

Macro Stickies and Screening

- Background
- Research Objective
- Results and Discussion
 - **PSA Particle Screening**
 - PSA Particle Breakage
 - PSA Particle Extrusion
- Overall Conclusions
- Future Research



Pressure Sensitive Adhesives

- Pressure sensitive adhesive base polymers consist of acrylic or rubber-based polymers
- Glass transition temperature is below room temperature and depends on the adhesive formulation
- Young's modulus and shear strength are low and depend on the adhesive formulation and the system temperature

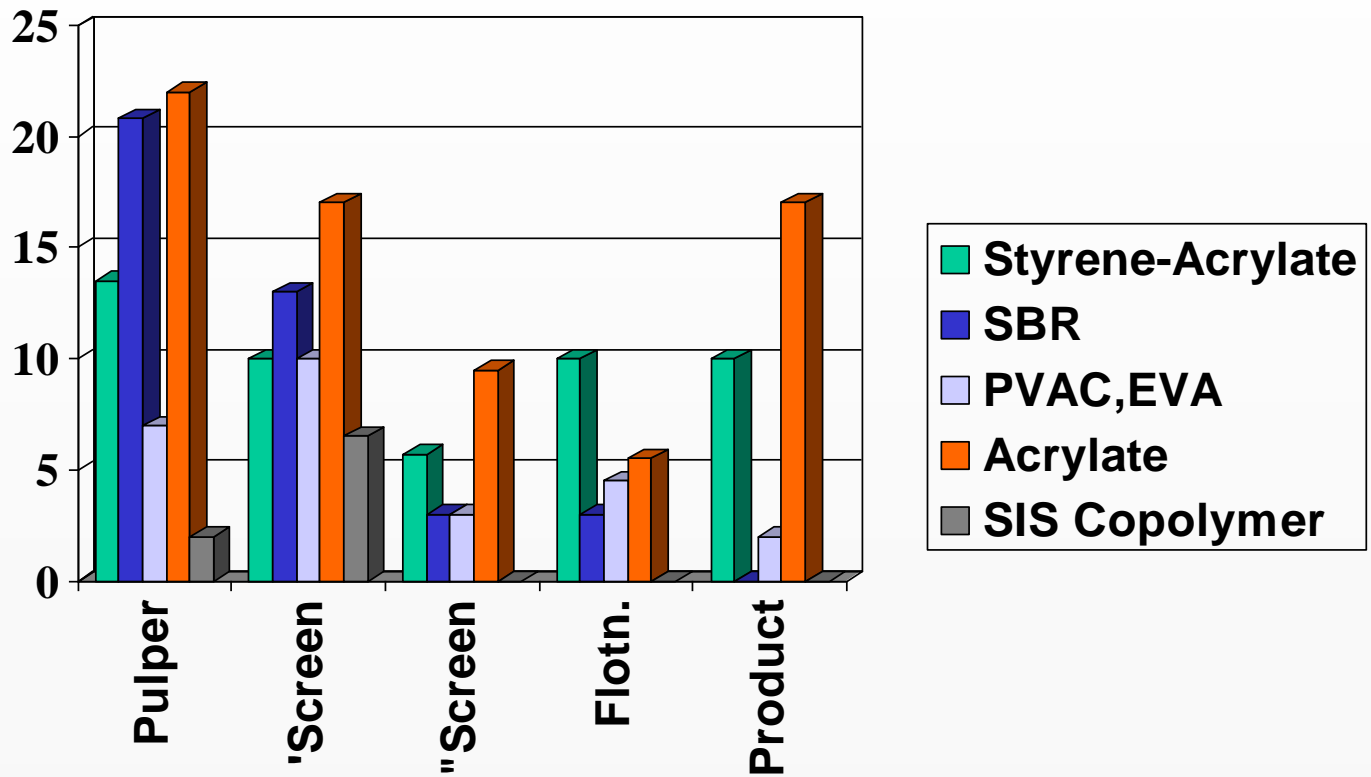
Pressure Screening

- Pressure screening is considered to be the most effective way to remove adhesive contaminants from pulp
- Typical removal efficiencies of adhesive contaminants range from 50 to 80% for commercial pressure screens



Analysis of Stickies -- SOW

M. A. Pikulin, AF&PA and USPS Joint Conference to
Address PSA Issues, June 1996



Particle Breakage

- Breakage of PSA particles depends on the:
 - Shear/tensile strength of the PSA
 - Shear/tensile forces in the device
- If the forces in the device are greater than the strength of the PSA material, then the PSA material will break

Research on Screening of Stickies

- Studies of the effects of operating parameters and equipment on removal efficiency by:
 - Consistency, slot velocity, and slot width [Vitori, Pulp and Paper Canada, 1993]
 - Reject rate, rotor speed, and slot velocity [Heise, Tappi Journal, 1992]
 - Consistency, reject rate, rotor speed, slot velocity, and slot width [Seifert, et. al., 5th Research Forum on Recycling, 1999]
 - Consistency, rotor speed, slot velocity, and slot width [Saint Amand and Perrin, Tappi 1998 Pulping Conference, 1998]

Results from Previous Research

- Removal efficiency increased to a maximum at an optimum consistency
- Removal efficiency increased as the:
 - Reject rate increased
 - Rotor speed, slot velocity, or slot width decreased
- Weaknesses in the studies were:
 - Undefined materials
 - Relationships between efficiency and operating conditions were defined but not explained
 - Little insight provided on the mechanism of passage

Outline

- Background
- Research Objective
- Results and Discussion
 - **PSA Particle Screening**
 - PSA Particle Breakage
 - PSA Particle Extrusion
- Overall Conclusions
- Future Research



Research Objective

- To understand how the operating conditions and adhesive formulation affect the passage of pressure sensitive adhesive particles in industrial and laboratory screens

Outline

- Background
- Research Objective
- Results and Discussion
 - **PSA Particle Screening**
 - PSA Particle Breakage
 - PSA Particle Extrusion
- Overall Conclusions
- Future Research

