Progress in Pulp Refining Research Seminar
September 12th 2003, UBC, Vancouver

Bar clearance developments in laboratory LC-refining

Tom Lundin

ÅBO AKADEMI UNIVERSITY
Porthansgatan 3 FIN-20500 Åbo Finland

Background

Licentiate Thesis:

"LC-refining of softwood-bleached kraft pulps with special reference to pulp suspension rheology": ÅA 2002

Main Goal:

–To investigate the pulp flow conditions in LC-refining and to clarify their effects on the beating of reinforcement fibres

- Main objectives
  - Effects of refining parameters (*n, c, SEL, SEC*)
  - The role of flow conditions in the refining zone
  - Floc-size modification by dispersion

Introduction

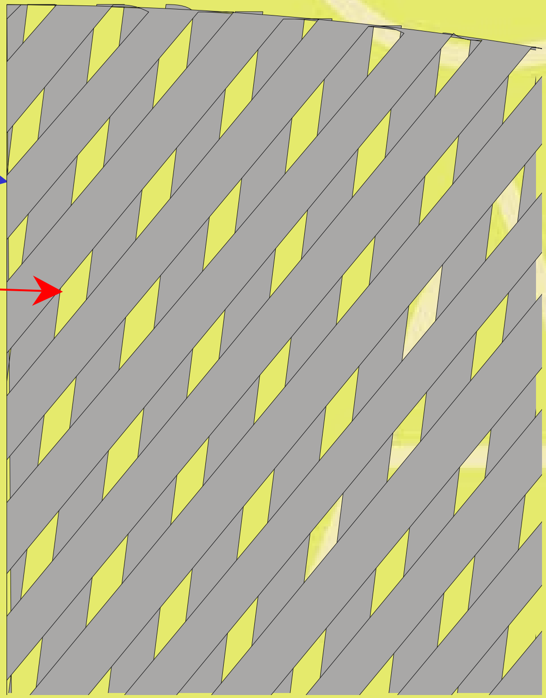
- LC-refining
  - High-speed shear action by metal bars supplying mechanical energy (impacts) to fibre(floc)s for fibre modification purposes.
- Main effects
  - Fibre cell wall modification
    - Delamination, internal fibrillation,
      - Hydration, swelling, fibre-collapse
    - Fibrillation
      - External fibrils and fines-release
  - Fibre shortening
    - Improved formation
    - Fines formation

} Improves fibre bonding potential resulting in enhanced paper sheet quality

Theory

- Pulp transportation volume V_T (grey)
- Refining area x bar clearance = impact transfer volume V_I
  - Bar clearance determined physically by:
    - Floc size
      - Consistency
      - Fibre length (aspect ratio)
      - Network strength
    - Refining intensity
      - Bar width
      - P/n $\propto$ torque
      - Cutting length
      - Cutting angle
    - Shear rate

Fibre mat



$$V_T >> V_I$$

Theory

- Adapted bar clearance at a specific intensity:
  - Direct indication (physical measure) of fibres at shear
- Is the fibre-conformation in V_I dependent on
  - Rotational speed,
  - Pulp consistency, or
  - Cutting length?

Theory

- Identified parameters related to the rheological behaviour of a fibrous suspension:
  - Fibre concentration (flocculation and viscosity)
  - Fibre morphology
    - Fibre length (average and distribution)
    - Fibre aspect ratio
    - Fibre coarseness
    - Fibre-to-fibre surface friction
  - Fibre flexibility
  - Degree of shear (fibre flocculation)

