PERLMUTTER &IDEADEVELOPMENT

AFS AMERICAN FILTRATION & SEPARATIONS SOCIETY

CONTINUUM APPROACH TO OPTIMIZING DOWNSTREAM FINAL DRYING WITH UPSTREAM SOLID-LIQUID FILTRATION

Barry A. Perlmutter
President
Perlmutter & Idea Development LLC
(P&ID)

13TH WORLD FILTRATION CONGRESS
SAN DIEGO CALIFORNIA USA OCTOBER 5-9, 2022

BARRY A. PERLMUTTER

Perlmutter & Idea Development LLC

Matthews, North Carolina 28106

E-mail: barry@perlmutterideadevelopment.com

Website: https://perlmutterideadevelopment.com/

Barry is President of Perlmutter & Idea Development LLC. He has over 40 years of technical engineering and business marketing experience in the field of solid-liquid separation including filtration, centrifugation, and process drying. His strong professional skills focus on process solutions, innovation strategy, market expansion and business development. Barry has published and presented worldwide on applications in the Fluid, pharmaceutical, and energy/environmental industries and has been responsible for introducing many European companies and technologies into the Americas marketplace. He is an author of Elsevier's "Solid Liquid Filtration Handbook" and editor of a second book for Elsevier, "Integration & Optimization of Unit Operations."

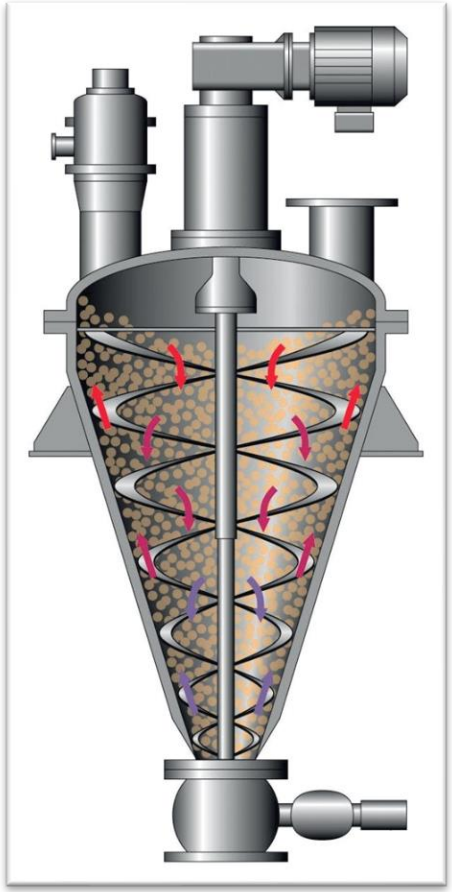
PRESENTATION OVERVIEW

- Most often when analyzing a new process development approach, engineers take a “silo” approach and look at each step independently
- This presentation illustrates that by taking an integrated and holistic approach and looking at each step not individually but as an integrated-continuum, the process solution becomes more efficient
- Data is presented showing how to balance each of process steps for maximum efficiency
- Three Applications:
  - Continuous Pressure Filtration to Batch Conical Dryer
  - Batch Centrifugation to Batch Conical Dryer
  - Batch Centrifugation to Batch “Nauta-Type” Dryer

