205 – Forming Handsheets



a



b



c

a) TAPPI Handsheet forming , b) Handsheet pressing, c) Handsheet drying

100 g/m² Handsheets were formed at a temperature of 45°C to simulate papermaking process

T205 – Forming Handsheets

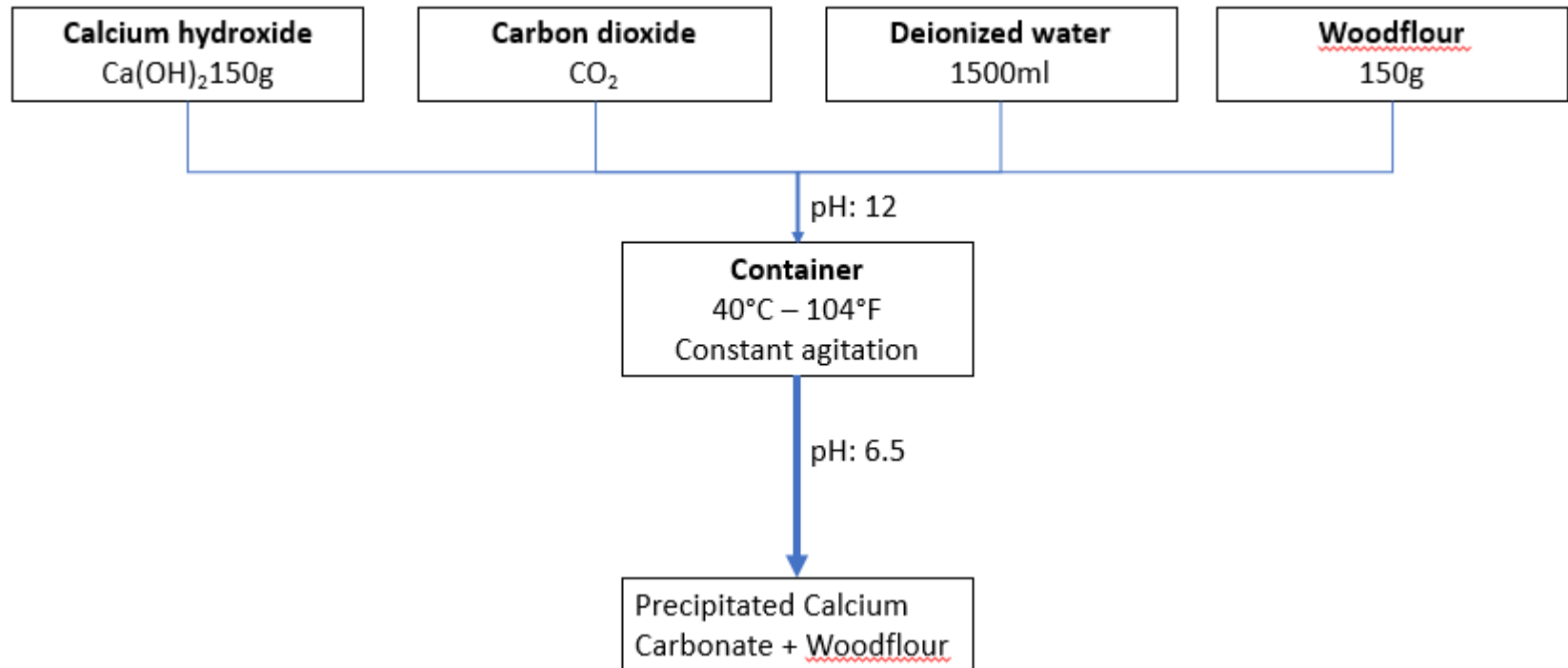


a) Dayton photo dryer, b) Control unit, c) Handsheet drying , d) Drying felt/cylinder