Specifications

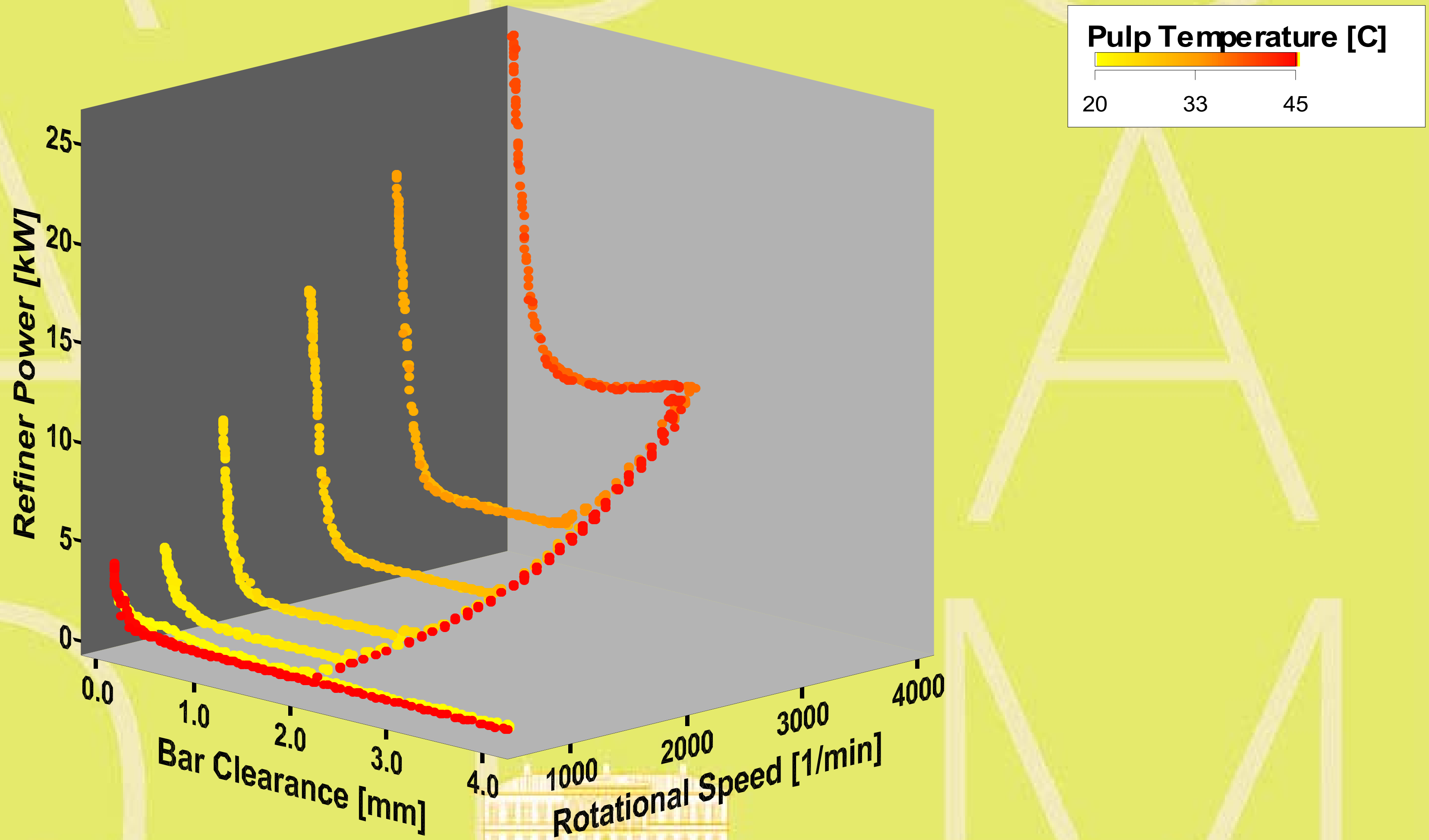
- ProLab™ Refiner:
  - Pulp suspension volume *V*: 40-70 L
  - Fibre concentration *c*: 3-7%
  - Pulp temperature *T*: 0-90 °C
  - Pulp flow *V*: 60-120 L/min
  - Feeding pressure *p*: 0-6 bar
  - Rotational speed *n*: 600-5000 r/min (5-35 m/s), pumping/non-pumping
  - Refining energy *SEC*: 0-1000 kWh/t, 0-50 kWh/t per passage
  - Refining intensity *SEL*: 0.5-5 J/m
  - 7 fillings (3 cutting lengths; 6 soft- and 1 hardwood fillings)

Experimental

- Refiner power determined at
  - Pulp consistencies 0, 1, 2, 3, 4, 5 and 6%
  - Rotational speeds 600-4000 rpm
  - Bar clearances (2 mm to minimum) at 600, 1500, 2250, 3000 and 4000 rpm (sequentially) → increasing SEC
- ECF-bleached softwood reinforcement pulp (2.2 mm)
- Two cutting lengths (30.8 and 52.0 m/rev)