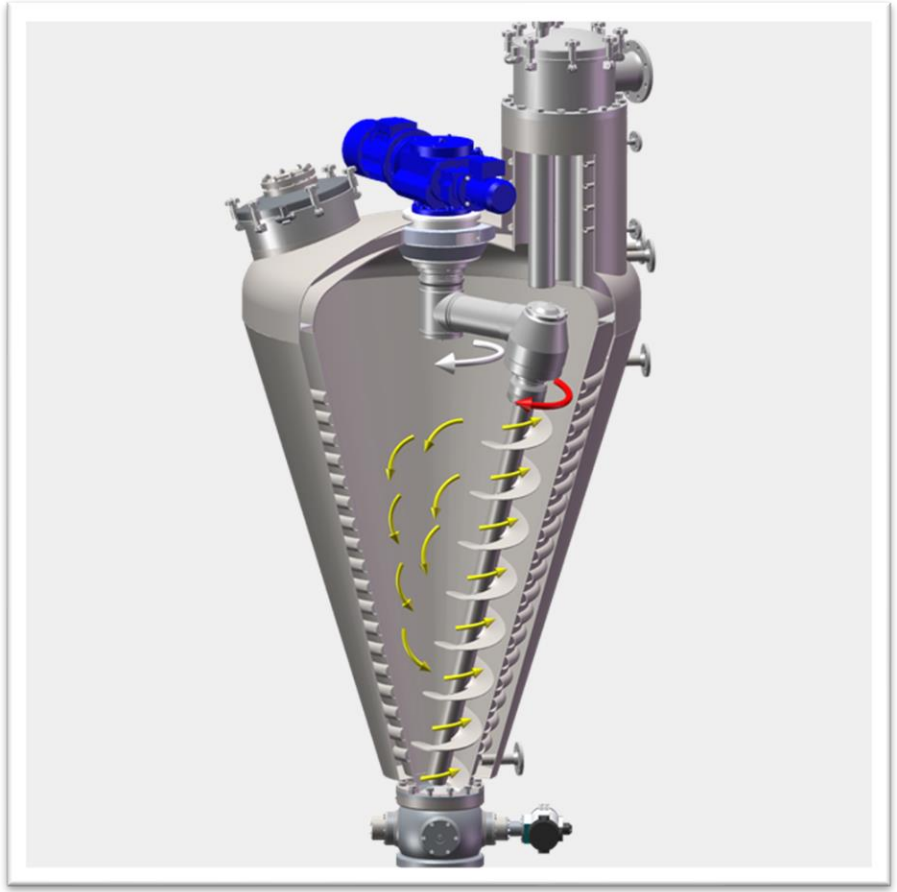
ALTERNATIVE TECHNOLOGIES OVERVIEW

- Solid-Liquid Filtration Technologies
  - Continuous Pressure Filter
    - “Single-Drum” Design
    - “Drum with Individual Cells” Design
  - Batch Centrifuge
    - Vertical Peeler
    - Horizontal Inverting

ALTERNATIVE TECHNOLOGIES OVERVIEW



Conical Dryer



“Nauta-Type Dryer

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 1: Continuous Pressure Filtration to Batch Conical Dryer

- This specialty chemical process has crystals in a methanol slurry which must be filtered, washed, dewatered and then dried

- Objectives for Expansion:
  - Continuous Operation from Batch Operation
  - Maximum solid-liquid filtration performance
  - Low wash ratios for minimum wash media consumption
  - Lowest possible residual moisture in discharged filter cake
  - Final moisture of <1.0%

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 1: Continuous Pressure Filtration to Batch Conical Dryer

- The standard approach is to optimize the solid-liquid filtration step with maximum washing and pre-drying efficiency and then with this information optimize the downstream drying

- The operating company, however, took a different approach and looked at the process as an integrated-continuum from solid-liquid filtration through cake washing and dewatering to final drying.

- The Integrated-Continuum Approach" resulted in operational energy and nitrogen savings as well as lower capital and installation costs for a more efficient and reliable process.

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 1: Continuous Pressure Filtration to Batch Conical Dryer

LAB TESTING

CAKE STRUCTURE /PROCESS RESULTS

- Cake Thickness (25 mm)
- Pressure Filtration (4 barg)
  - Flux rate (Less than 2 minutes @ 200 kg DS/m^2/hour);
  - Suitable for continuous pressure filtration
- Filter Media (14 um)
- Cake Washing (Efficient wash ratios of 0.7 to 1.2 kg MeOH/kg DS)
- Cake Drying (11 – 30%)
- Cake Discharge (Good)

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 1: Continuous Pressure Filtration to Batch Conical Dryer

LAB TESTING SCALE-UP

- Media = 14 micron and a cake thickness of 25 mm
- Filtration times and filtrate quality were achieved
- Efficient wash ratios of 0.7 to 1.2 kg MeOH/kg DS
- The moisture content varied between 11 – 30% based upon the nitrogen for blowing for drying
- Sizing of the Continuous Pressure Filter for moisture of 11% resulted in a filtration area of 2.88 m2 with a nitrogen solvent recovery package to reduce the nitrogen usage
- This is the important point for the optimization testing of the dryer.