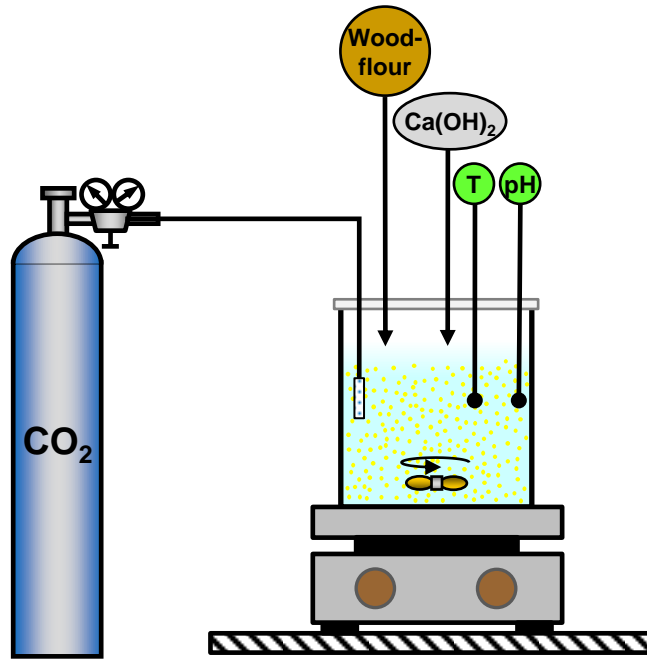
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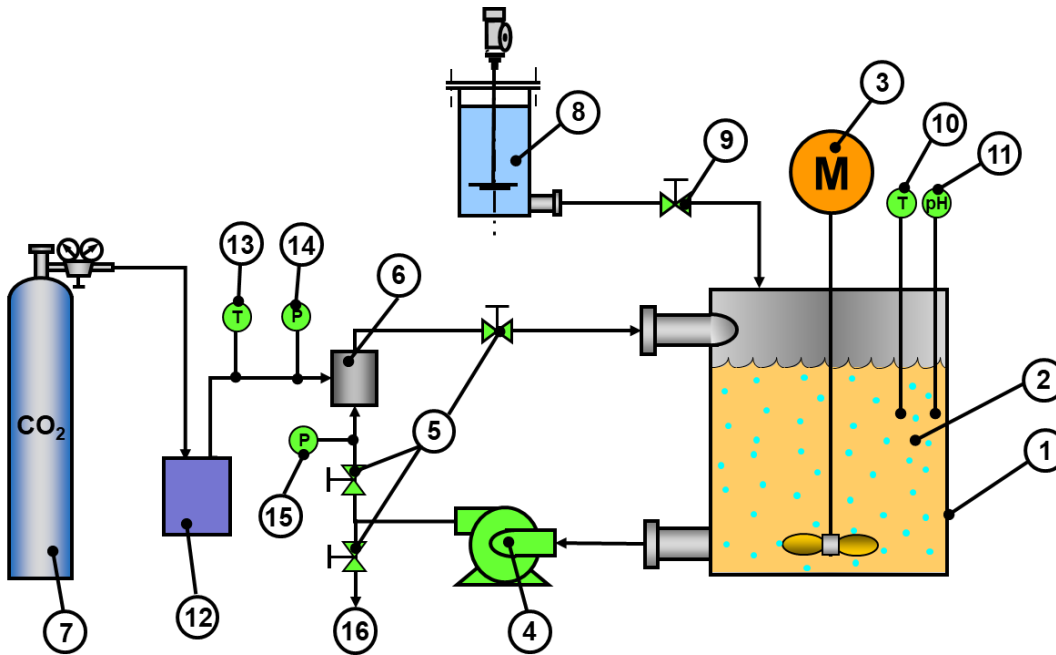
Making Woodmeal/Woodflour PCC and Other