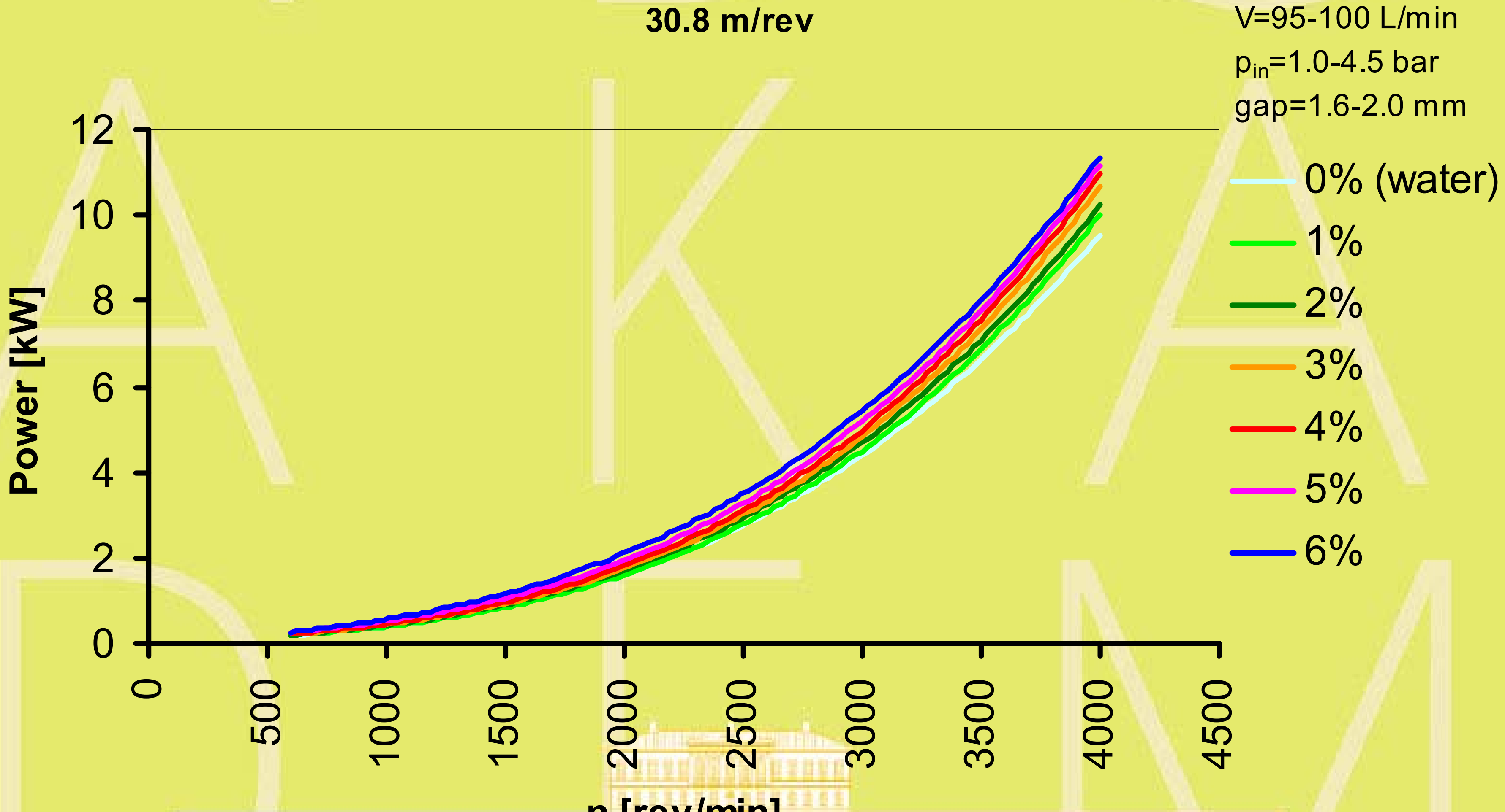
Results

52.0 m/rev, 6%



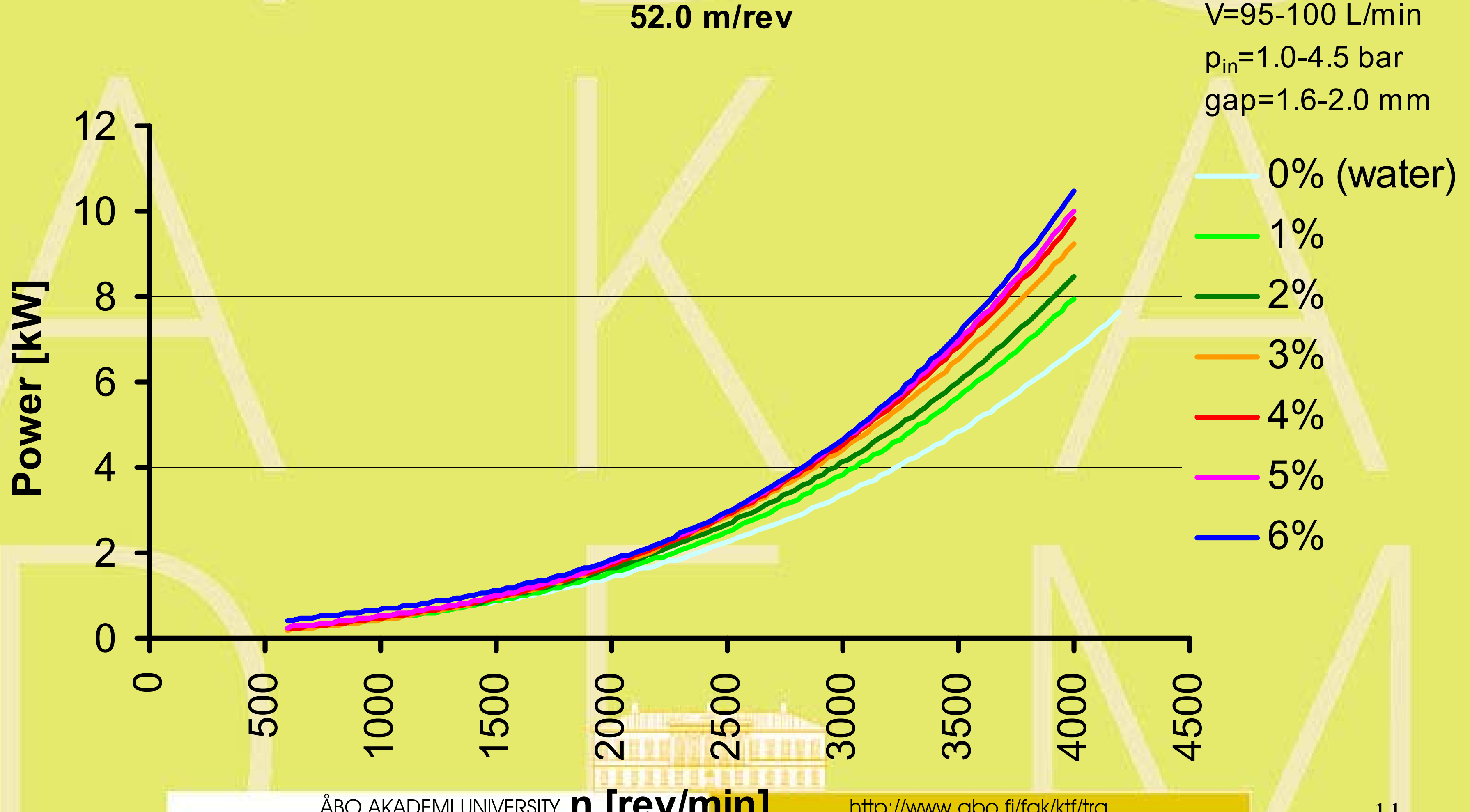
Results