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 1: Continuous Pressure Filtration to Batch Conical Dryer

PROCESS DRYING RESULTS

Initial moisture	Max. product temp.	Vacuum (mbar)	Drying time	Final moisture	Dryer Size
17.5%	65°C	100 - 300	45 min	<1.0%	2.4 m3
11.6%	95°C	5-120	35 min	<1.0%	1.9 m3
30 %	65°C	100 - 300	63 min	<1.0%	3 m3

The conclusion from the testing shows a small increase in the drying time and dryer sizing from a cake moisture of 30% moisture as compared with 11.6%.

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 1: Continuous Pressure Filtration to Batch Conical Dryer

- Initial Design
  - Filter Size: 2.88 m^2 with 11% moisture using 260 m^3/hr N_2 + Vacuum
  - Dryer Size: 1.93 m^3
  - Dryer Cycle Time: 35 minutes
  - Total System Budget Price: $2 million
- Optimized Design
  - Filter Size: 1.44 m^2 with 30% moisture using 200 m^3/hr N_2 + Vacuum
  - Dryer Size: 3.0 m^3
  - Dryer Cycle Time: 60 minutes
  - Total System Budget Price: $1.5 million

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 2: Batch Centrifugation to Batch Conical Dryer

LAB & PILOT TESTING-CENTRIFUGATION

Pharma Product C:

Required capacity, dry solids: 1200 kg in 6 days (20 h day) ➔ 10 kg/h

Option 1 with No Pre-drying :

Capacity for 600 mm centrifuge, Residual Moisture is approximately 10 % w/w

Option 2 with Pre- drying:

Capacity for 600 mm centrifuge with Pressure Gas at 49°C, Residual Moisture is approximately 4 % w/w

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 2: Batch Centrifugation to Batch Conical Dryer

LAB & PILOT TESTING-CENTRIFUGATION

Pharma Product M:

Required capacity dry solids: 1000 kg in 4 days (20 h day) ➔ 12.5 kg/h

Option 1- Centrifugation with No Pre-drying

Capacity for 600 mm centrifuge, Residual Moisture is approximately 35 % w/w

Option 2- Centrifugation + Pre- drying

Capacity for 600 mm centrifuge with Pressure Gas at 25°C, Residual Moisture is approximately 17 % w/w

EXAMPLE 2: Batch Centrifugation to Batch Conical Dryer

LAB & PILOT TESTING-DRYING

Pharma Product C:

Required capacity solid dry: 1200 kg in 6 days (20 h day) ➔ 200 kg/day with < 1% hexane

