Lake States TAPPI Energy Forum

Spiral Plate Refining

Bridgewood Conference Center
Neenah, Wisconsin
May 14,2008

Planned Path

- Meter two refiners prior – Baseline
- Install one set of spiral plates and meter
- Compare pulp properties – Baseline and after switching plates
- Comparing Energy Used – per ton
- Write up Case Study

Actual Path

- Meters not installed prior to change
- Pulp properties before refining
- Pulp properties after refining
- Comparing energy used

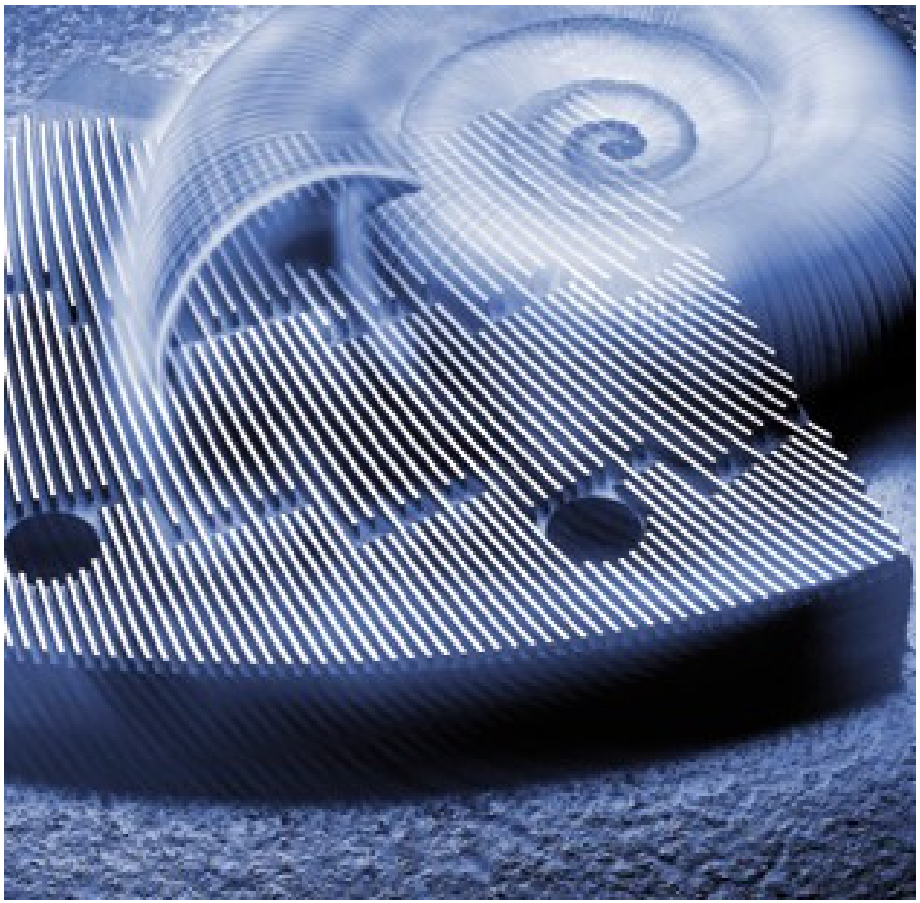
Fiber Classifications

Unrefined	Spiral Plates Sample	Standard Plate Sample
% on 14 Mesh	8.0	18.7
% on 28 Mesh	25.2	24.3
% on 48 Mesh	21.7	18.5
% on 100 Mesh	16.7	11.2
% on 200 Mesh	3.6	3.4
% thru 200 Mesh	24.8	23.9
+28 Mesh	33.2	43.0

Pulp Properties

Unrefined	Spiral Plates Sample	Standard Plate Sample
Bulk (cm^3/g)	8.0	18.7
Burst Index ($kPa.m^2/g$)	25.2	24.3
Tear Index ($mN.m^2/g$)	21.7	18.5
Tensile Index (N.m/g)	16.7	11.2
% Stretch	3.6	3.4
T.E.A (J/m^2)	24.8	23.9

The Logarithmic Spiral Design



The Durametal Difference

For info on the logarithmic spiral search the web, keyword: Spira Mirabilis

R&D Conclusion on Fiber Quality Drivers

- Number of Fiber Treatments
- Severity of Treatments
  - Fiber Compression in the Gap
  - Speed of Impact
- Number of Fiber Layers
  - Consistency

LemaxX Design Strategy

- Maximize the Number of Treatments
  - Achieve Ideal Intensity Level for Given Fiber Type
- Provide Treatments Homogeneously
  - Increase Gap Stability
- Use Lowest Possible Energy
  - Improve Energy Transfer Efficiency
- Optimize Hydraulic Capability
  - Increase Capacity and Lifetime