- Idling power increased with consistency



Results

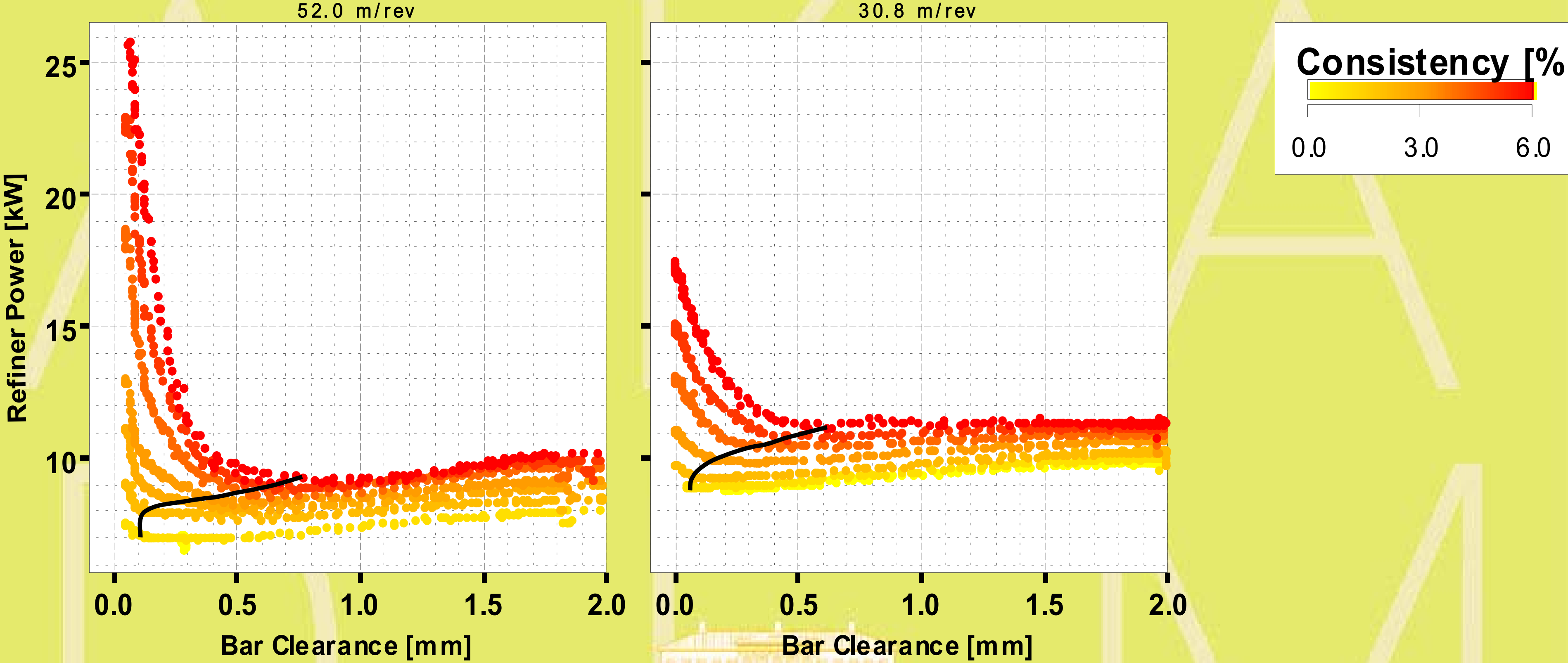
- Idling power increased with consistency