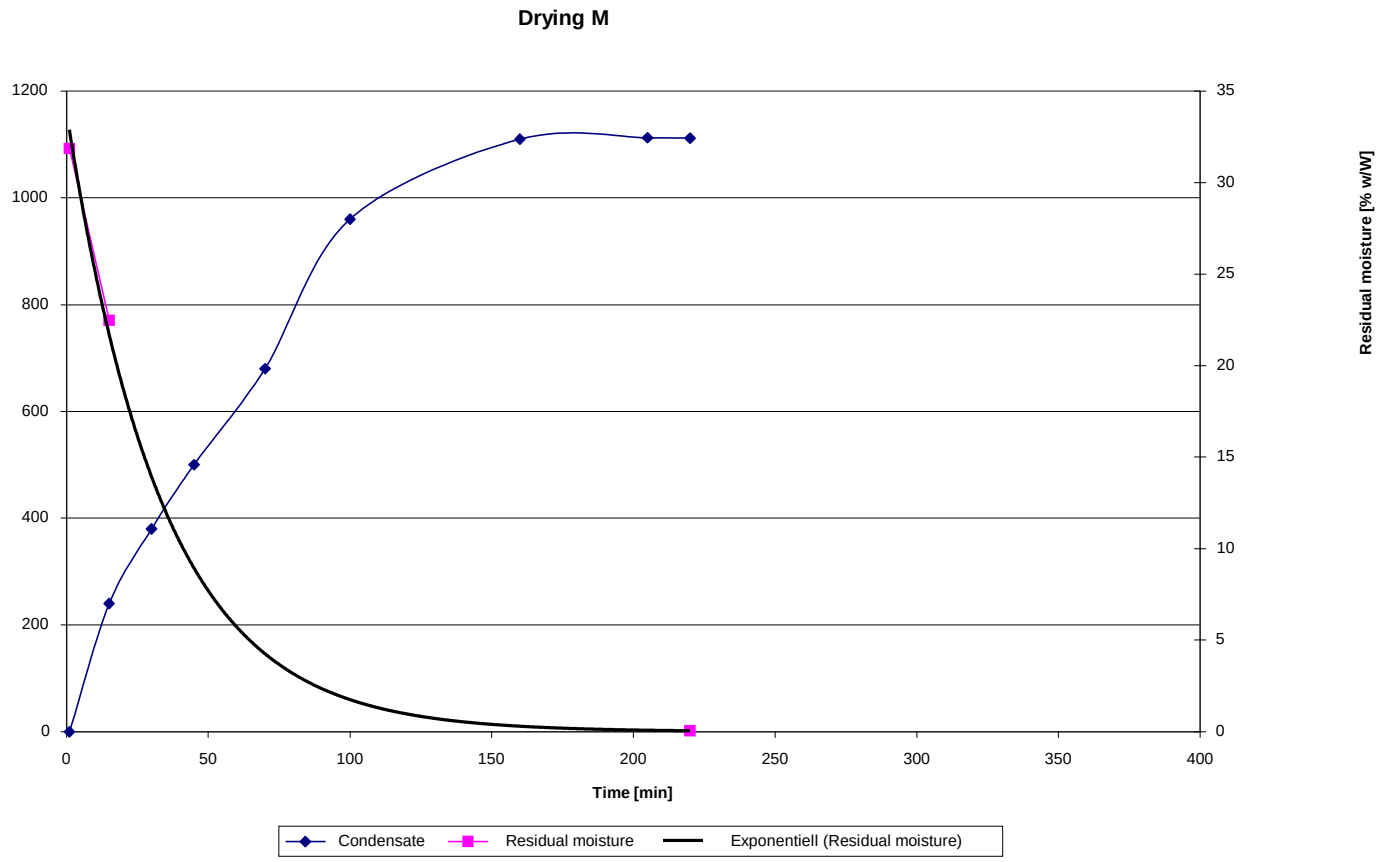
Pharma Product M:

Required capacity solid dry: 1000 kg in 4 days (20 h day) ➔ 250 kg/day with < 100 ppm heptane

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 2: Batch Centrifugation to Batch Conical Dryer

LAB & PILOT TESTING-DRYING



PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 2: Batch Centrifugation to Batch Conical Dryer

FINAL PHARMA DESIGN

- One 800 mm Centrifuge
- No Pre-Drying for Nitrogen Savings
- One 1.5 m^3 Conical Vacuum Dryer
- Achieved Capacity with 10% Spare Capacity

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 3: Batch Centrifugation to Batch "Nauta-Type" Dryer