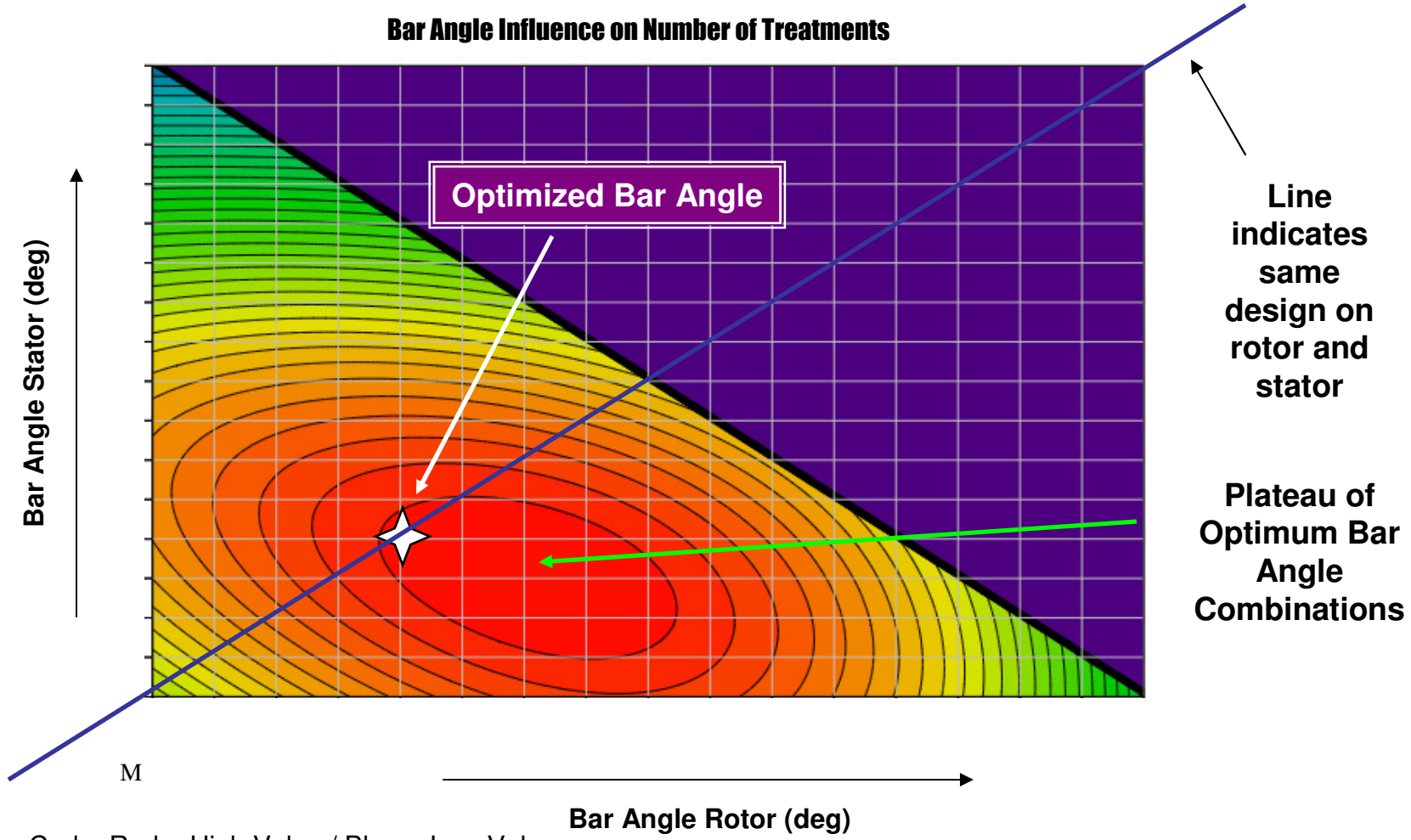
Maximize Number of Treatments

- Optimize Bar Angle
  - Covering Probability of Bar Leading Edge
  - Total Edge Length on Plate
- Adjust Design to Fiber Type
  - Bar and Groove Geometry
  - Covering Likelihood of Bar Top Surface Area

Bar Angle Optimization

- Effects of bar angle increase
  - More Fibers between Bars
  - Less Installed Edge Length
- Optimization process balancing these effects
  - Contour Plot Analysis