Making Woodmeal PCC and Other



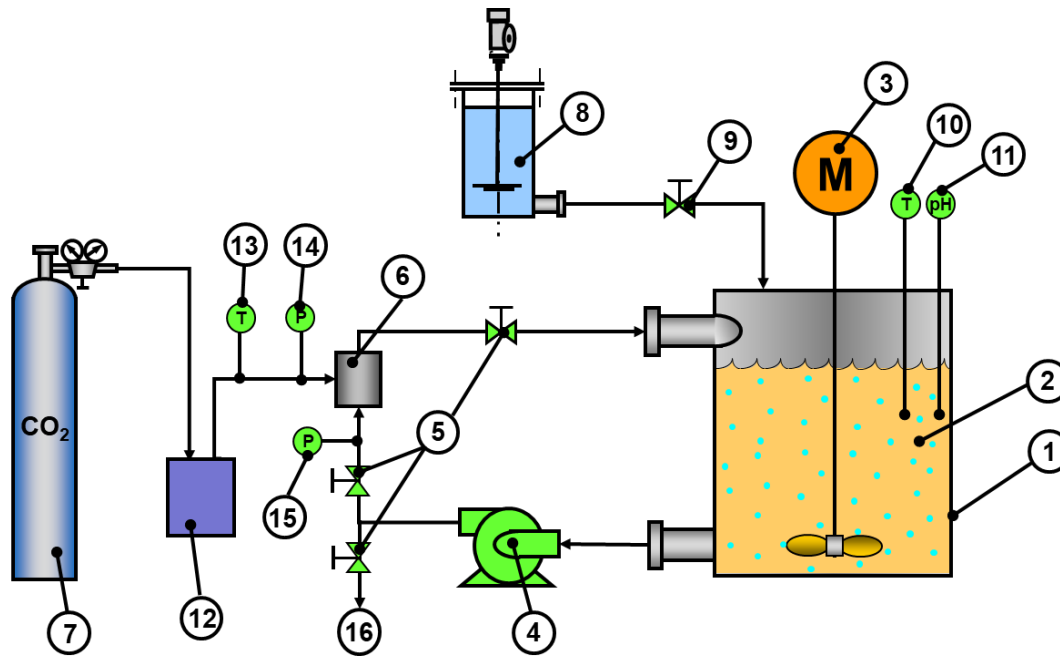
Making In-situ PCC



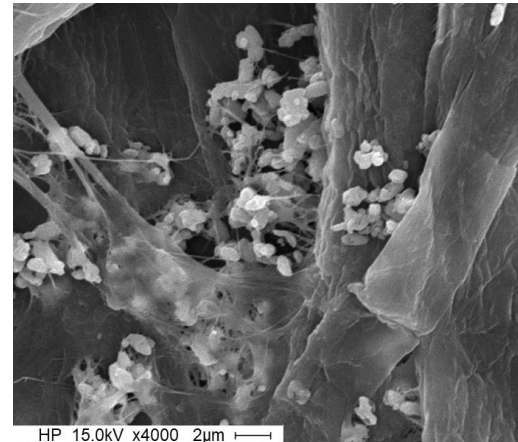
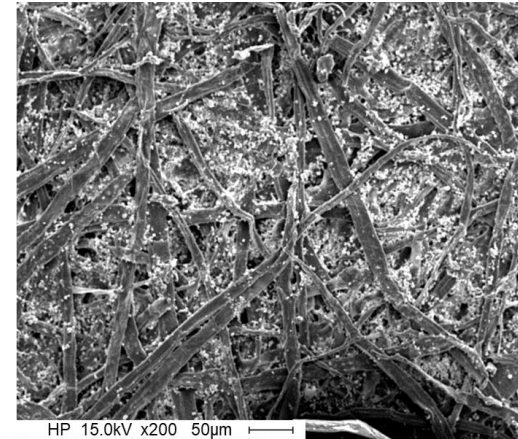
- 1) 1000 I tank, 2) Pulp fiber suspension, 3) 0.375 kW propeller mixer
4) 0.75 kW impeller pump, 5) Ball valve, 6) Static mixer, 7) CO₂ Tank with pressure transducer and flow adjustment, 8) lime tank, 9) Dosing valve