DECISION ANALYSIS & LAB TESTING

- Multipurpose Pharma Plant
  - Product A: 400 tons/year and Product B: 100 tons/year
- Centrifuge Choices
  - One (1) x 1000 mm
  - Two (2) x 800 mm
  - With or Without Pre-Drying
    - Product A: 23% to 42% LOD
    - Product B: 18% to 23% LOD
- "Nauta-Type" Conical Screw Dryer Choices
  - Two (2) x 200-liter dryer or Two (2) x 250-liter dryer
  - One (1) x 400-liter dryer

PERLMUTTER &IDEADEVELOPMENT

EXAMPLE 3: Batch Centrifugation to Batch "Nauta-Type" Dryer

FINAL PHARMA DESIGN

- Multipurpose Pharma Plant
  - Product A: 400 tons/year
  - Product B: 100 tons/year
- Centrifuge Decision
  - **One (1) x 1000 mm**
  - **Without Pre-Drying**
- Nauta Conical Screw Dryer Decision
  - **One (1) x 400-liter dryer**

PERLMUTTER &IDEADEVELOPMENT

SUMMARY & TAKEAWAYS

- As operating companies develop new and unique chemical processes, there are many choices for filtration, cake washing, dewatering and drying.
- Engineers must evaluate all outcomes to make an informed and successful decision.
- Technical evaluation and, as shown, laboratory and pilot testing are critical for a successful decision and project.
- The take-away is that close collaboration between the operating company and the vendor will allow for creative problem-solving and process solutions to achieve the desired quality and production requirements.

PERLMUTTER
&IDEADEVELOPMENT

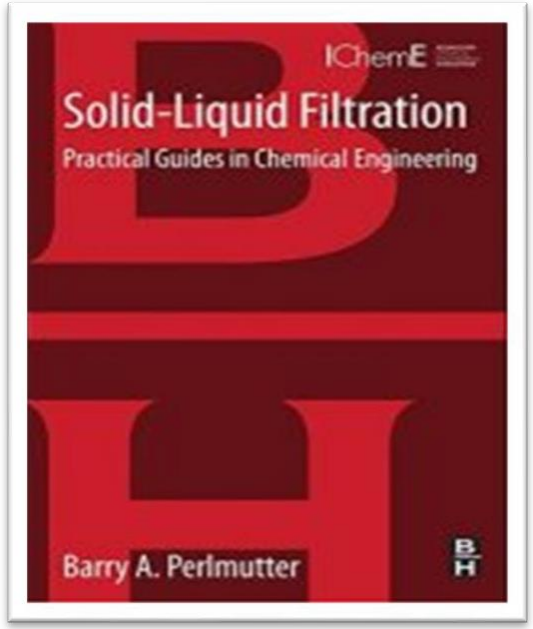
Barry A. Perlmutter, President

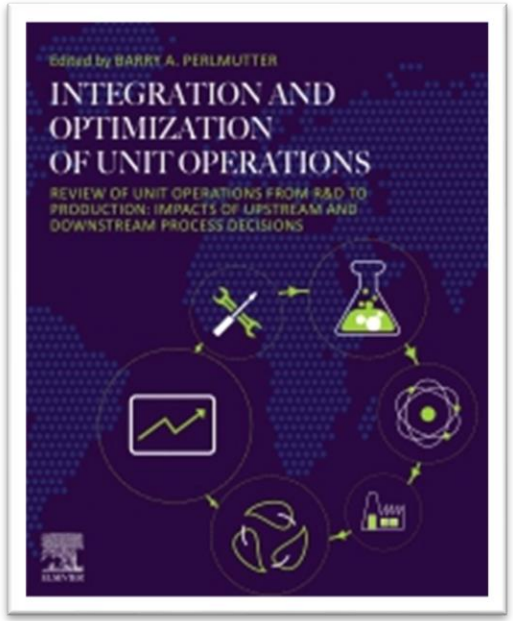
E-mail: barry@perlmutterideadevelopment.com

Telephone: +1.704.996.0466

Website: https://perlmutterideadevelopment.com/

Solid-Liquid Filtration





Integration & Optimization of Unit Operations