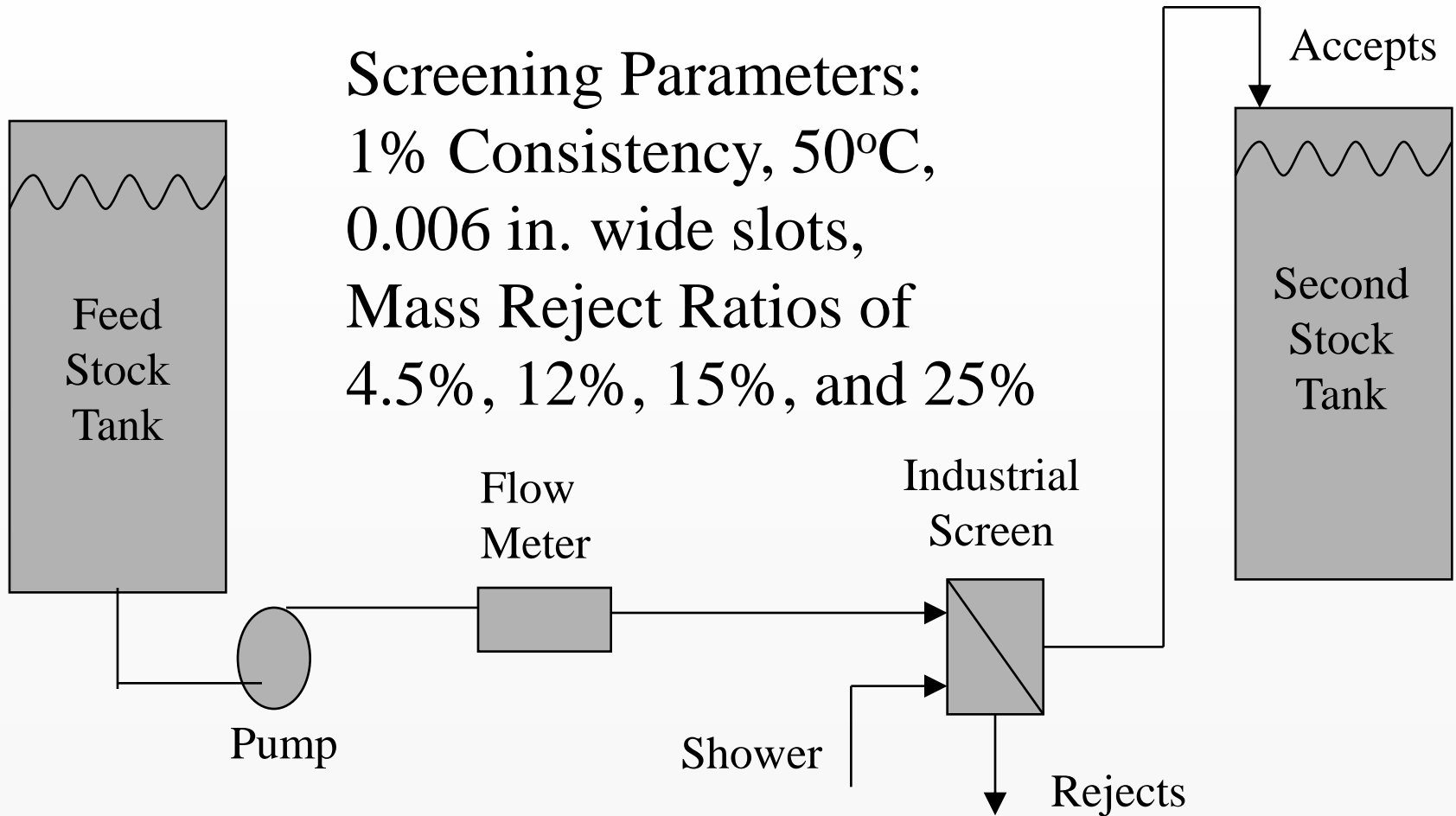


PSA Particle Screening

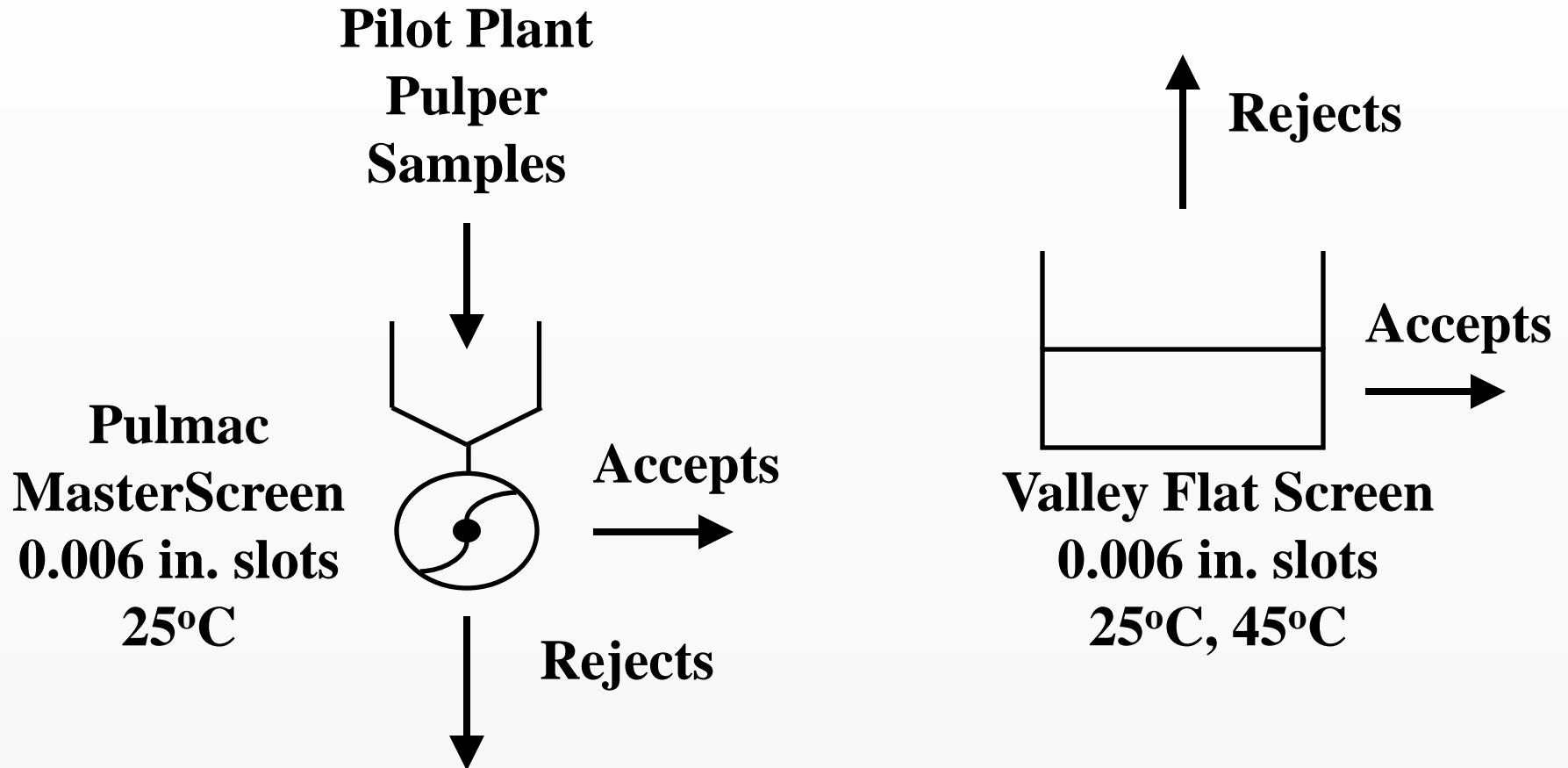
- **Do pressure sensitive adhesive particles behave differently in industrial pressure screens than in laboratory screens?**
- Approach: Study the removal of pressure sensitive adhesive particles by an industrial pressure screen and laboratory screens

Pilot Plant Layout

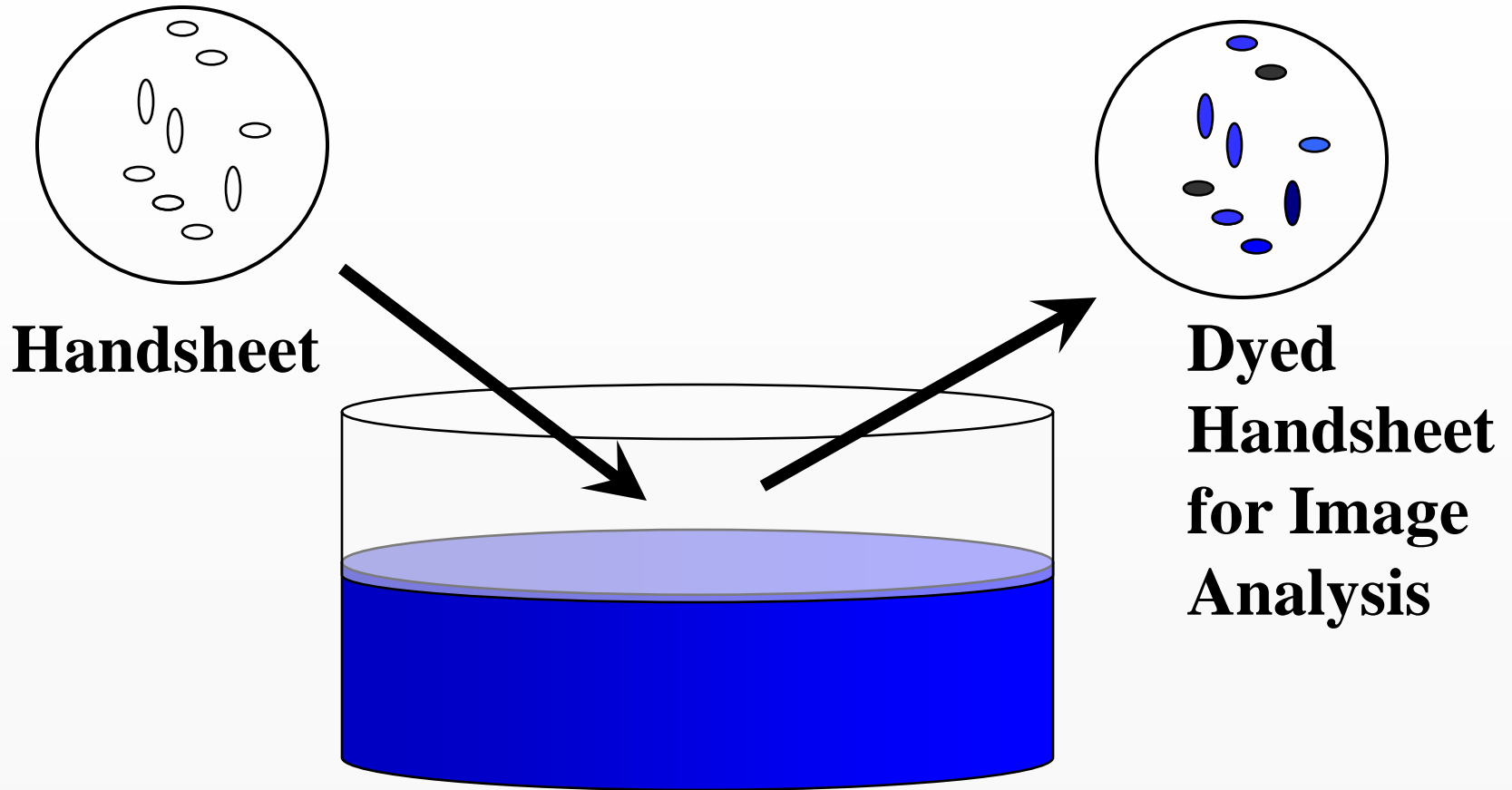
Screening Parameters:
1% Consistency, 50°C,
0.006 in. wide slots,
Mass Reject Ratios of
4.5%, 12%, 15%, and 25%