ProLab

Results

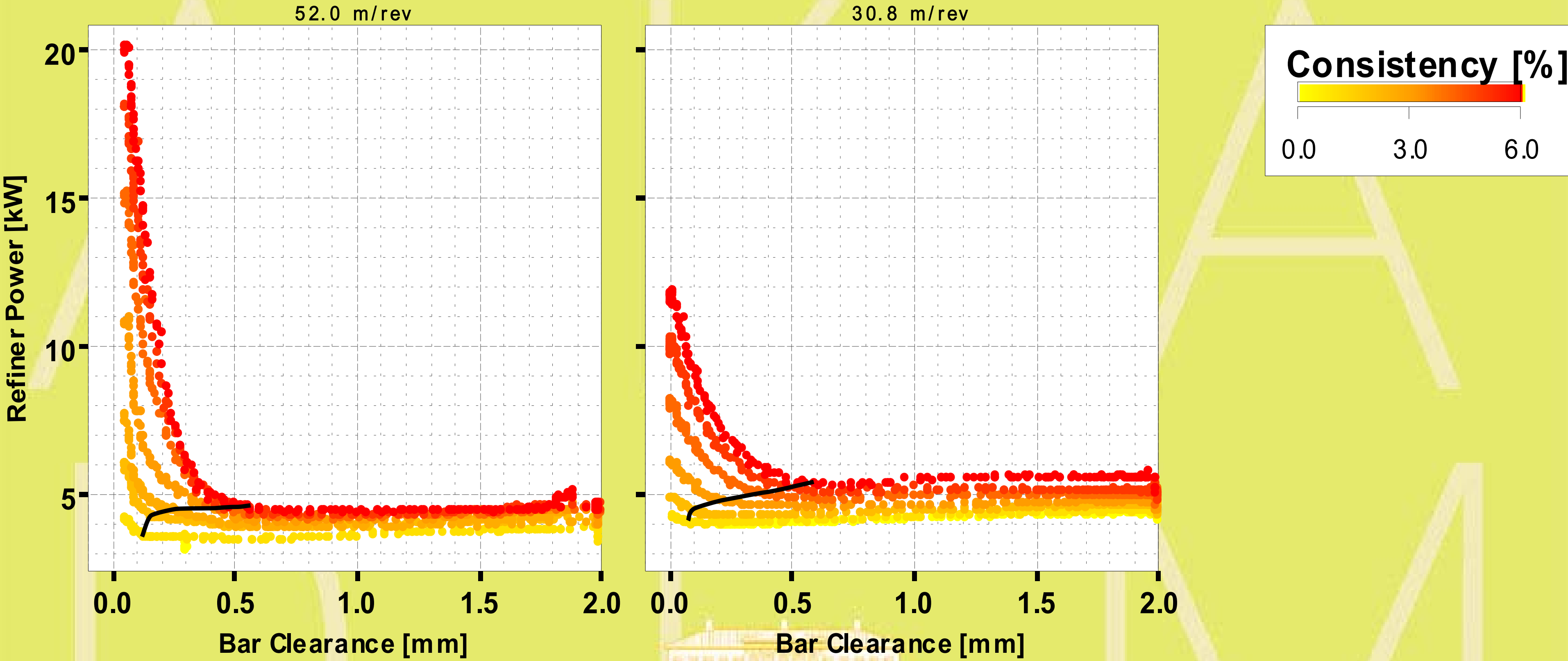
4000 rpm



Results

ProLab

