PPPL PRINCETON PLASMA PHYSICS LABORATORY

Implementing the Advanced Annular Couette Centrifuge Method to Optimize Liquid Centrifugation

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Advanced Annular Couette Centrifuge (AACC)

- The Advanced Annular Couette Centrifuge (AACC) was developed by researchers at PPPL
- Modified Taylor-Couette device that limits secondary flows and turbulence with a faster rotating inner cylinder and end-cap rings spinning at intermediate speeds
- Method to enhance separation efficiency of liquid centrifuges
- Promotes mixing and separation by keeping the liquid in one container and adjusting the two rings' speeds

Applications

- Focused on determining the effectiveness of implementing the AACC technology into current types of centrifuges used in the industries around the world
- AACC technology can reduce process times and cost efficiencies when implemented
- AACC method can be applied to the production of:
  - Fruit Juices and Processing
  - Paints, Dyes, and Inks
  - Animal Slurry

Fruit Juices and Processing

Application

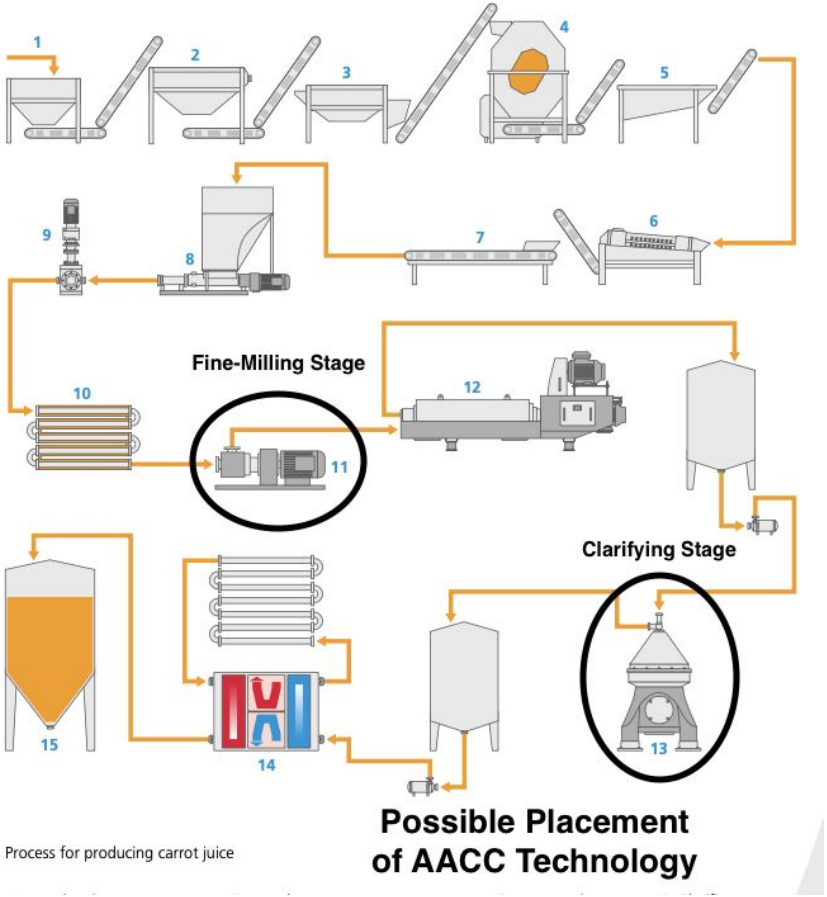
- Centrifugal separation technology to produce juices is both economical and efficient
- Commonly seen during the final stage of purification of liquids or for recovering of solids
- Used for berries, stone fruits, tropical fruits, apples, and vegetables
- Each fruit has its own unique processing line to achieve the desired final product

Implementing the AACC Technology

- Stages in the process:
  - Clarifying juice stage
  - Simultaneous separation and clarification of the juice
  - Trub and retentate processing
- Help with clarifying and fine-tuning the product before it continues to the final stages of evaporating to achieve a higher concentration
- Higher separation technology allowing future stage of centrifugation of the solid content