Lab scale screening

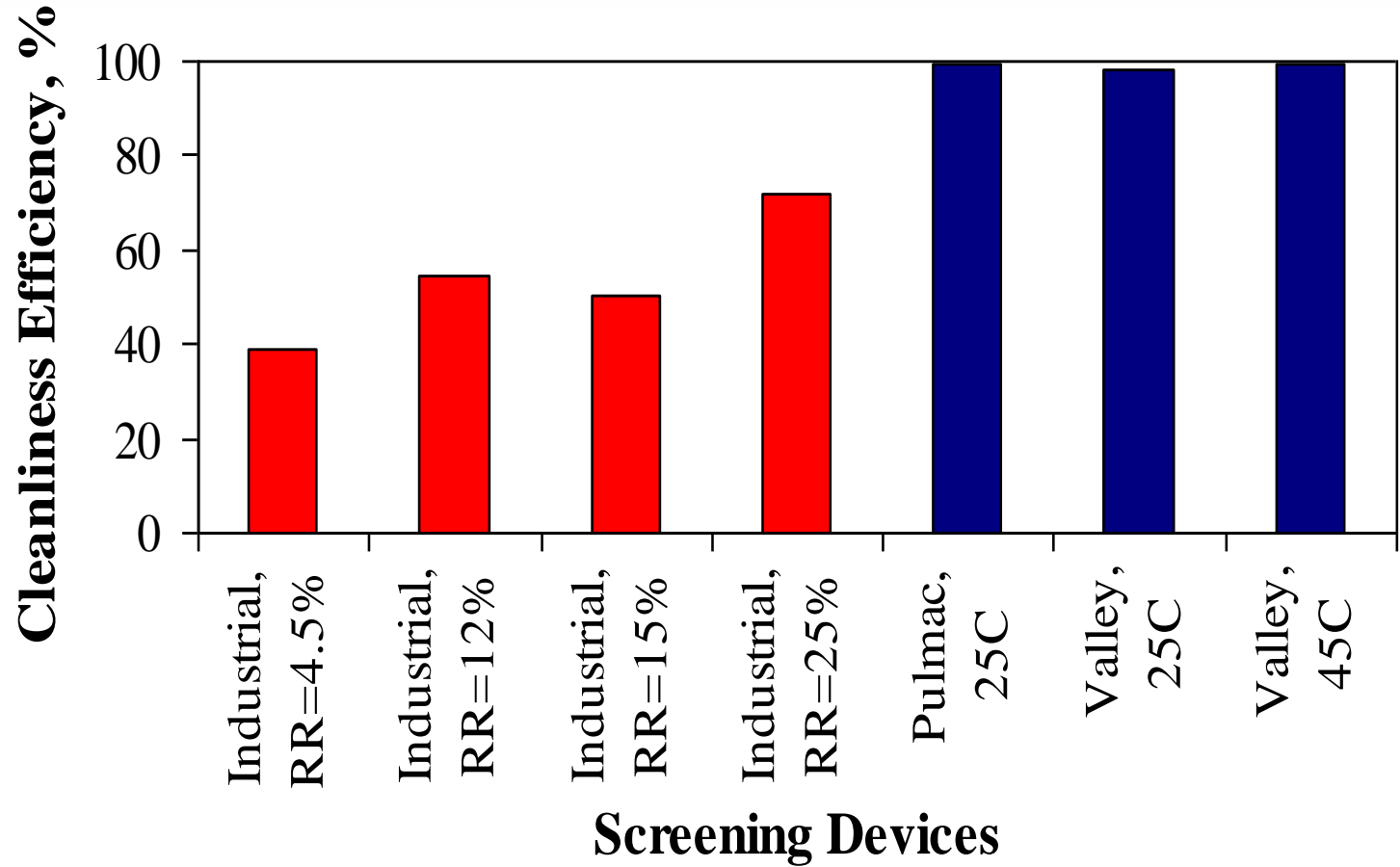


Detection of Stickies



Morplas Blue - Heptane Dye Solution

Cleanliness Efficiency of Industrial and Laboratory Screens



PSA Particle Screening

- Do pressure sensitive adhesive particles behave differently in industrial pressure screens than in laboratory screens?
- **Yes, pressure sensitive adhesive particles behave differently in industrial pressure screens (40-70% efficiency) than in laboratory screens (99% efficiency).**

Outline

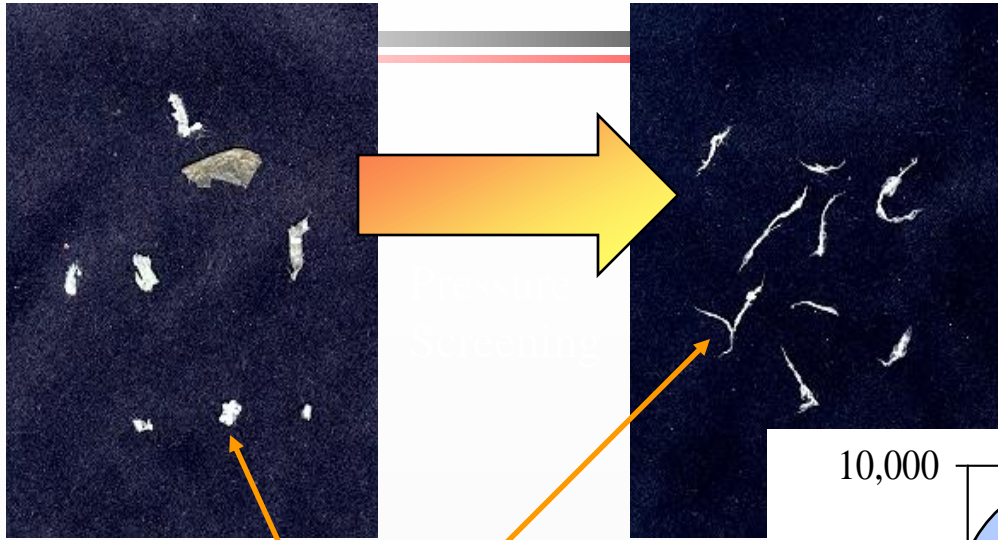
- Background
- Research Objective
- Results and Discussion
 - PSA Particle Screening
 - **PSA Particle Breakage**
 - PSA Particle Extrusion
- Overall Conclusions
- Future Research



PSA Particle Breakage

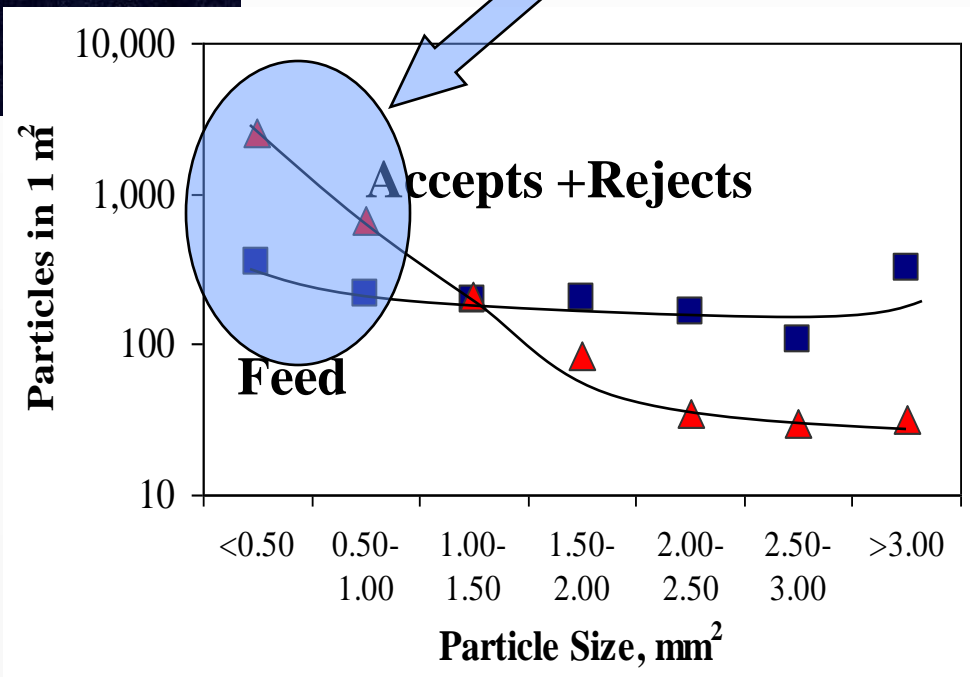
- **Do PSA particles breakdown in the industrial pressure screen?**
- Approach: Analyze the PSA particles before and after the industrial pressure screen