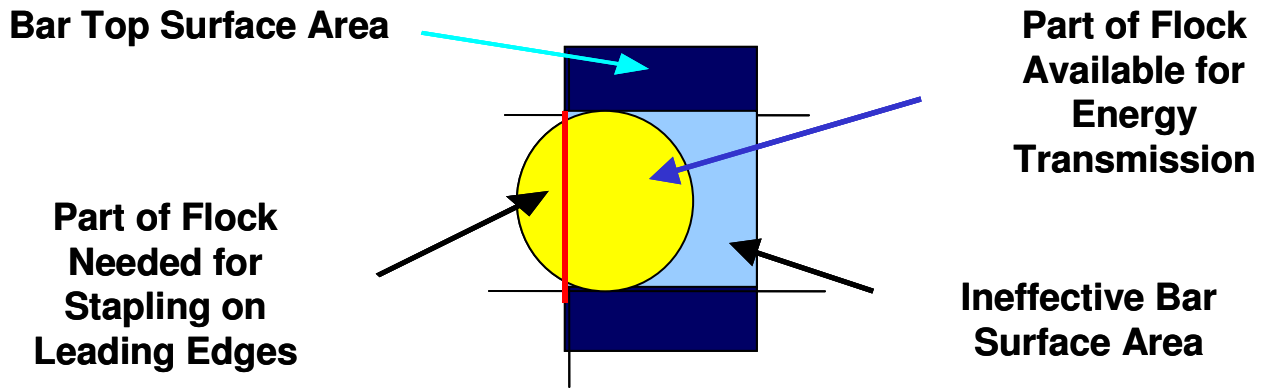
Bar Angle Optimization



Color Code: Red = High Value / Blue = Low Value

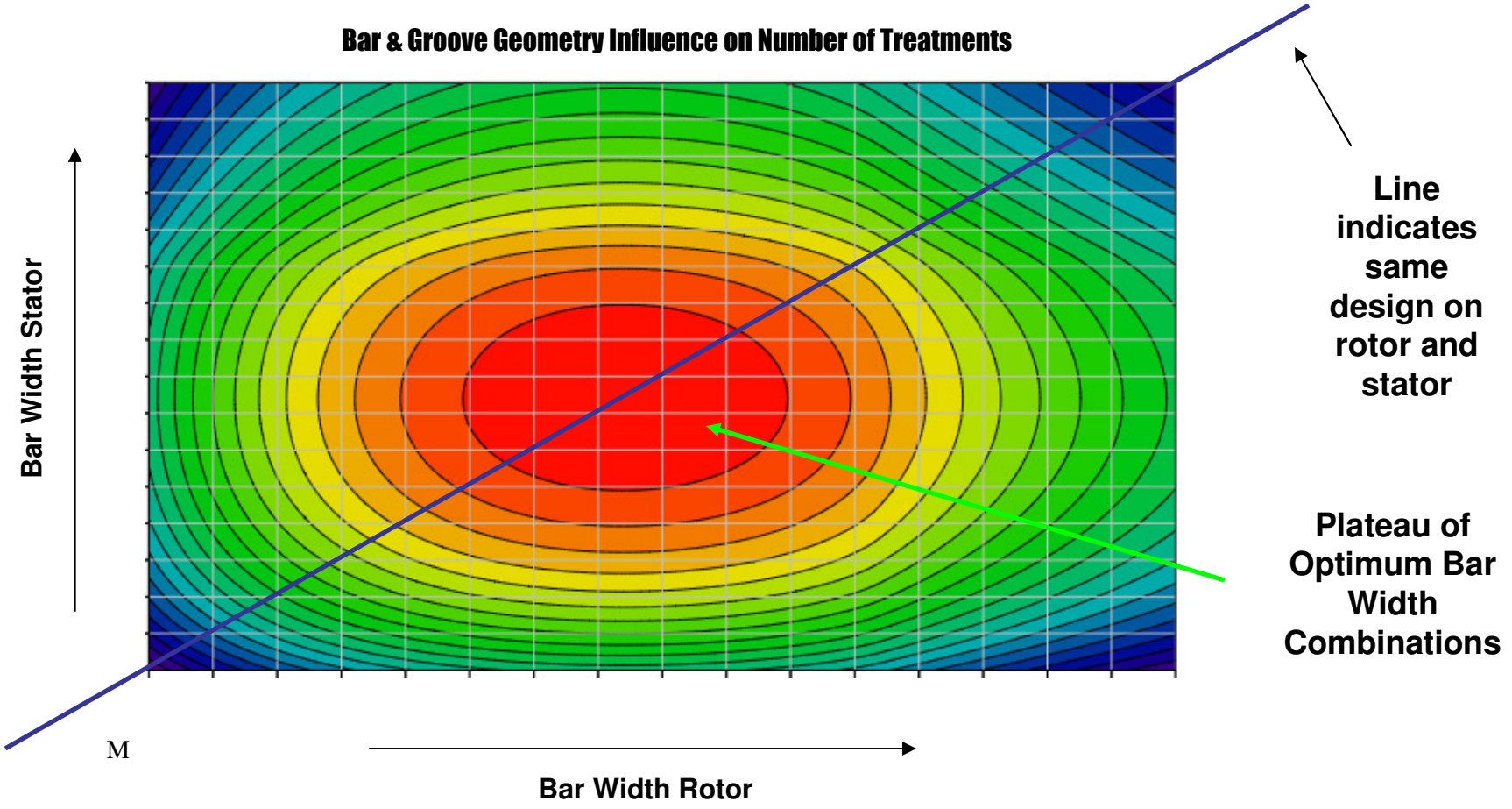
Design Adjustment to Fiber Type

- Counteracting Groove Width Targets
  - Operational Safety → High Groove Width
  - Number of Treatments → High Edge Length
- Bar width Adjustment
  - Size of Compressed Flock