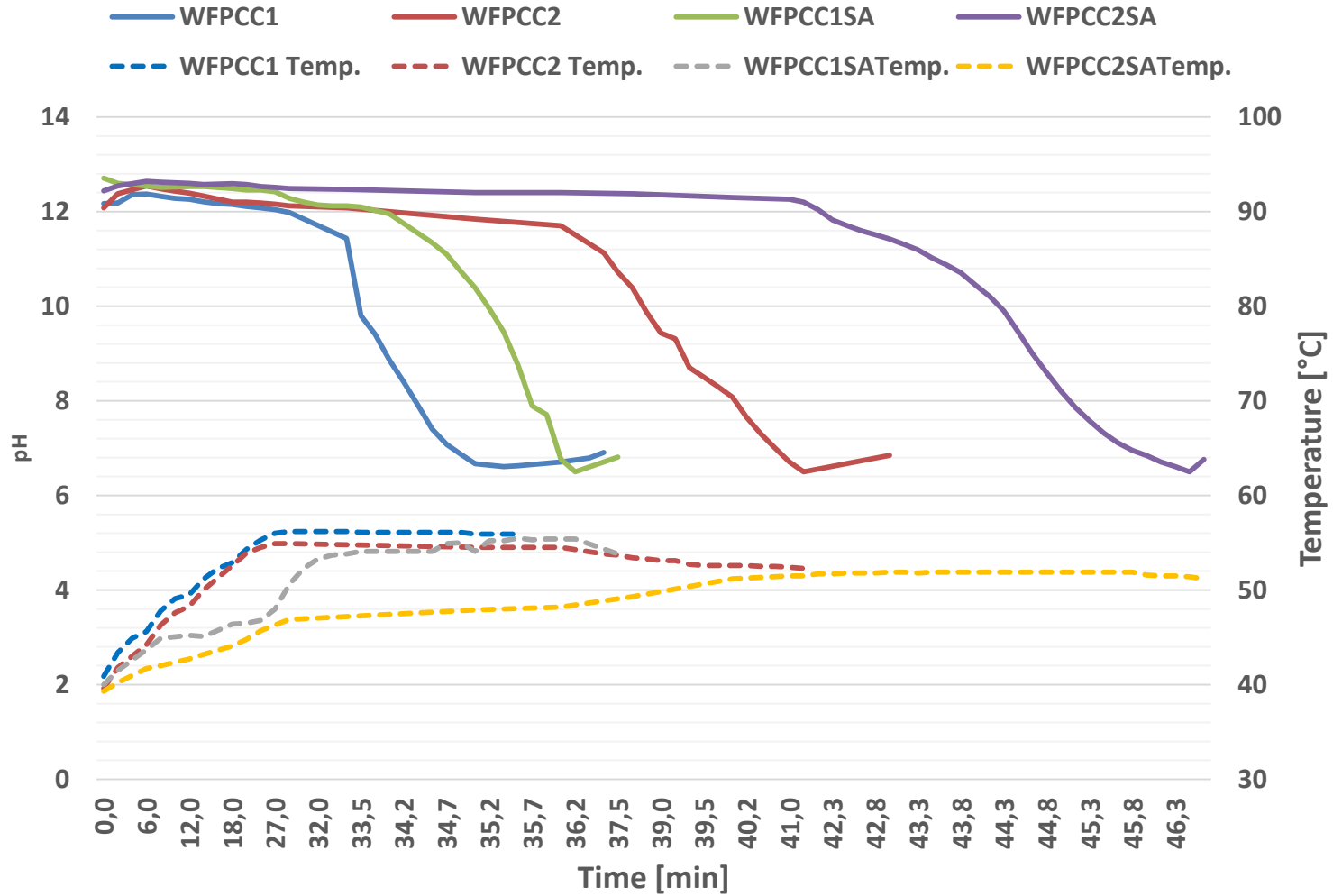
Making In-Situ PCC



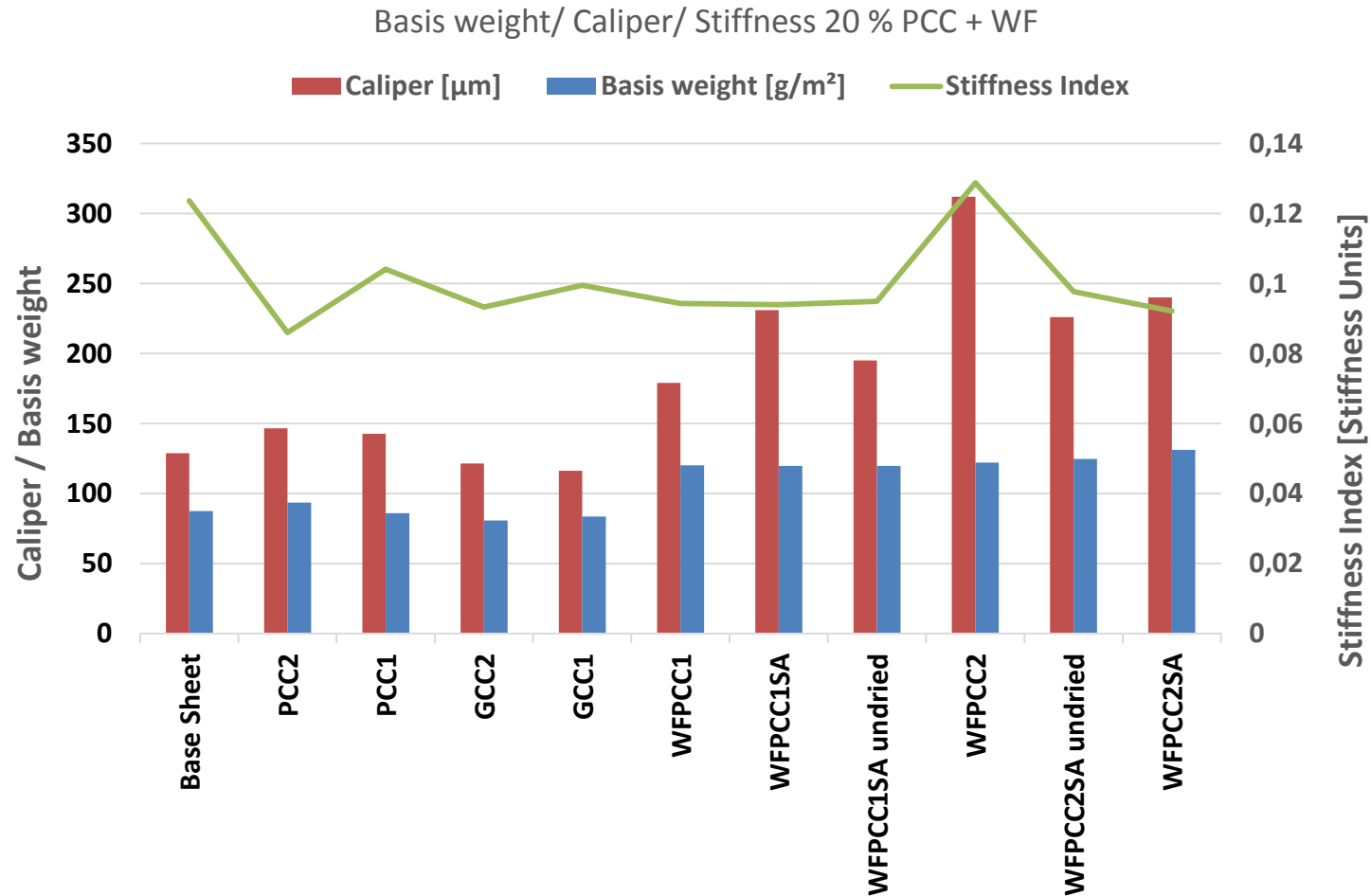