Intense Forces in a Industrial Slotted Pressure Screen Break/Deform Adhesives: Decreases Screening Efficiency

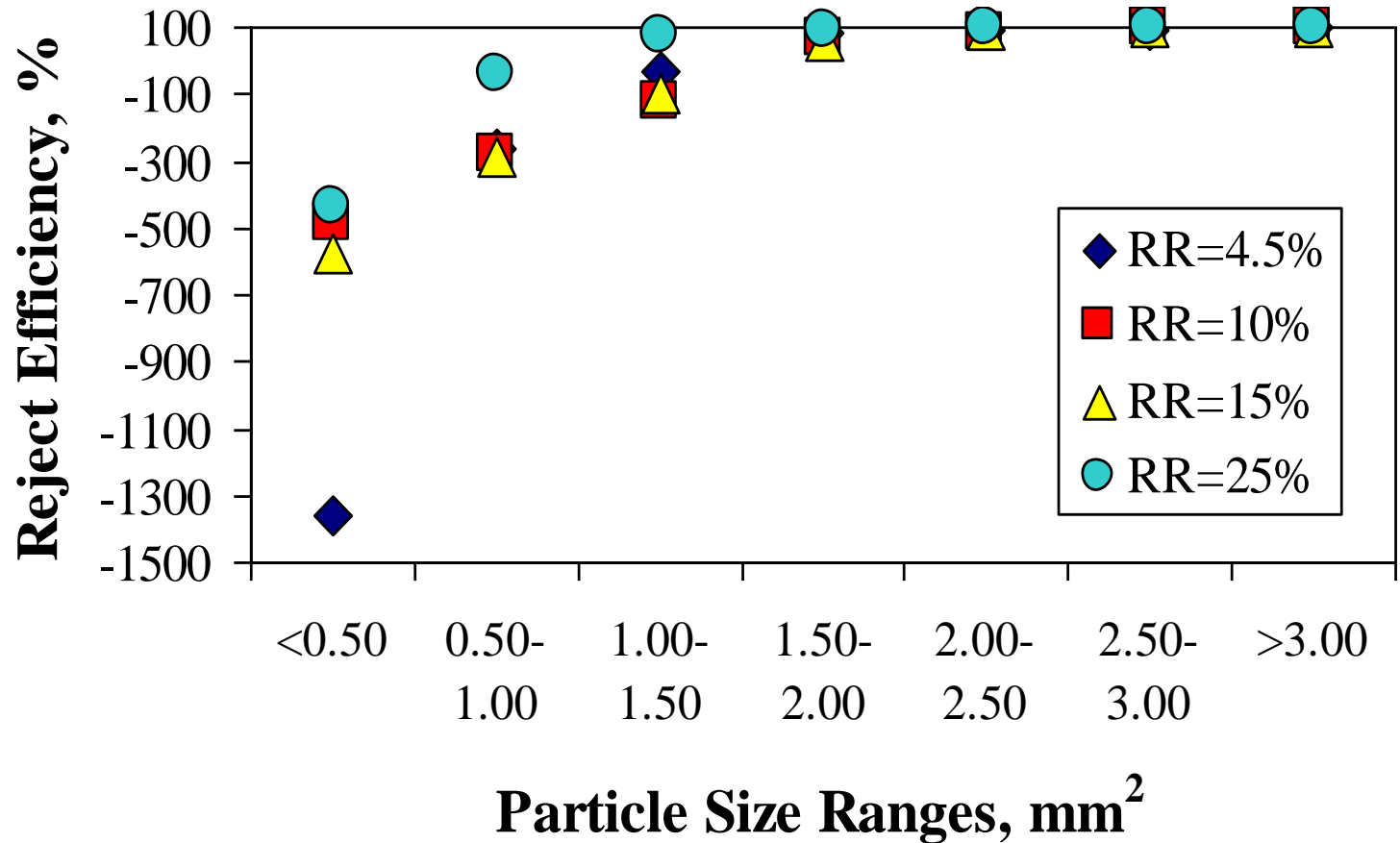


Shredding
makes
particles more
1-dimensional

Thousands of small
particles generated



Screen Removal Efficiency Versus Particle Size



PSA Particle Breakage

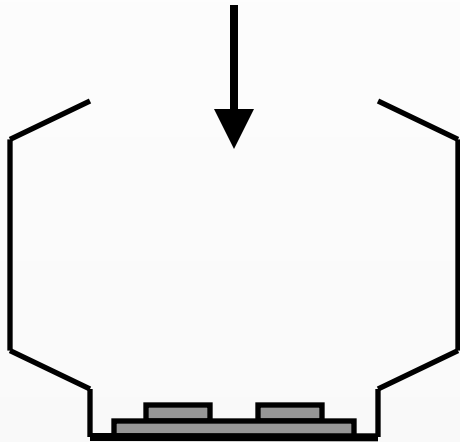
- Do PSA particles breakdown in the industrial pressure screen?
- **Yes, PSA particles do breakdown in the industrial pressure screen.**

PSA Particle Breakage

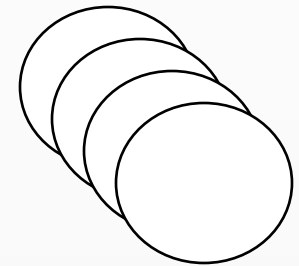
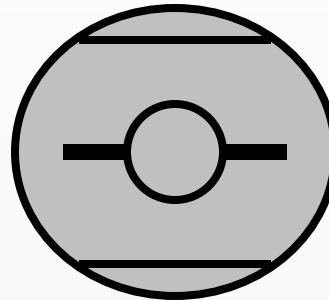
- **Which operating parameters in an industrial pressure screen have the most significant effect on the breakage of PSA particles?**
- Approach: Conduct a statistical analysis experiment using a high intensity laboratory mixer simulating forces in a screen with PSA particles