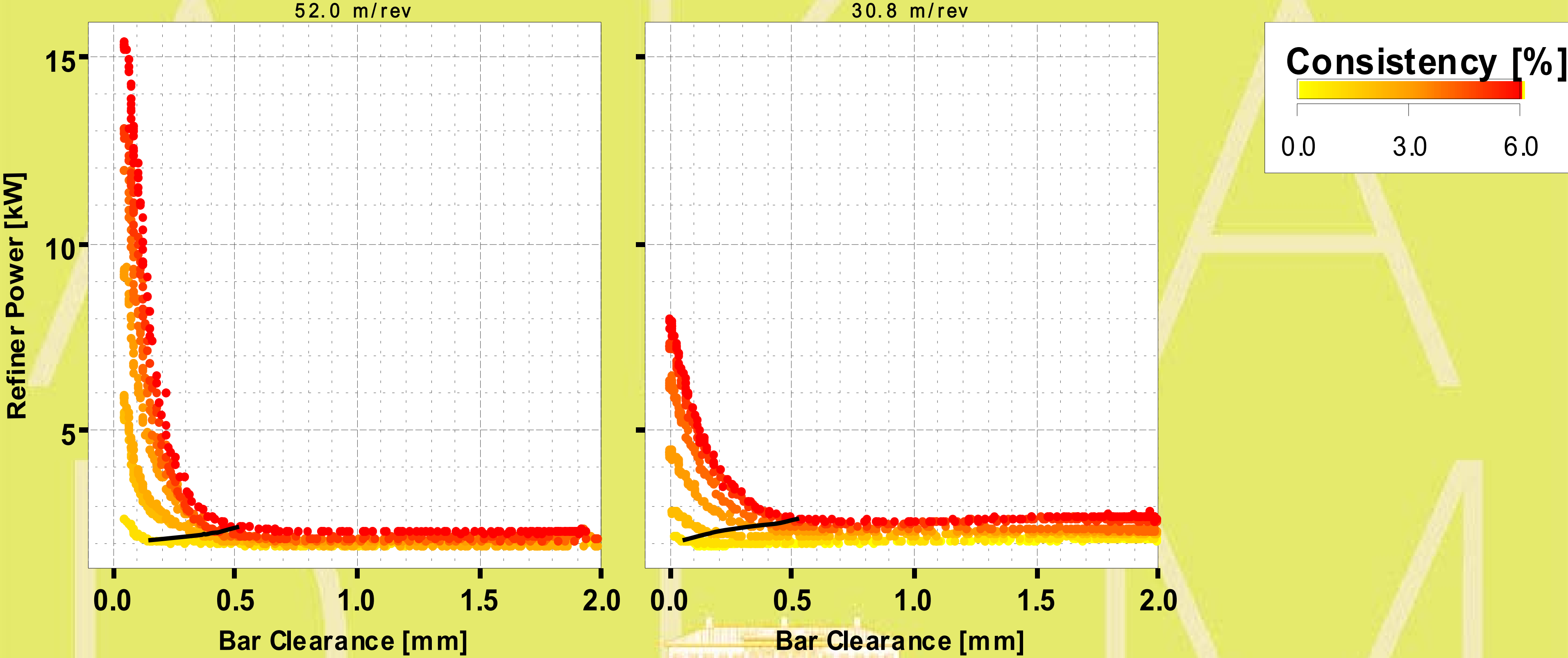
3000 rpm



Results

ProLab