Design Adjustment to Fiber Type

Softwood Chemical Pulp



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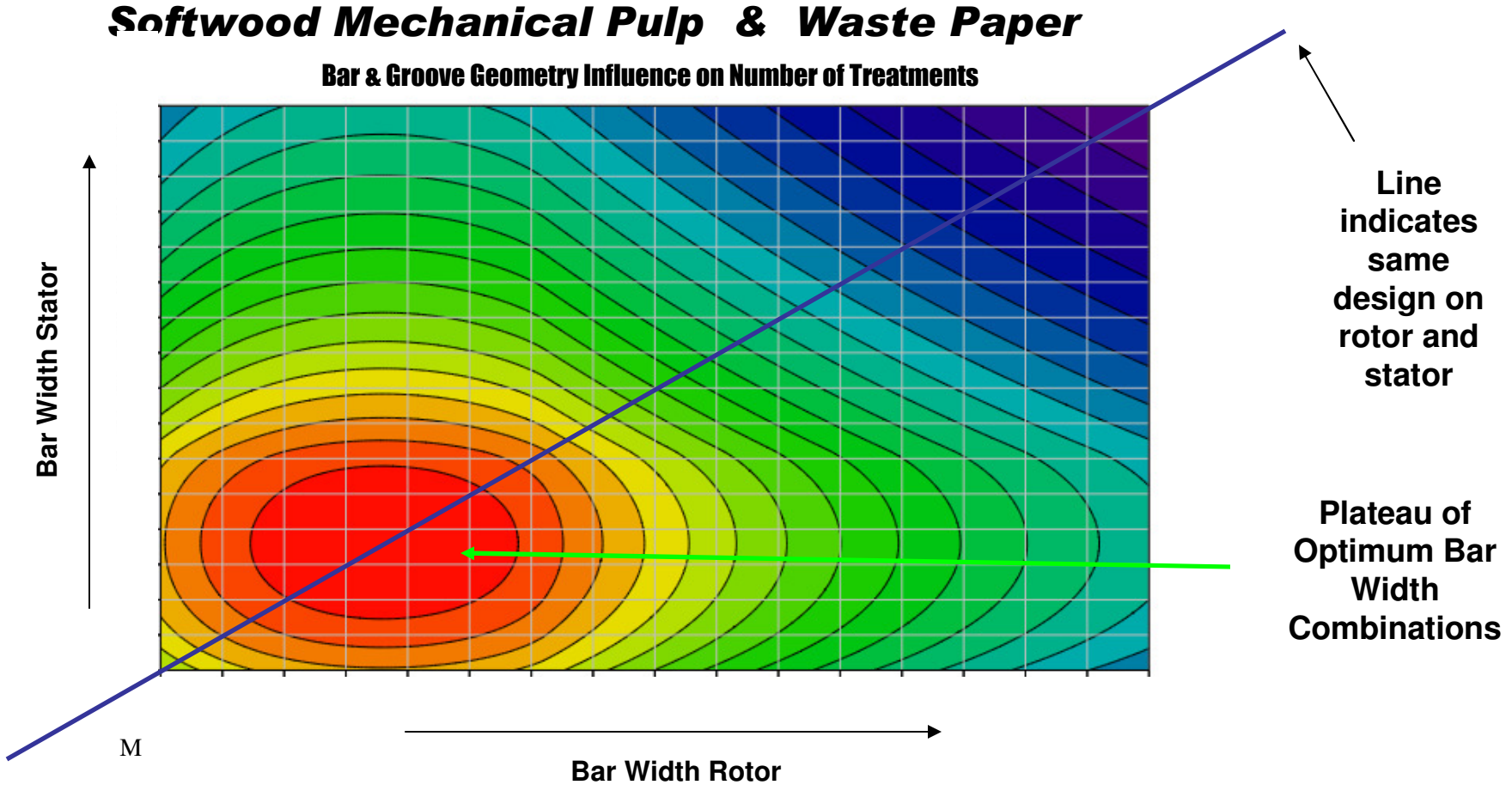
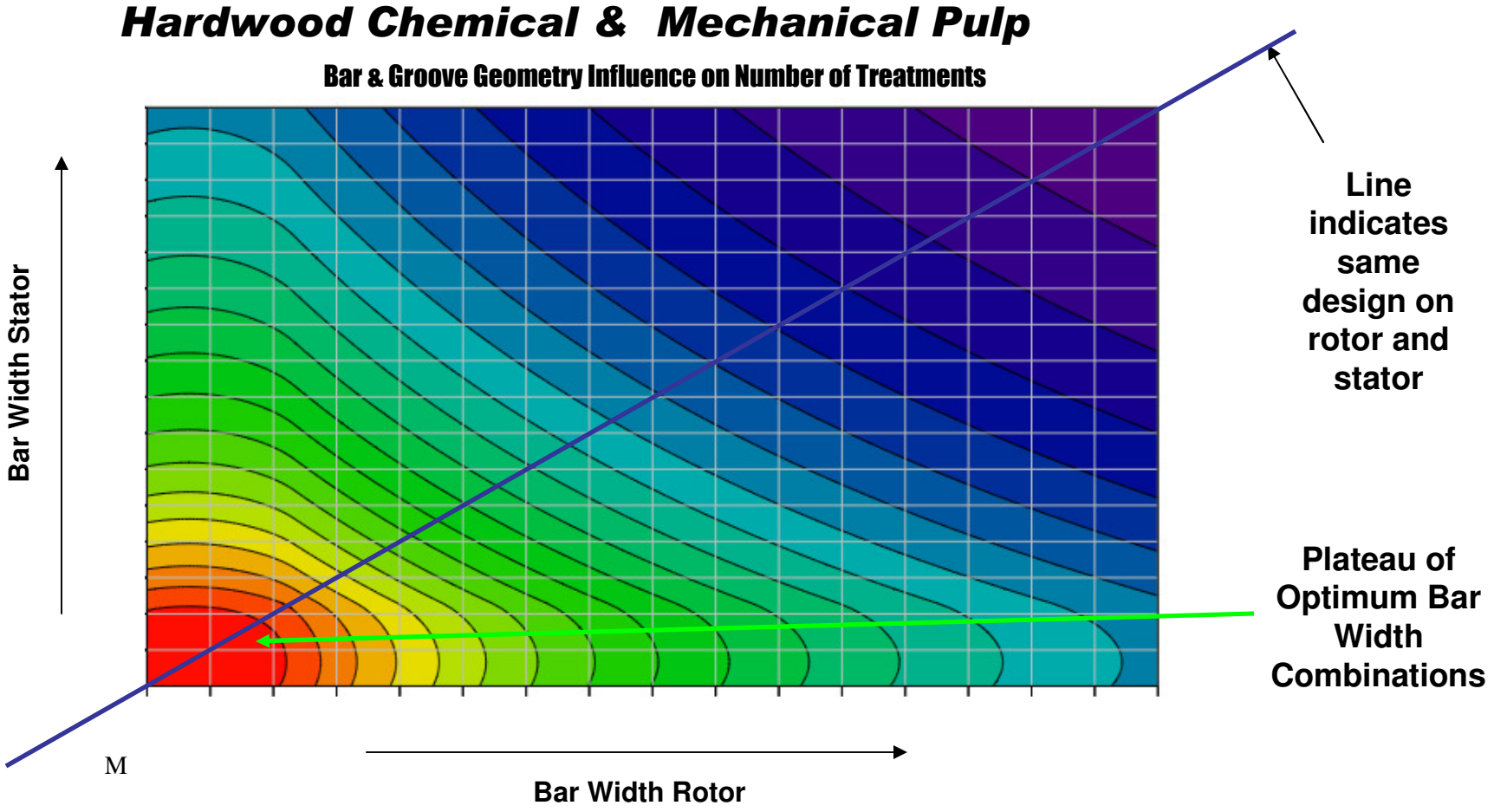
Design Adjustment to Fiber Type