Clarifying Stage

- Grape juice
  - Clarifying of the fresh juice
  - Polishing and clarifying the retentate in conjunction with ultrafiltration
- Carrot juice
  - Use as a fine-milling and clarifier



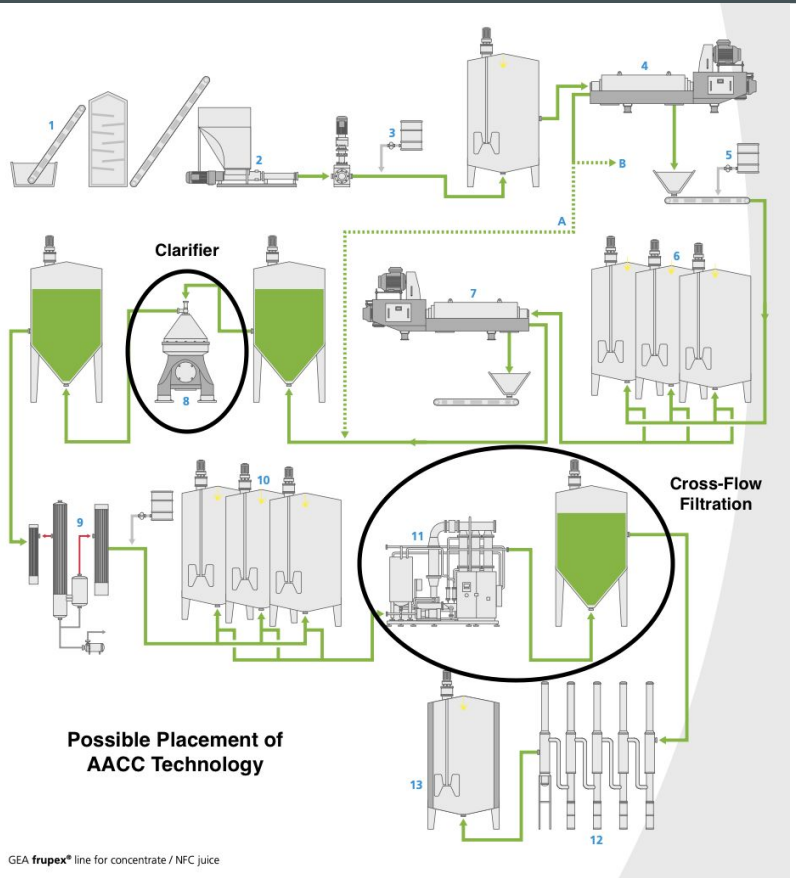
[1] Image from GEA Westfalia: "GEA Centrifuges for the Fruit-Processing and Juice Industries"

Trub Processing

- Trub is the smallest particles that are produced from the pulp of the fruit, the skin, cores or any unwanted substances that are in the juice during the extraction process
- Trub has to processed fresh
- Can separate the solids while the juice returns to the main flow
- This phase of separation can be performed continuously by a decanter

If the PPPL technology is used, the process can be faster with a shorter processing time

Apples



- Retained trub particles that are a byproduct of Cross-flow filtration
- AACC method would further fine and rapidly produce high-quality juice