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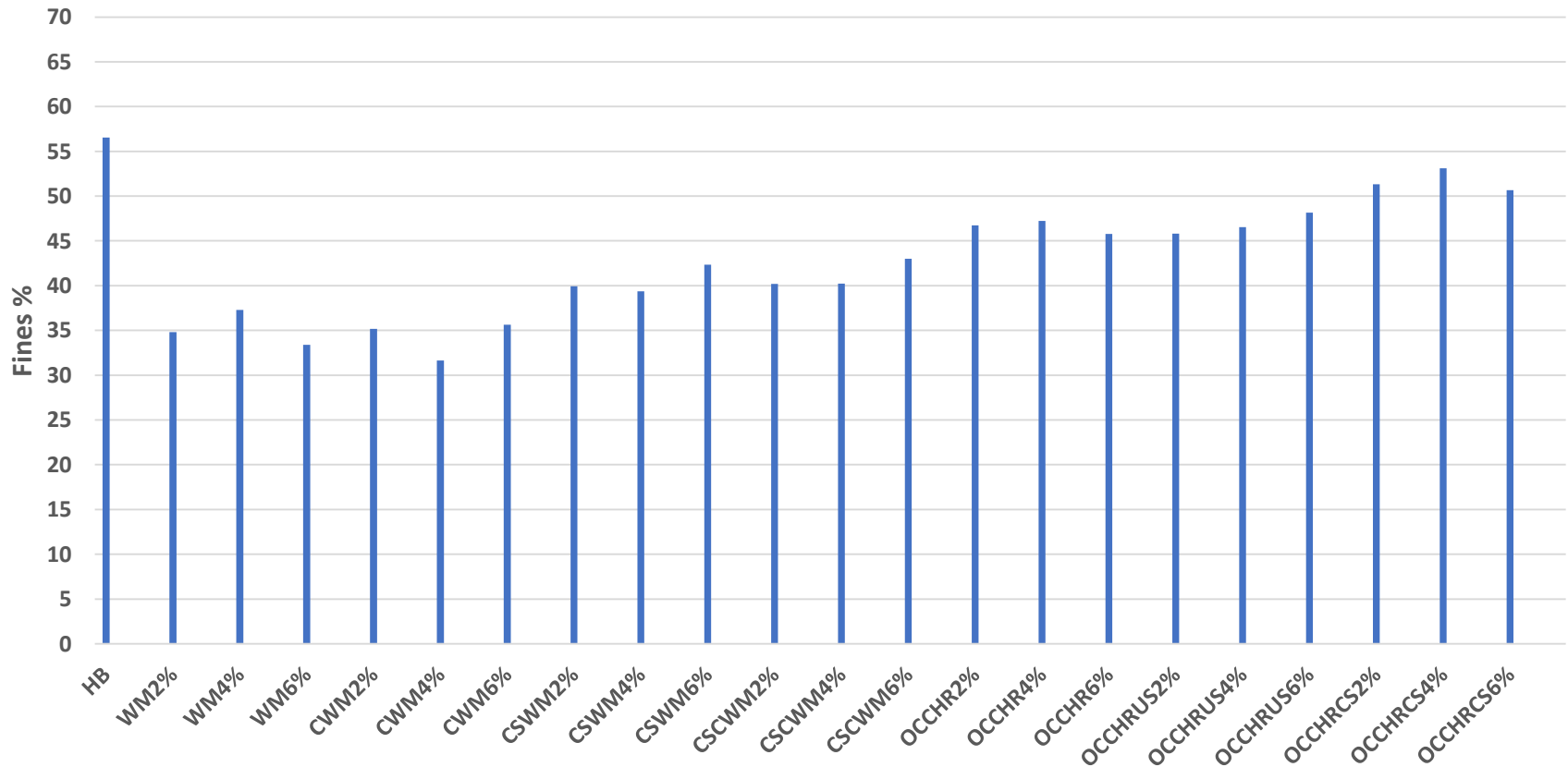
Selected Results- In-Situ PCC Manufacturing