Design Adjustment to Fiber Type



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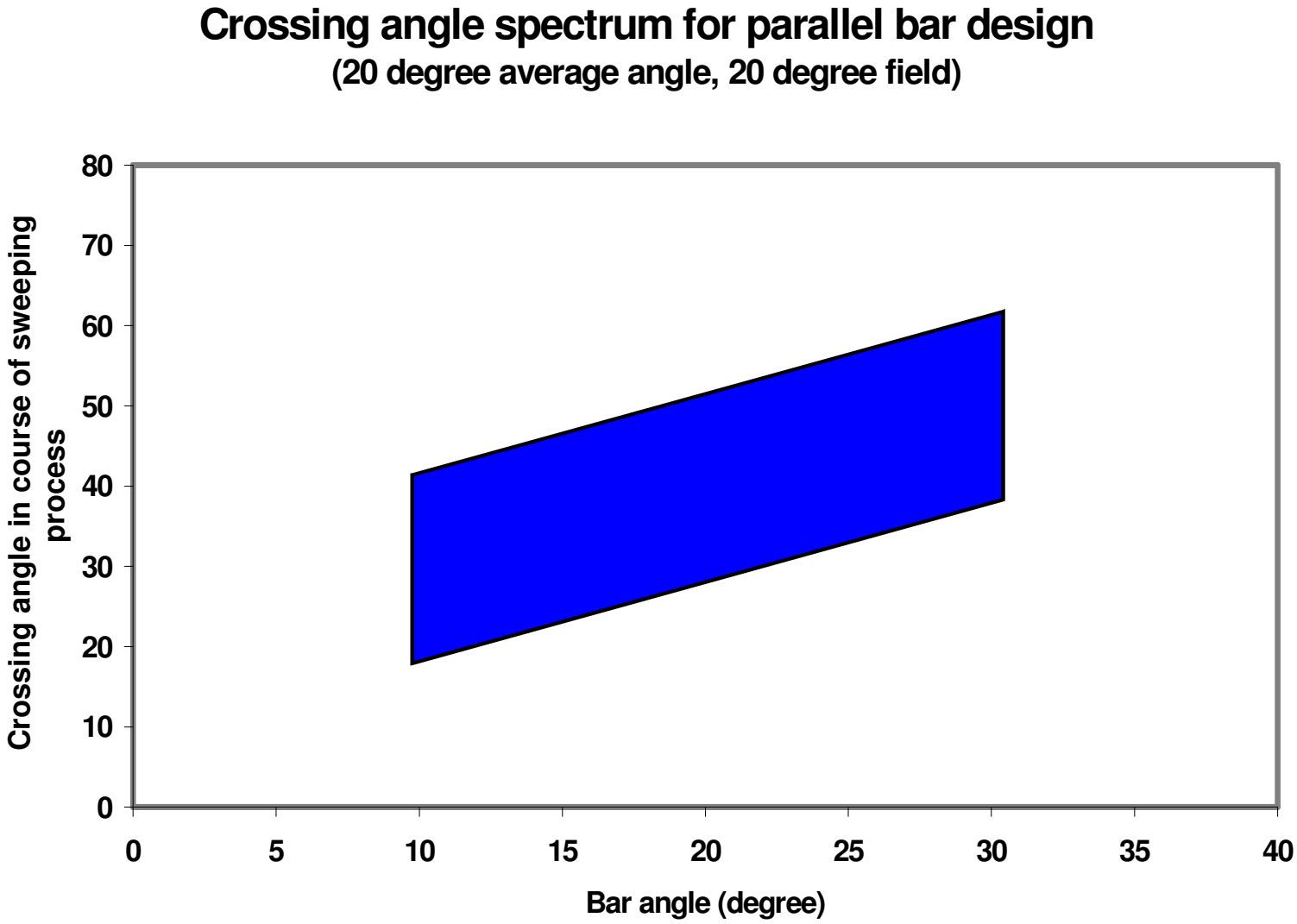
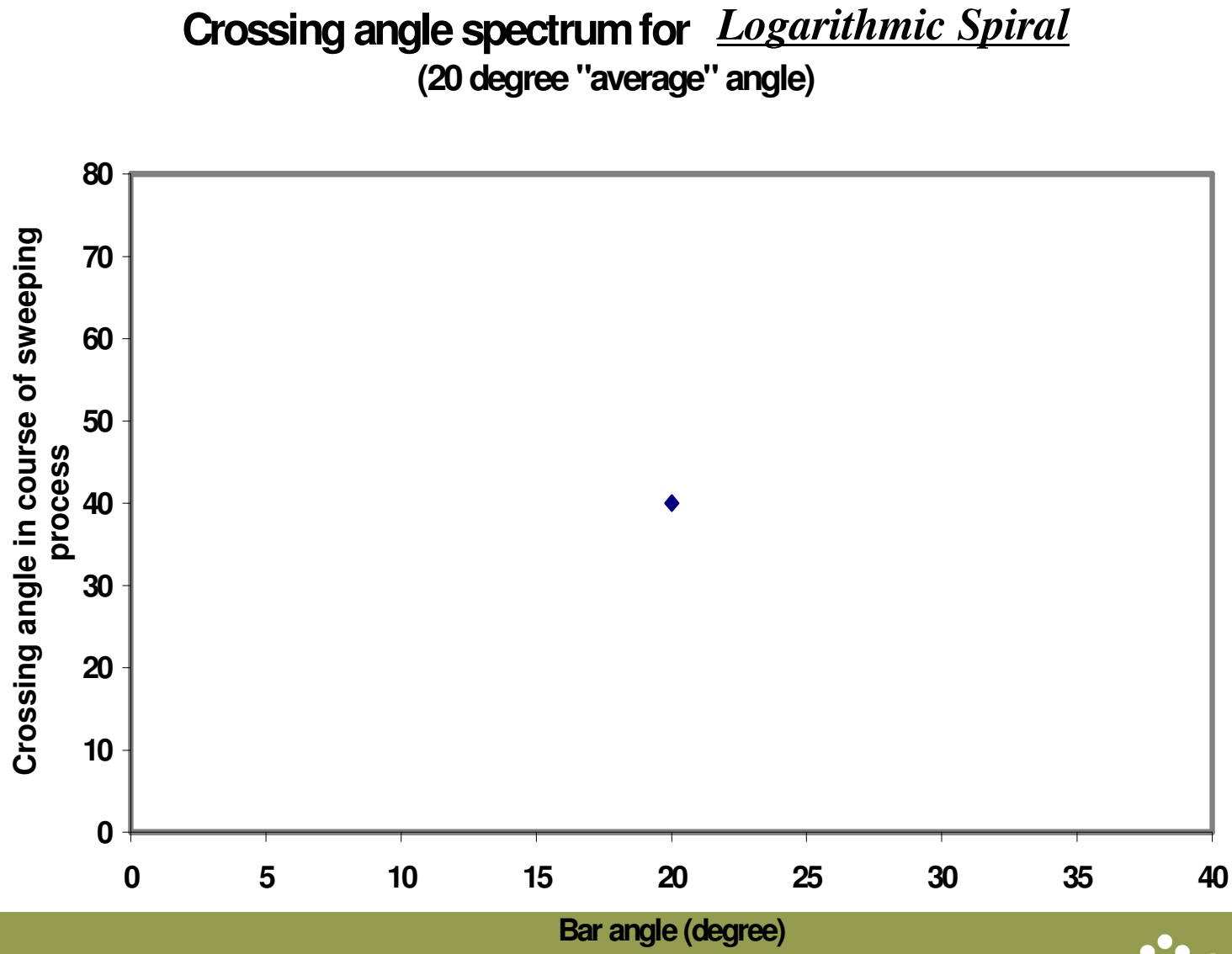
Homogeneous Fiber Treatment