Experimental Procedure

**Copy Paper with
Adhesive Labels
(1% by wt.)**



Samples



**Pilot Plant Pulper
10% K, 45°C, 20 min
80 OD lbs.**

**Quantum
High Shear Mixer
3 Liters
(vary parameters)**

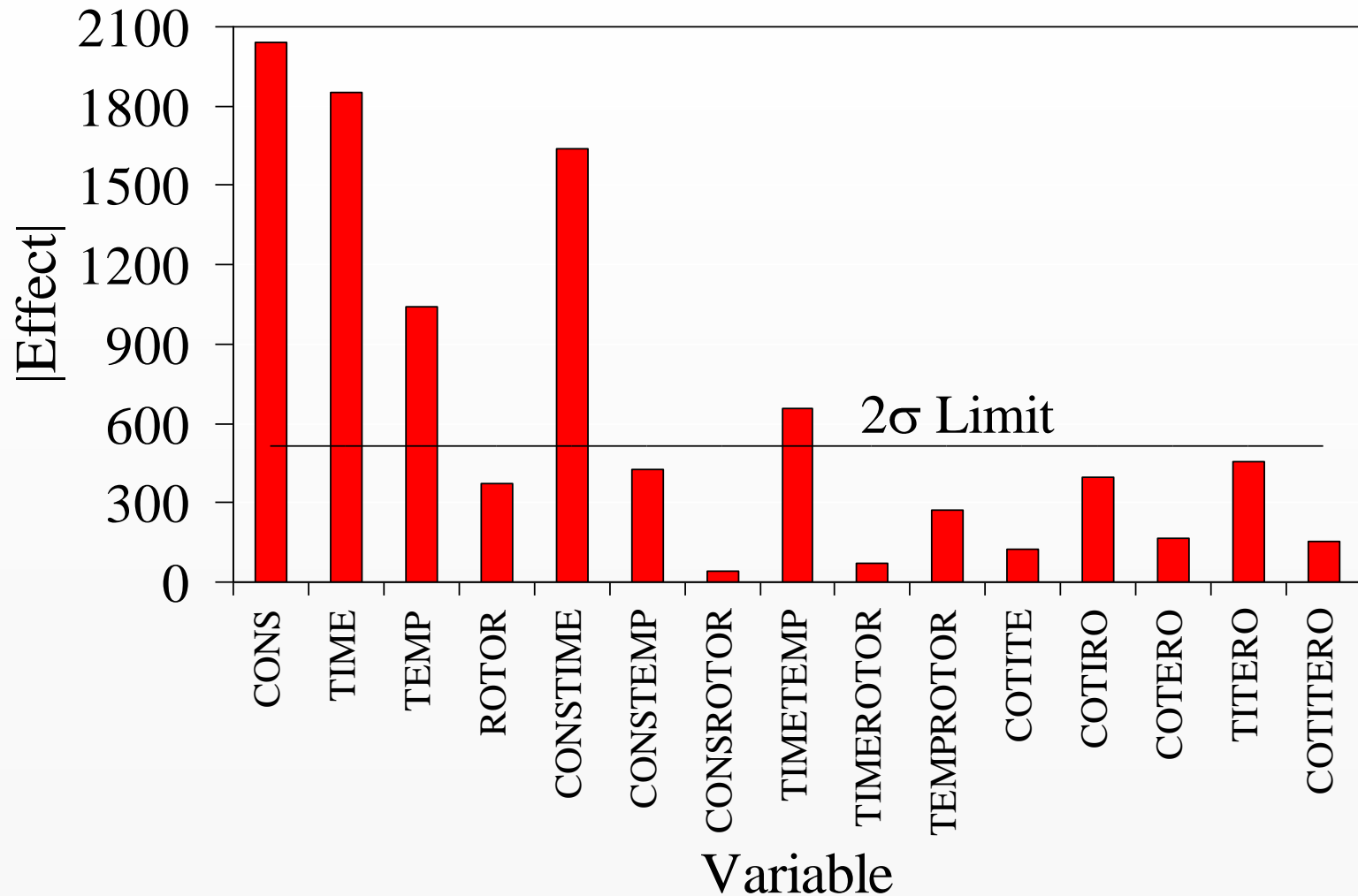
**Handsheets
Dyeing
Image Analysis**

Operating Parameters

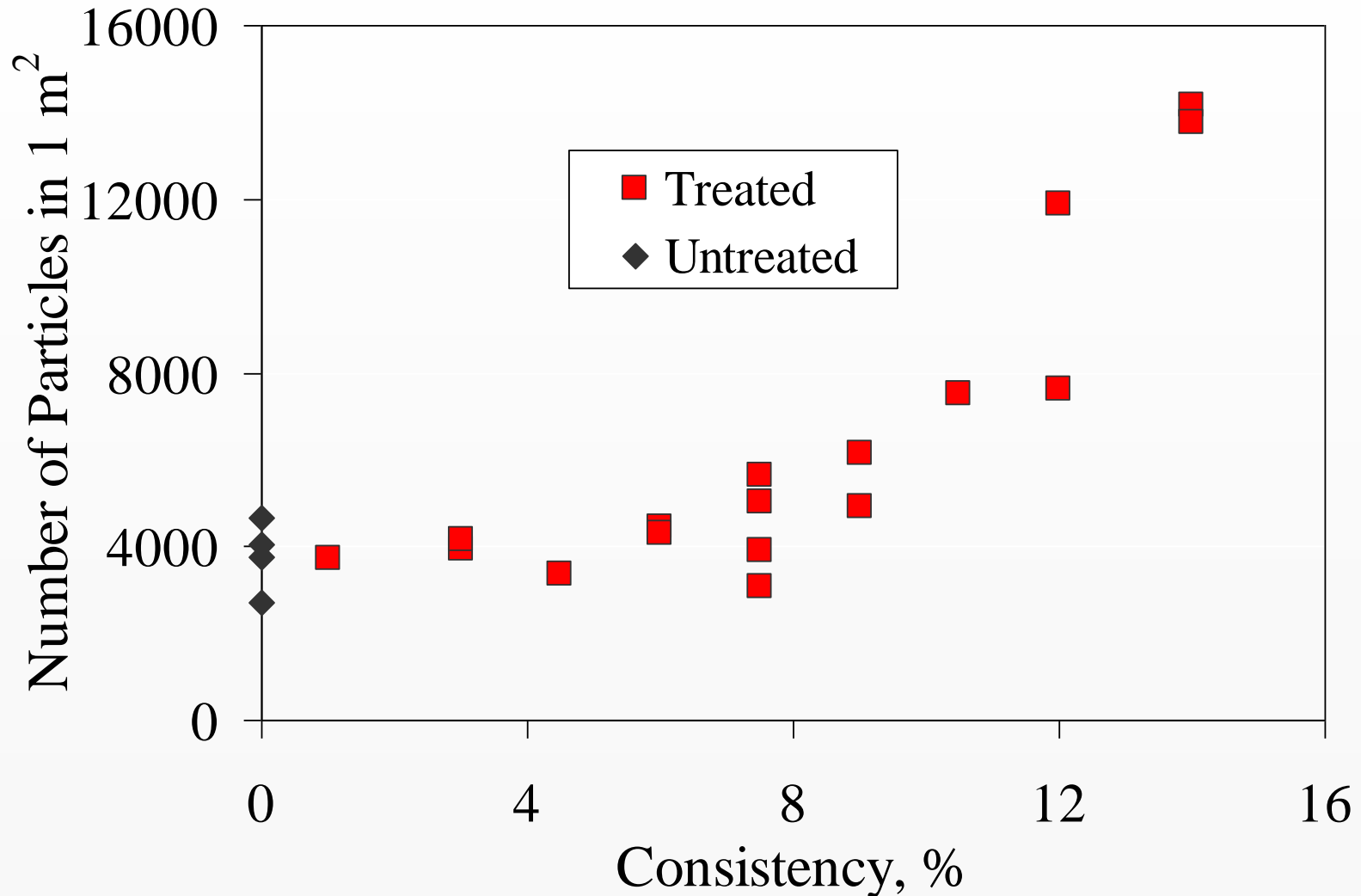
- Full Factorial Design Experiment with a Center Point

Variable	Low Value	Center Point	High Value
Pulp Consistency, %	3	7.5	12
Mixing Time, seconds	30	165	300
Initial Temperature, °C	20	35	50
Rotor Speed, rpm	600	1500	2400

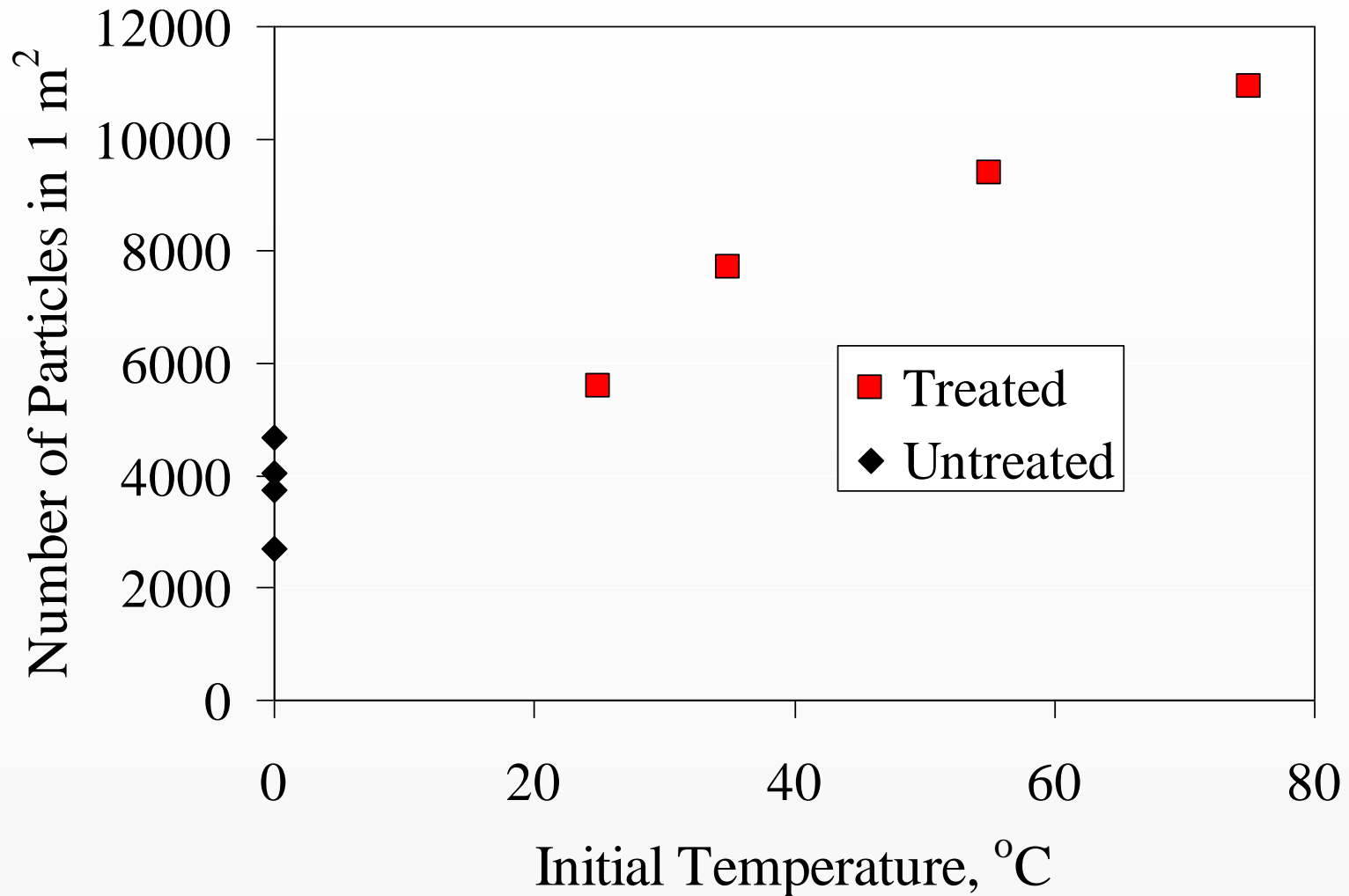
Pareto Analysis: Number of PSA Particles Versus Operating Variables