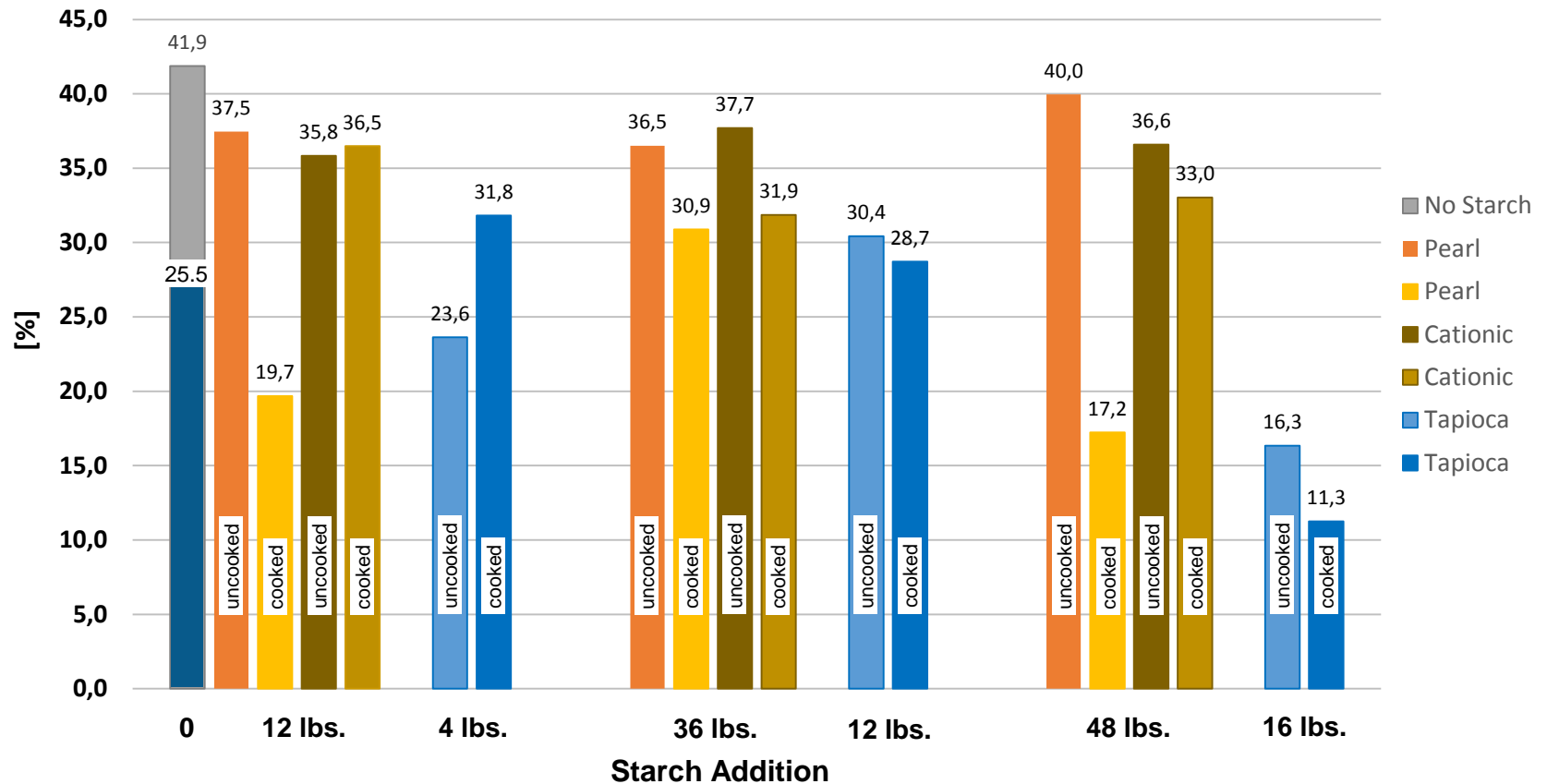
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