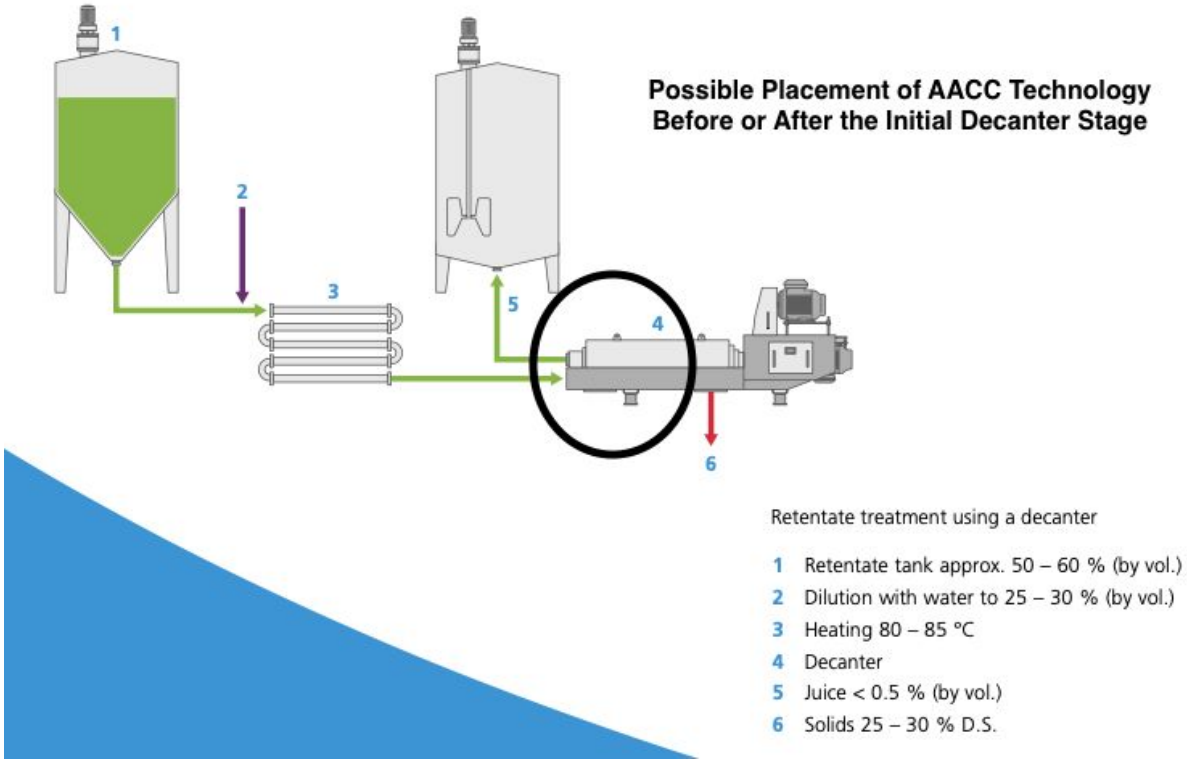
[1] Image from GEA Westfalia: "GEA Centrifuges for the Fruit-Processing and Juice Industries"

Retentate Processing

Placing the AACC method before or after could help aid the separation of solids from the juice, as the particles are smaller and can further be disposed of

- Adding the technology in a secondary current to the retentate circuit
- Improve cleaning intervals and permeate output as solids are continuously separated
- Using a separator instead of the decanter, as the process runs parallel with the regular juicing operation, the AACC method can be used to run consecutively with the decanter.
  - It would work as fast and be time-efficient

Retentate Processing



Example of Concentrating the Retentate in batches using a Decanter
[1] From GEA Westfalia: "GEA Centrifuges for the Fruit-Processing and Juice Industries"

Other Fruits

PPPL technology can improve the high-performance separator, polishing the juice to top filing quality

- Stone Fruits - plums are juiced directly after milling and stone removal
- Berry fruits
  - In the case of further processing the juice to obtain the flavor
  - Help with fining and filtration of the juice

Minimize the number of processing stages required for clarification as we can aid in the removal of coarse fibers

- The AACC method would aid in limiting the amount of solids in the juice
- Eliminating the need for 3- or 4-Stage arrangements of screws
- This would eliminate an extra decanter in the processing line

Paints, Dyes, and Inks

Industry Today

- Paints, dyes and inks have a small particle size that is no more than a few micrometers
- Requires high speeds and large clarification areas in the centrifuge to obtain the desired particle size class in the end product
- GEA Westfalia's system consists of chamber bowl and continuous disk stack centrifuges

AACC Method to Aid Production

- The separation technology of the AACC can aid the purification and centrifugation process
- Further efficiently polish the solids to improve the higher solids removal rate and loss of product
  - This can reduce or eliminate the need for a second processing step
- Smaller companies and manufacturers could use the technology as there could be a smaller discharge system
  - Inks are often mass produced causing the use of a large discharge port