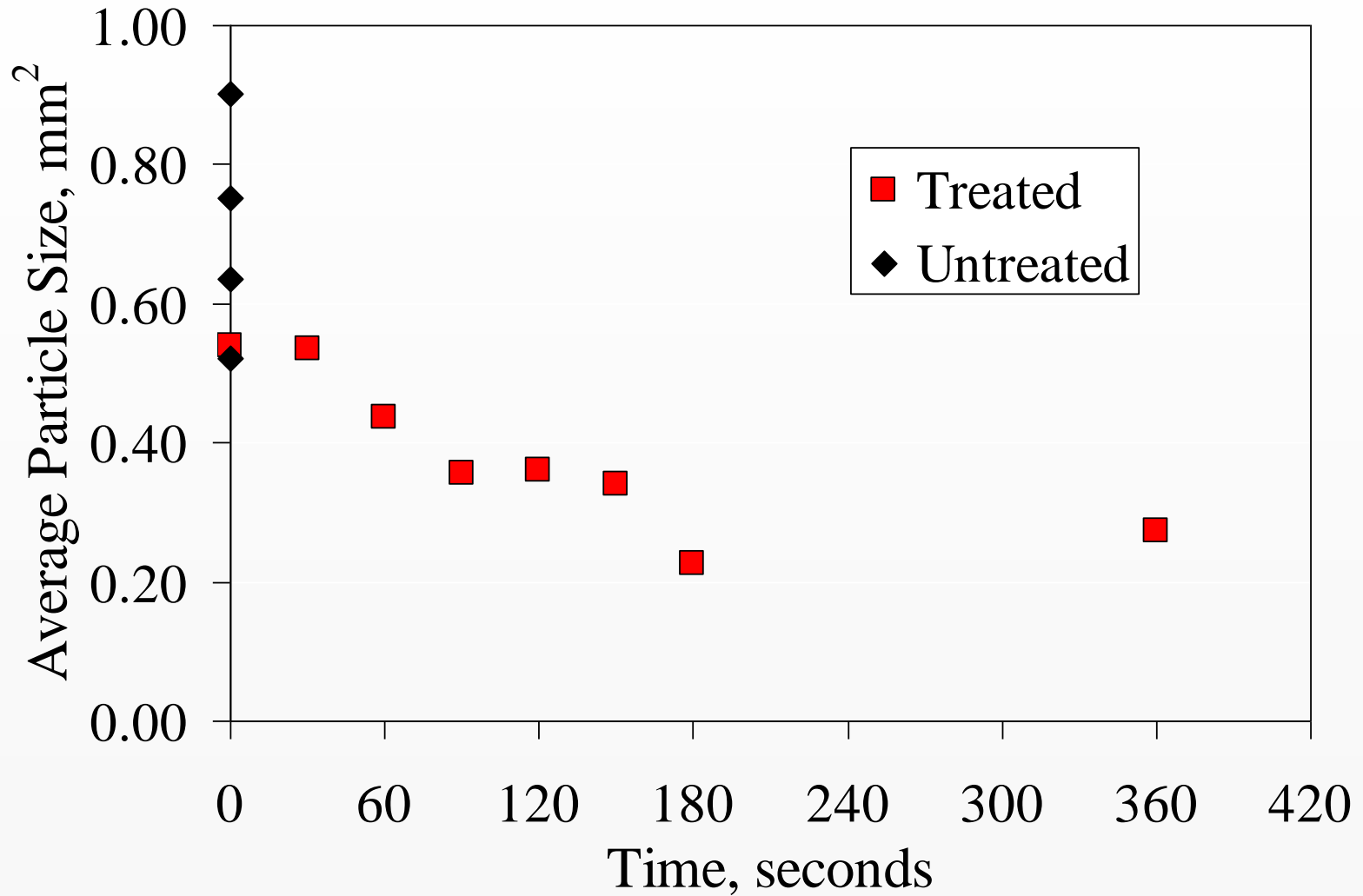
Number of Particles in 1 m² vs. Consistency



Number of Particles in 1 m² vs. Initial Temperature



Average Particle Size vs. Time



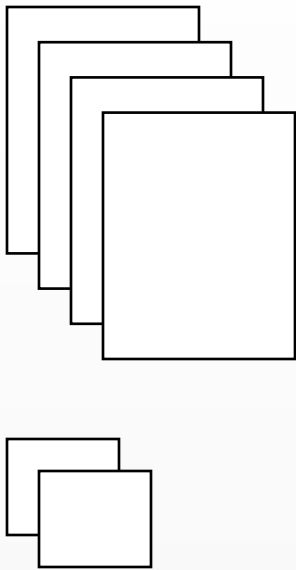
PSA Particle Breakage

- Which operating parameters in an industrial pressure screen have the most significant effect on the breakage of PSA particles?
- **The operating parameters of consistency, time, and temperature have the most significant effect on the breakage of PSA particles.**

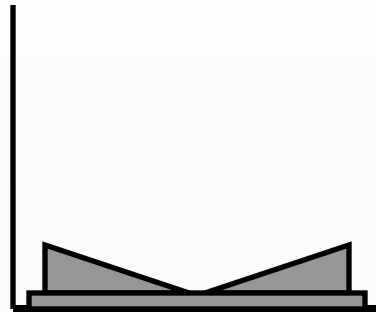
PSA Particle Extrusion

- **How do the pressure difference across the slot and operating temperature affect particle passage through a slot?**
- Approach: Measure the pressure difference at which PSA particles pass through the slot of a pressurized single slot device at different temperatures

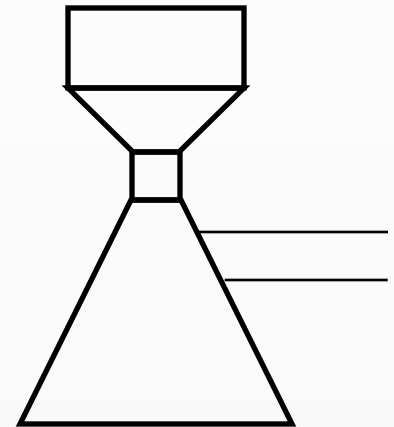
Experimental Procedure



450 OD g of paper
10 adhesive labels



450H Pulper
12% K, 45°C,
415 rpm, 60 min

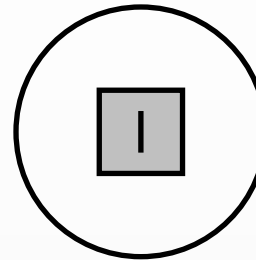


Single Slot Device
0.18 mm wide slot

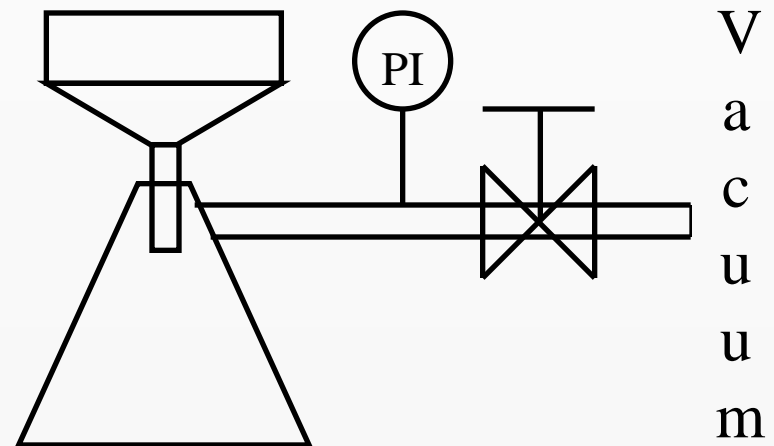
Single Slot Device Procedure

- Remove a PSA particle from pulp
- Measure the dimensions of the PSA particle under a microscope
- Place the PSA particle on the slot
- Add 1000 mL of deionized water
- Slowly open the vacuum line valve to increase the pressure difference across the slot
- If the particle passes through the slot, record the vacuum pressure at which the particle passes through the slot