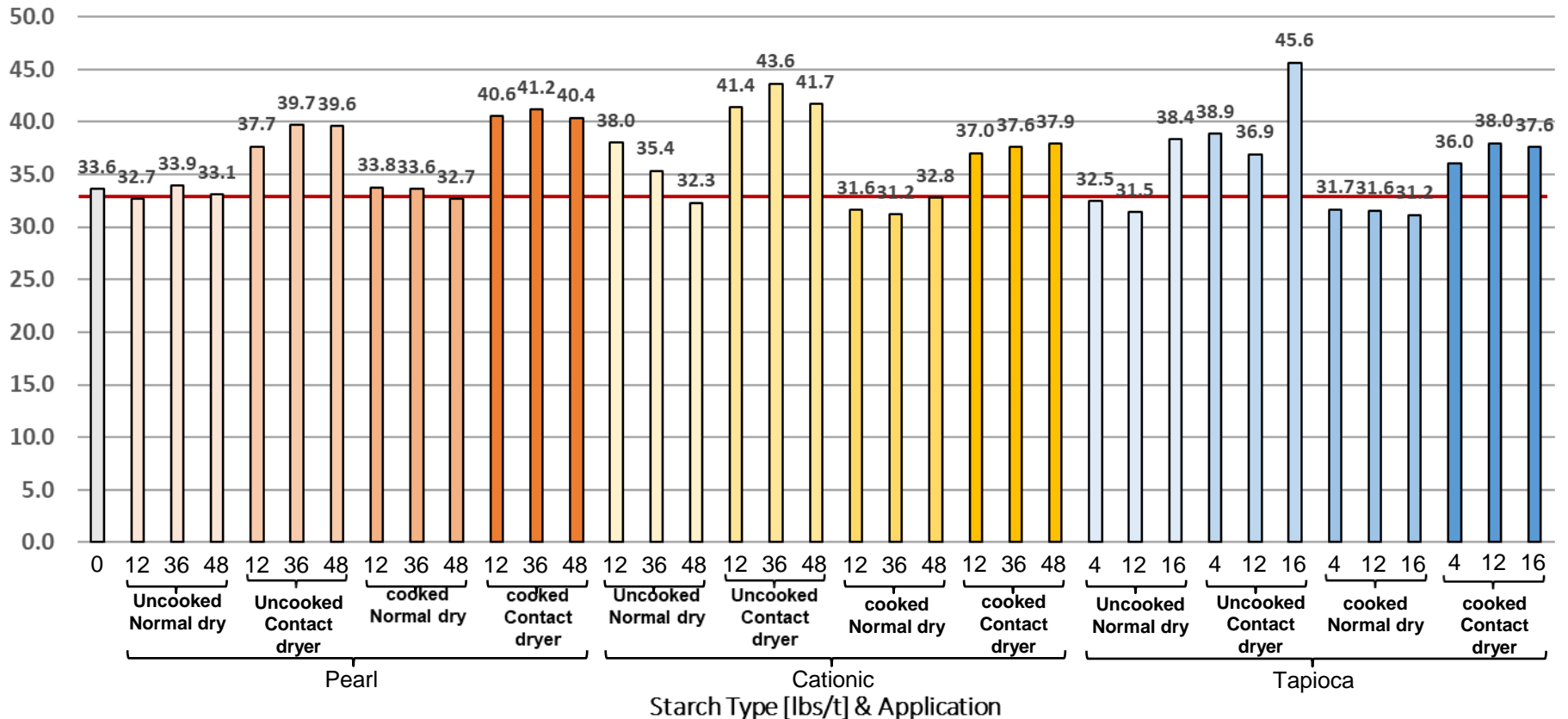
Selected Results- Fine Content Based on Additive Addition (Britt Jar)