- Crossing Point Theory Conventional Designs:
  - Significant Number Variability
  - Significant Crossing Angle Variability
  - → Significant Momentary Load Variations
- Goal: Load & Gap Stability
  - Crossing Angle Stability
  - Minimal Variation in Number of Crossing Points
- Solution: Bar Shape = Logarithmic Spiral

Homogeneous Fiber Treatment



Homogeneous Fiber Treatment



Lowest Possible Energy Consumption

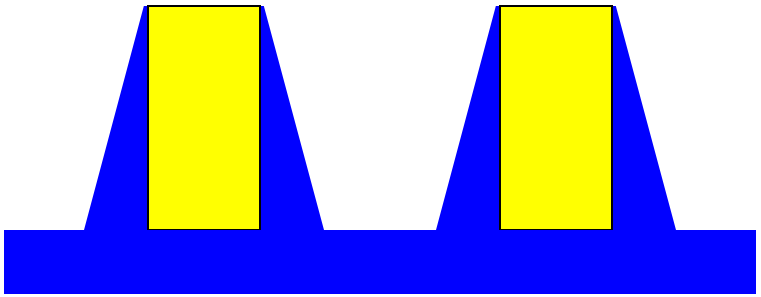
- Energy Transfer Equation:

$$P_{spec,net} = \tau_0 \cdot (CI \cdot SI)^n \cdot \frac{\sqrt{bp_R \cdot bp_S} \cdot \eta_{area}}{g \cdot c_{gap}} \cdot Z_P \cdot X$$

- Lowest Specific Energy Consumption
  - → Choose feasible minimum bar width on plateau of optimum bar width combinations