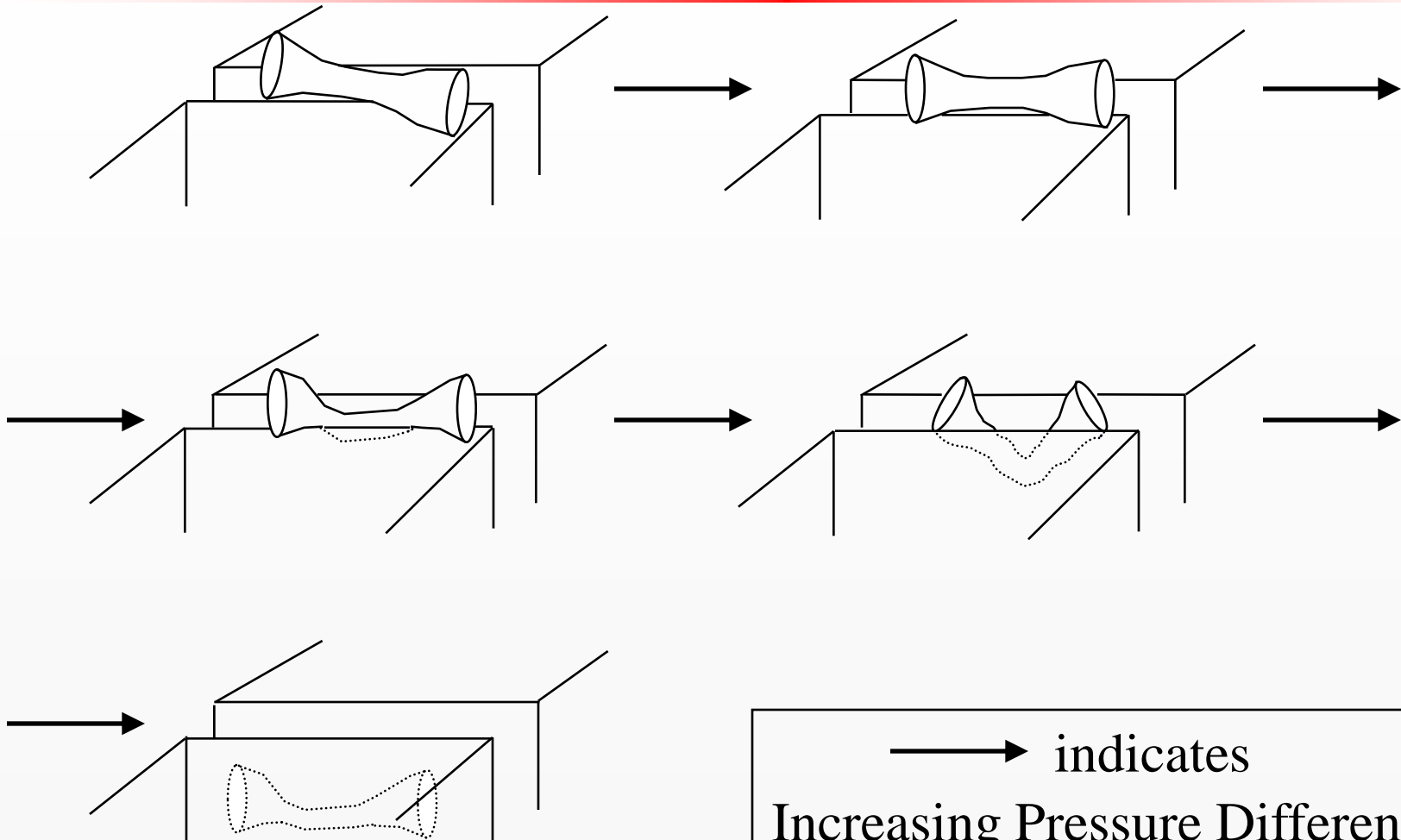
Top View



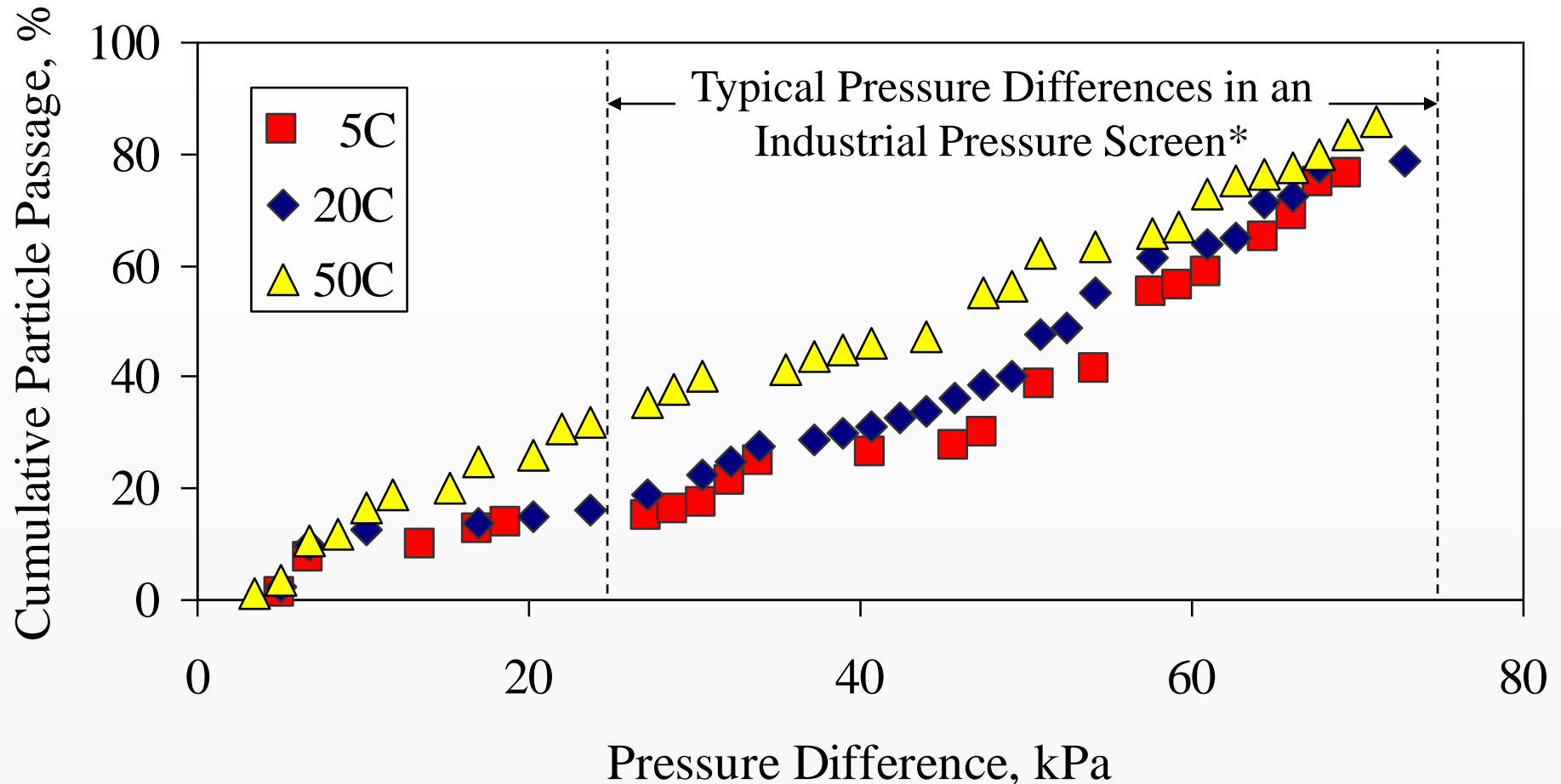
Side View



Commonly Observed Particle Passage Process



Cumulative Particle Passage Versus Pressure Difference



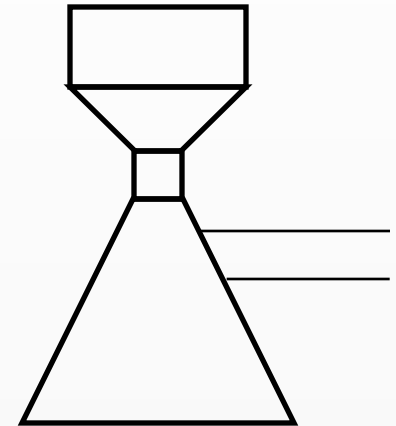
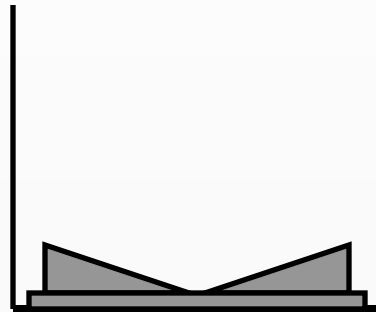
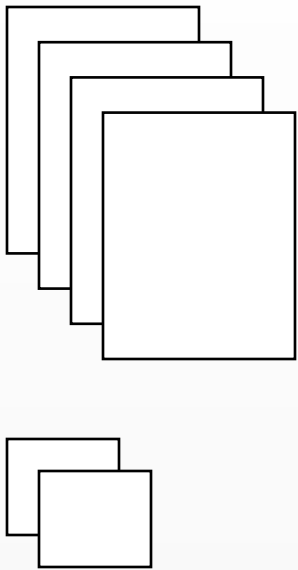
PSA Particle Extrusion