Due to the small particle size, the AACC method would prevent potential clogging due to the sticky colors, dyes, and inks during the speedy discharge of the output

Animal Slurry

Animal Slurry and Manure Separation

- Animal slurry contains plant nutrients and, if left untreated, can lead to odor emissions or discharge to the environment
- Current challenge of reducing cost and improving the efficiency of animal slurry separation
- Separation allows water to be recycled and the solids to be re-used as compost or fertilizer

Current Separation Process

- Many different types of separators can be used for this process:
  - Floor scrapers
  - Draining and pump systems
- Solid-liquid separation can be forced using centrifuges
- In house separation will help remove costs and improve efficiency
- Major disadvantages to the current processes are that they require investments in expensive equipment, require maintenance, and have limited life-span

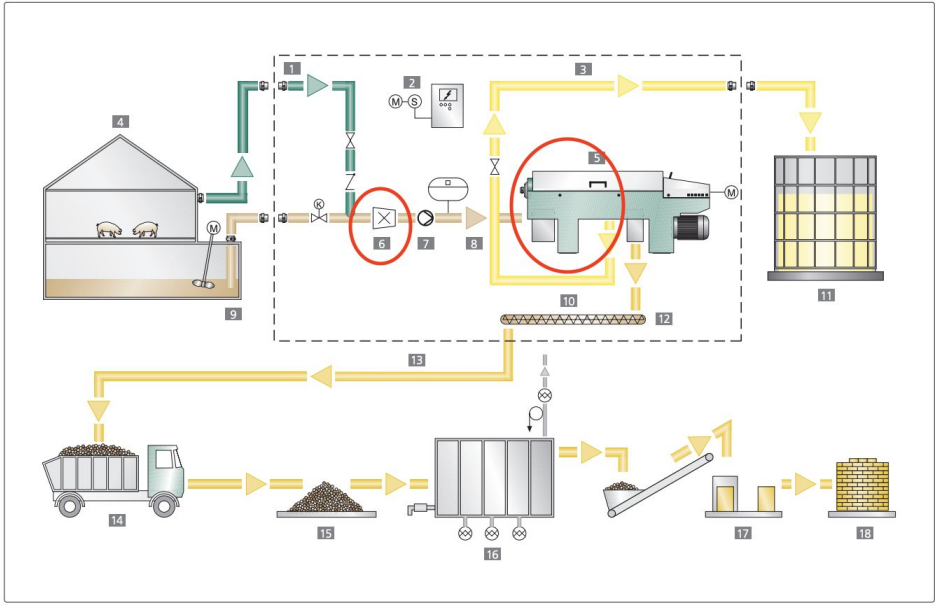
Limit Clogging in Filters

- Filters are commonly used to retain solid fractions during the separation process
- Small particles tend to get caught in the filter media, reducing filtering efficiency
- The AACC can limit the risk of sedimentation or blockage that occurs in pipes and channels during post-separation treatment

The AACC technology can limit the amount of clogging by these small particles by increasing separation before going through the filter

Processing of Liquid Manure

- AACC separation technology allows for further clarification during the decanter stage (5) or the macerator stage (6)
- Separation during macerator stage will further separate larger-sized particles from the liquid mixture



[2] Image from GEA Westfalia: "Image Brochure Environmental Technology"

Reducing the Amount of Batch Settling Systems

The AACC technology can decrease the amount of batch settling systems and improve the continuous sediment separation

- The small particles increase the viscosity of the slurry liquid, limiting the amount that can be separated efficiently
- Mechanisms of batch settling systems, rather than a system that is continuously separating, can solve this issue
- By reducing the total time of separation, it will limit the fermentation that occurs in the slurry

- Further identify if the AACC technology can be applied in:
  - Milk De-fattening
  - Fish Farm Purification
  - Immiscible fluids
  - Dewatering efficiency in different levels of oil viscosity
- Contacting companies like GEA Westfalia and Flottweg
- Discover the limiting factor in these process lines

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- Thank you also to Dr. Erik Gilson.

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