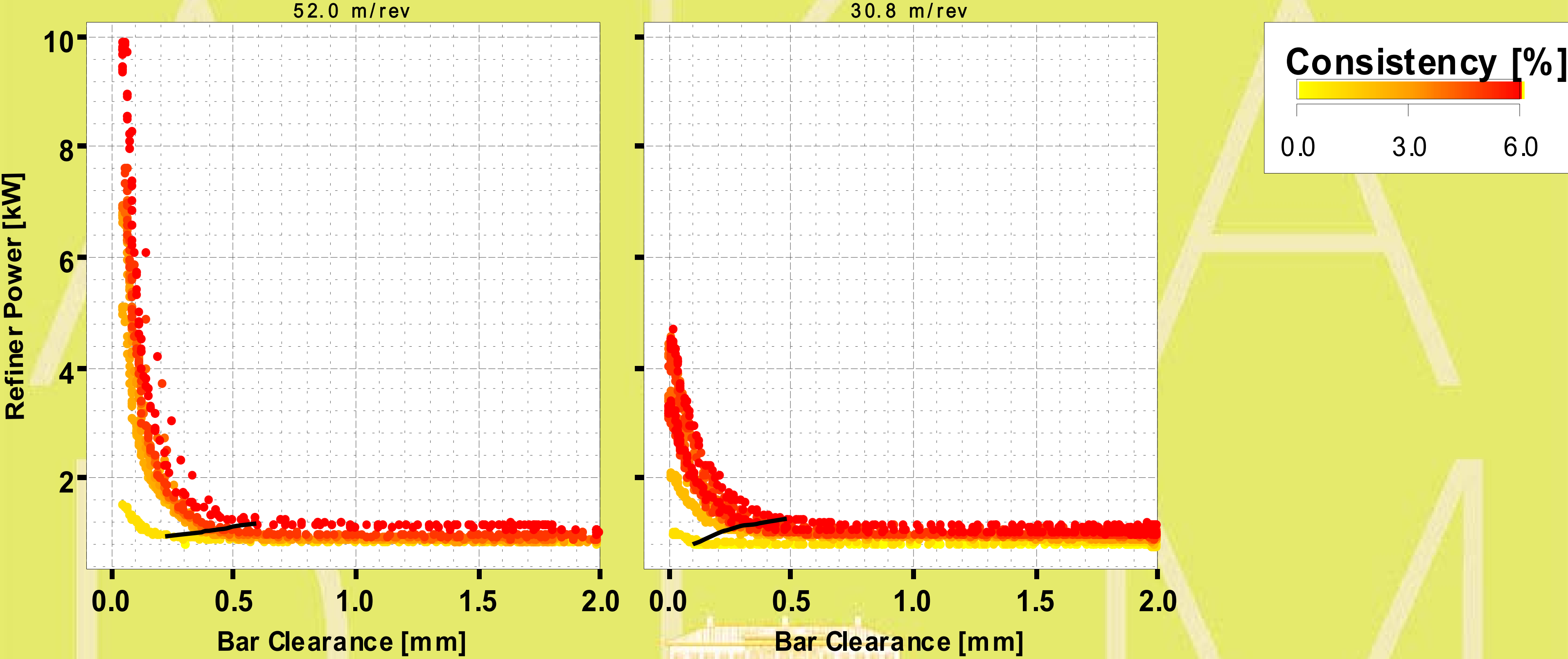
2250 rpm



Results

ProLab

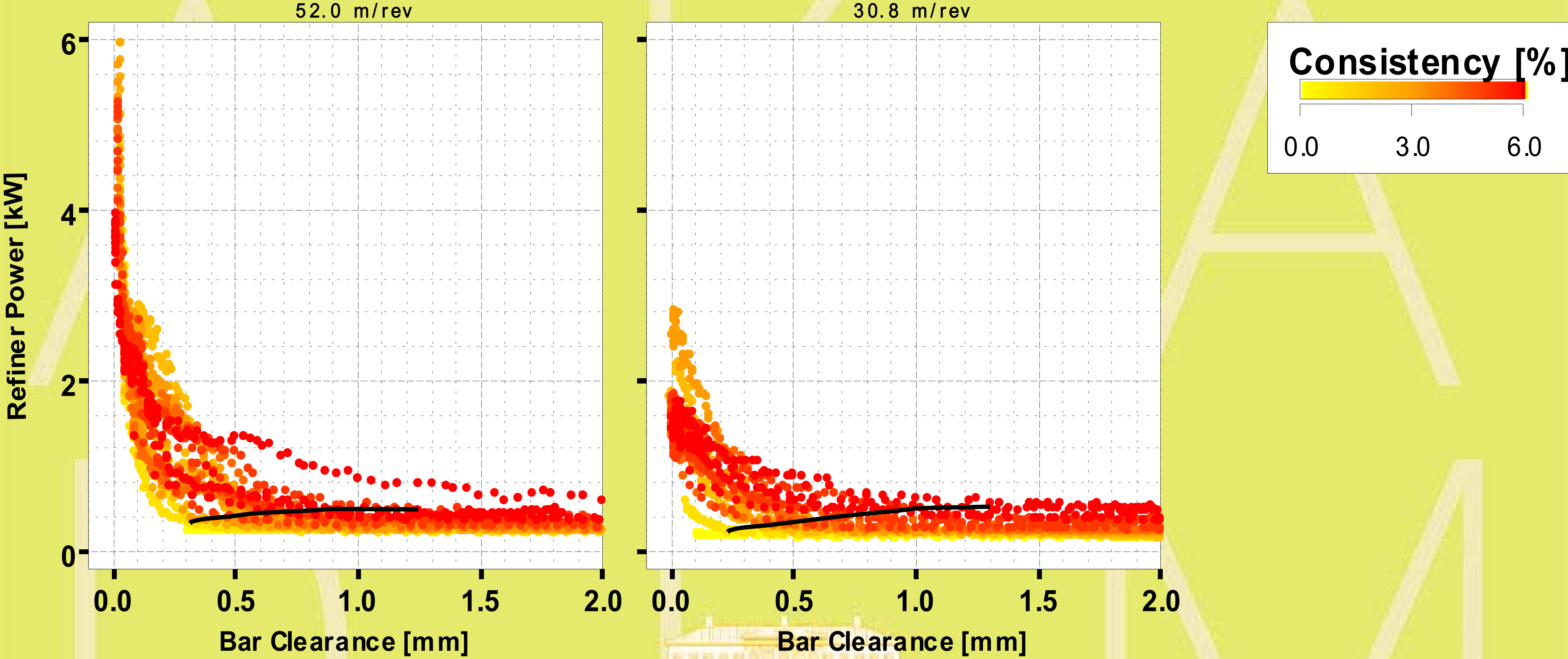