Selected Results- Fine Content Based on Starch Addition (Britt Jar)



Selected Results - Tensile Index [kNm/g]



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Conclusion – What we learned

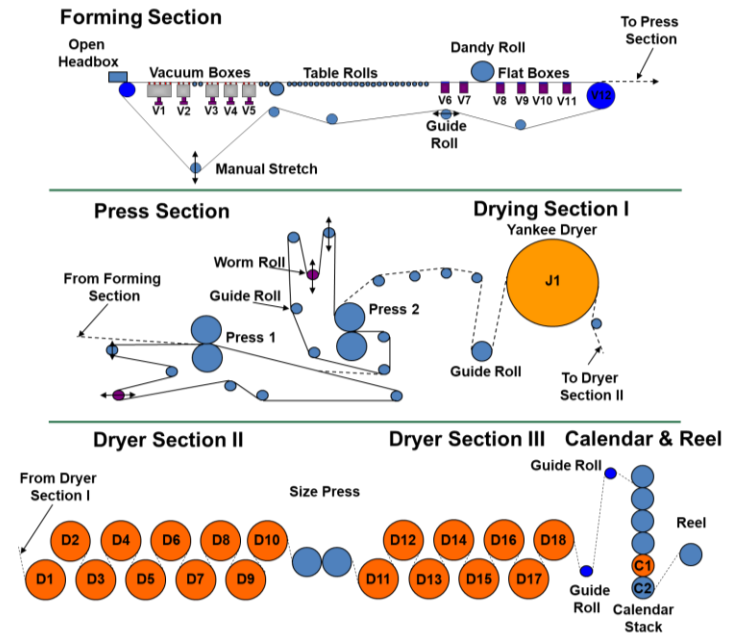
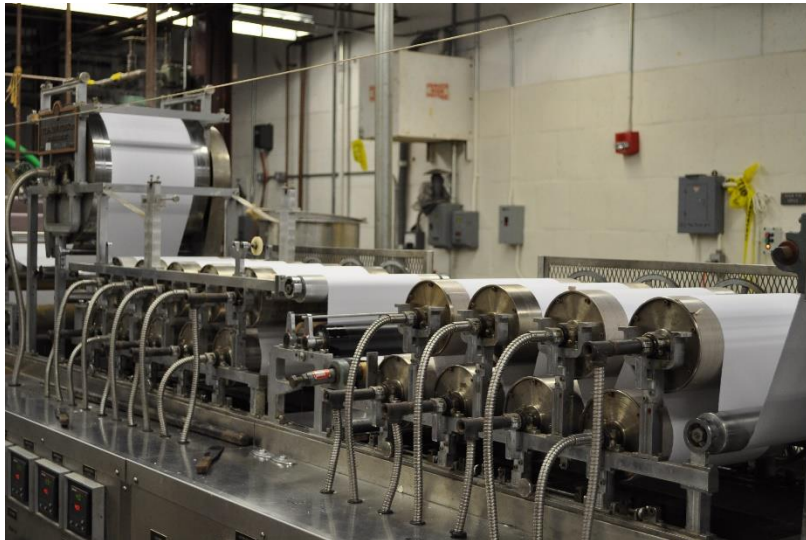
- **In-situ PCC can be manufactured of up to 100% filler content based on OD fiber with various raw materials.**
- **TAPPI Handsheet making from up to 20 g/m² containing up to 100% high refined pulp.**
- **Handsheet forming, starch addition & heat activation is important for testing outcome**
- **Unmodified pearl starch seems to work best for “our” OCC.**
- **Finer woodmeal works better the coarse woodmeal**
- **High refined pulp increases fine content, paper strength ?**
- **Higher concentrations of dry strength additives may increase mill costs without offering substantial benefits –cost analyses?**

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Next Steps:

- Continue handsheet study on recycled material followed by
- 12" pilot paper machine runs



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1. <https://www.suny.edu>
2. <https://www.suny.edu/about/fast-facts/>
3. The Future of Global Packaging to 2022, Smithers Pira
4. <https://www.statista.com/topics/1701/paper-industry/>
5. Doelle K, Lee AT, et.al., Laboratory paper machine evaluation of Poly-Lactic Acid (PLA) on paper properties of unbleached recycled pulp, *Lignocellulose Journal*. 2014;3(1):51-58.
6. Dölle K., Bajrami B. (2021). “In Situ Precipitated Calcium Carbonate in the Presence of Pulp Fibers – A Beating Study”. *Journal of Engineering Research and Reports*, 20(8), 1-17.
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Thank you:

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Questions

&

Answers