- How do the pressure difference across the slot and operating temperature affect particle passage through a slot?
- **Increasing the pressure difference across the slot or the operating temperature increases particle passage through a slot.**

PSA Particle Extrusion

- **Do the mechanical properties of the PSA formulations affect the passage of PSA particles through a slot?**
- Approach: Analyze particle passage in the single slot device for PSA films with different formulations

Experimental Procedure

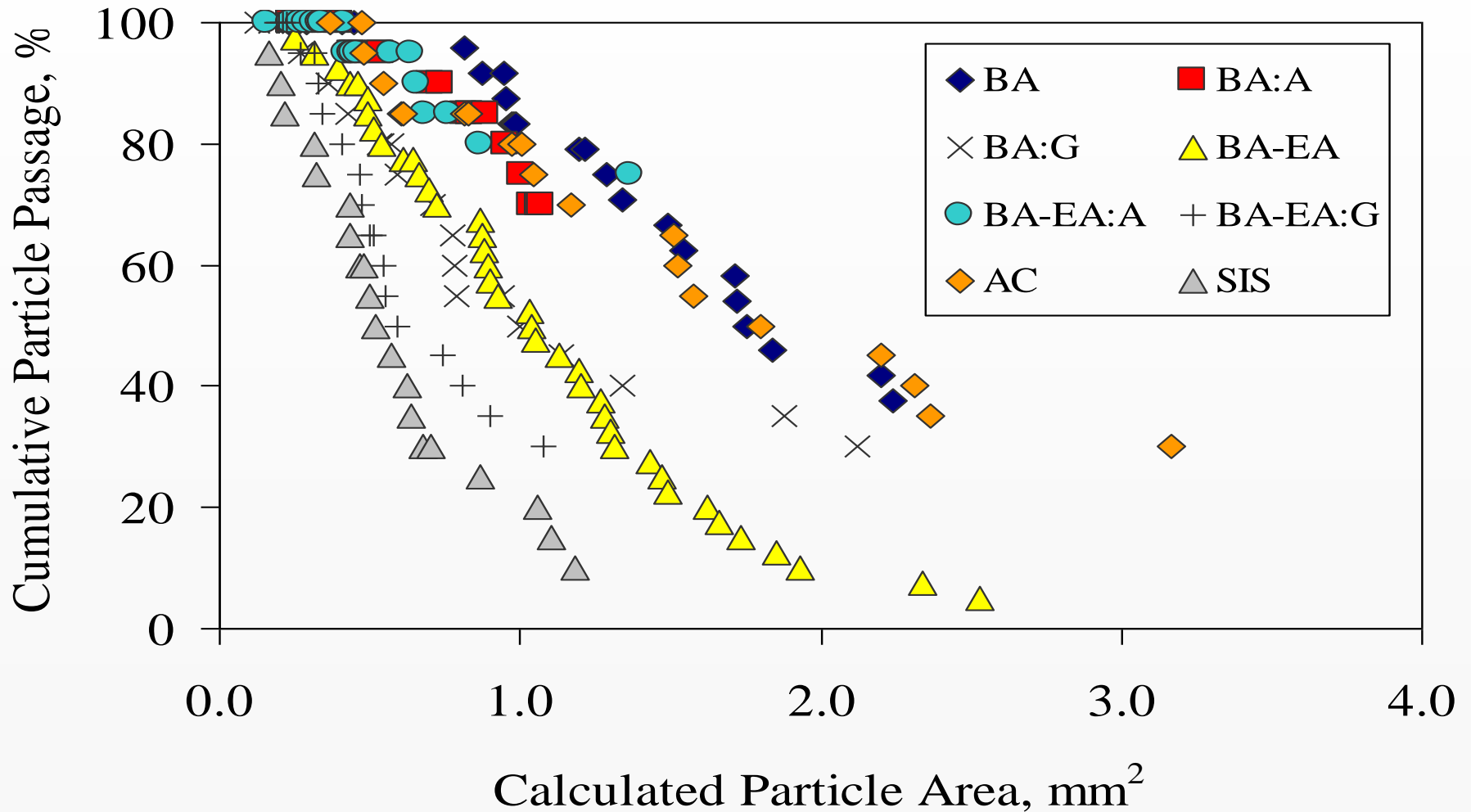


450 OD g of paper
6 adhesive labels

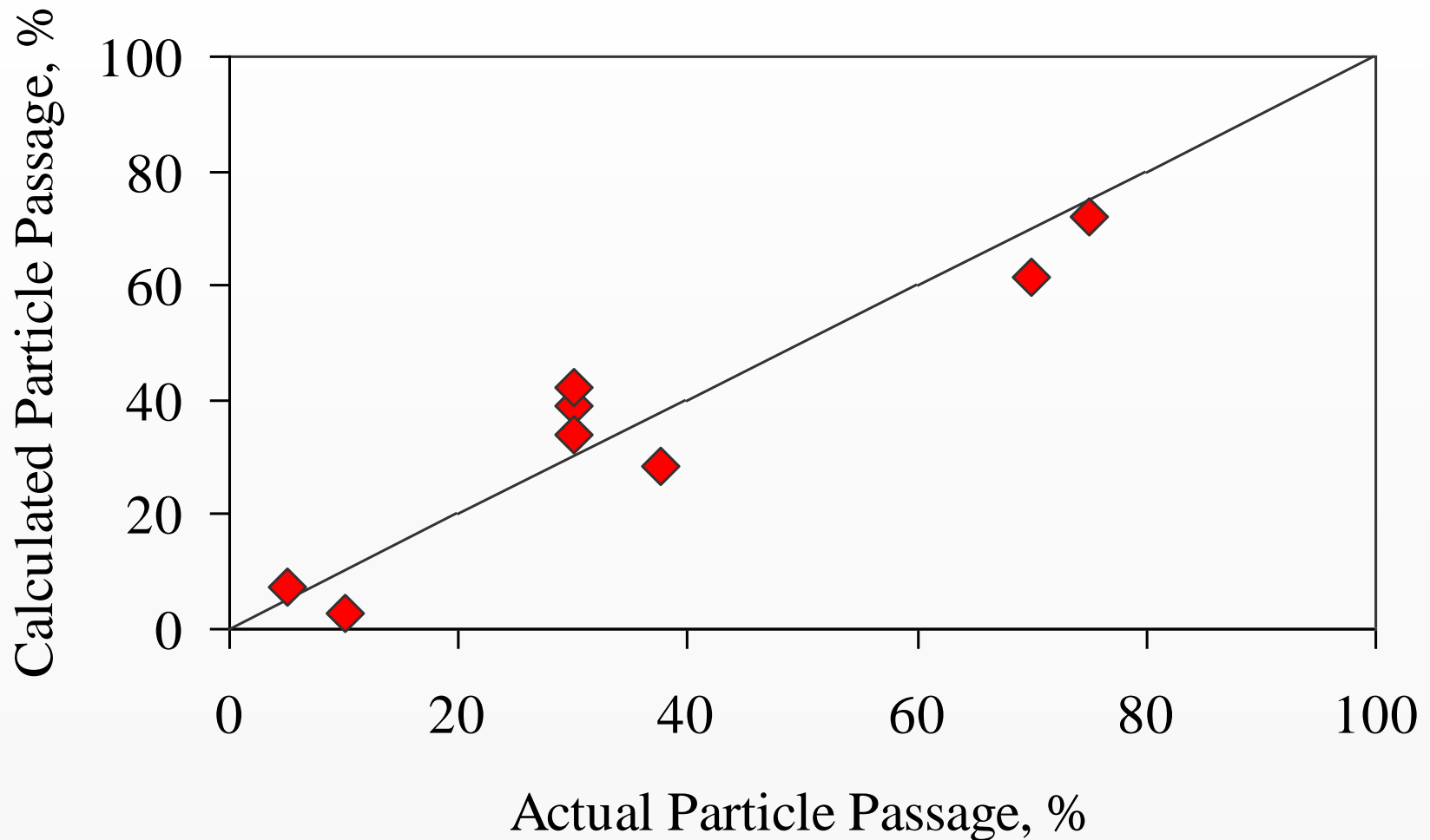
450H Pulper
12% K, 45°C,
415 rpm, 30 min

Single Slot Device
0.18 mm wide slot

Particle Passage Versus Particle Area for Eight Different Formulations



Calculated (Yield Stress and Area) Versus Actual Particle Passage



PSA Particle Extrusion

- **Do the mechanical properties of the PSA formulations affect the passage of PSA particles through a slot?**
- **Answer: yes, yield strength and size are the most critical properties**

Overall Conclusions

- PSA particles break down in industrial pressure screens
- Consistency, temp and time affect breakage
- PSA particles extrude in industrial pressure screens
- Pressure drop, temp, and particle size and stiffness affect passage