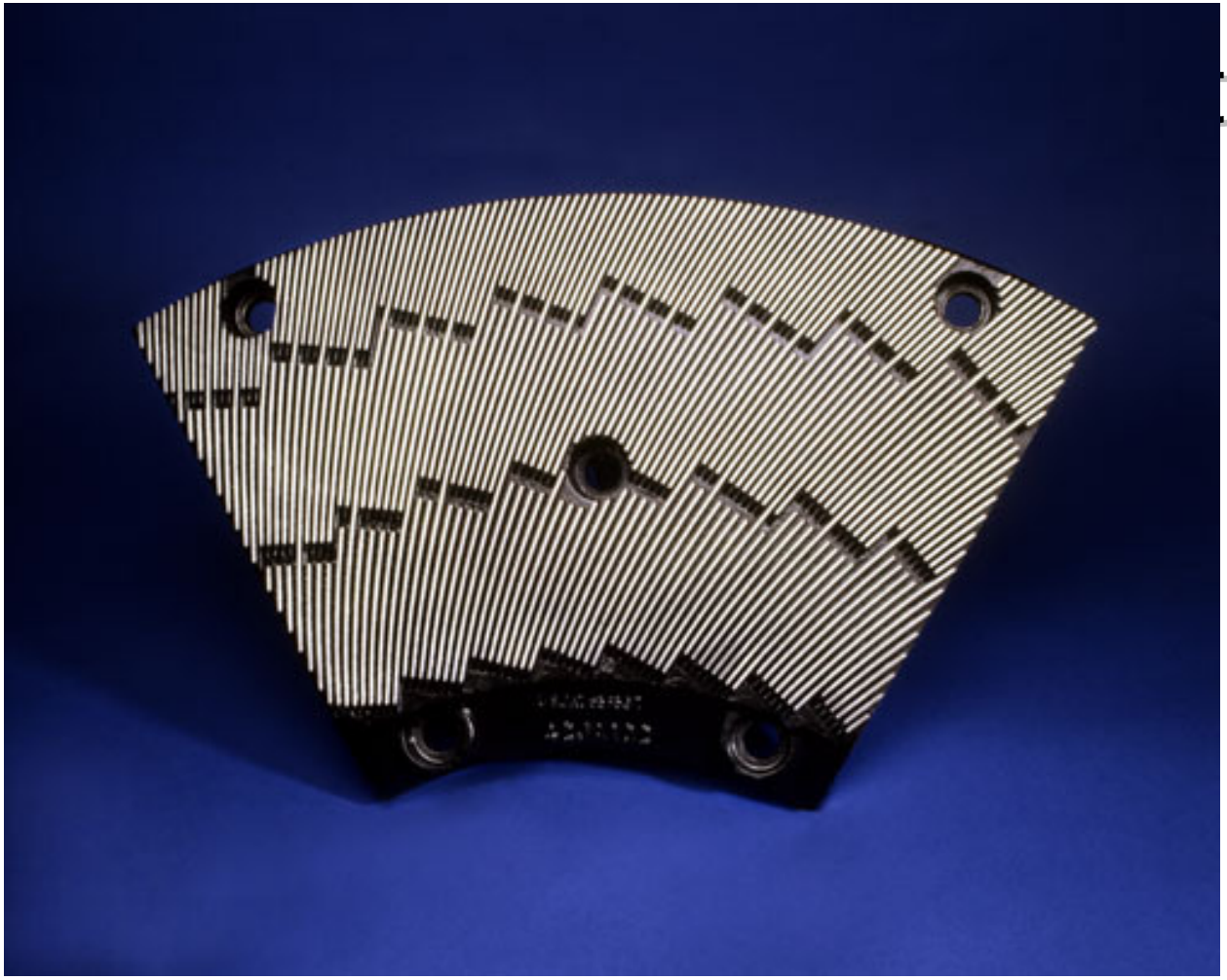
Optimum Hydraulic Capability

- Dominant Factors for Lifetime
  - Open Area & Groove Width
  - Draft Angle
    - **The More Influence, the Narrower the Grooves and the Higher the Bars**
- Dominant Factor for Fiber Quality Stability
  - Bar Edge Condition
- → Lowest Possible Draft Angle



Optimum Hydraulic Capability

- Logarithmic Spiral
  - Groove Widens with Increasing Radius
  - → Improved Plugging Resistance & Easy Cleaning
- Multi-Zone Concept
  - High Bar Density
  - More Open Area at ID for Proper Feeding
  - Zone Transition Management with Patented Z-Transition



Fiber Classifications

Refined	Spiral Plates Sample	Standard Plate Sample
% on 14 Mesh		
% on 28 Mesh		
% on 48 Mesh		
% on 100 Mesh		
% on 200 Mesh		
% thru 200 Mesh	Started with more and finished with less fiber – less shorter	
+28 Mesh	Started with less and finished with more fiber – more longer	

Pulp Properties

Refined	
Bulk (cm^3/g)	Similar
Burst Index ($kPa.m^2/g$)	Much larger increase
Tear Index ($mN.m^2/g$)	Same to smaller decrease
Tensile Index (N.m/g)	Much larger increase
% Stretch	More stretch
T.E.A (J/m^2)	Much greater increase

What's Next

- Metered without graphing function.
- Monitor until we are satisfied with energy vs. similar pulp
- We would have interest in a second site.

Questions ?

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