1500 rpm



Results

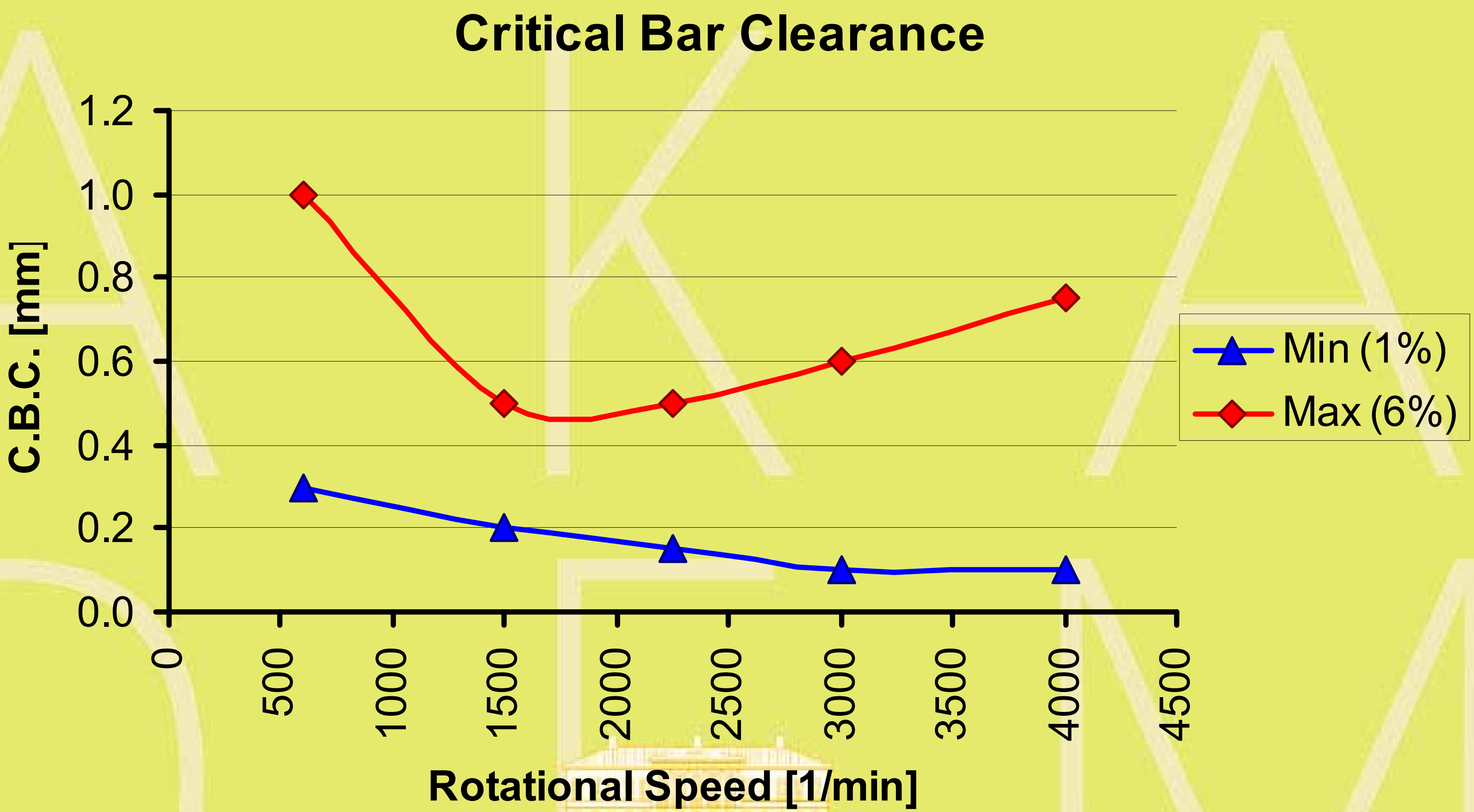
ProLab

600 rpm



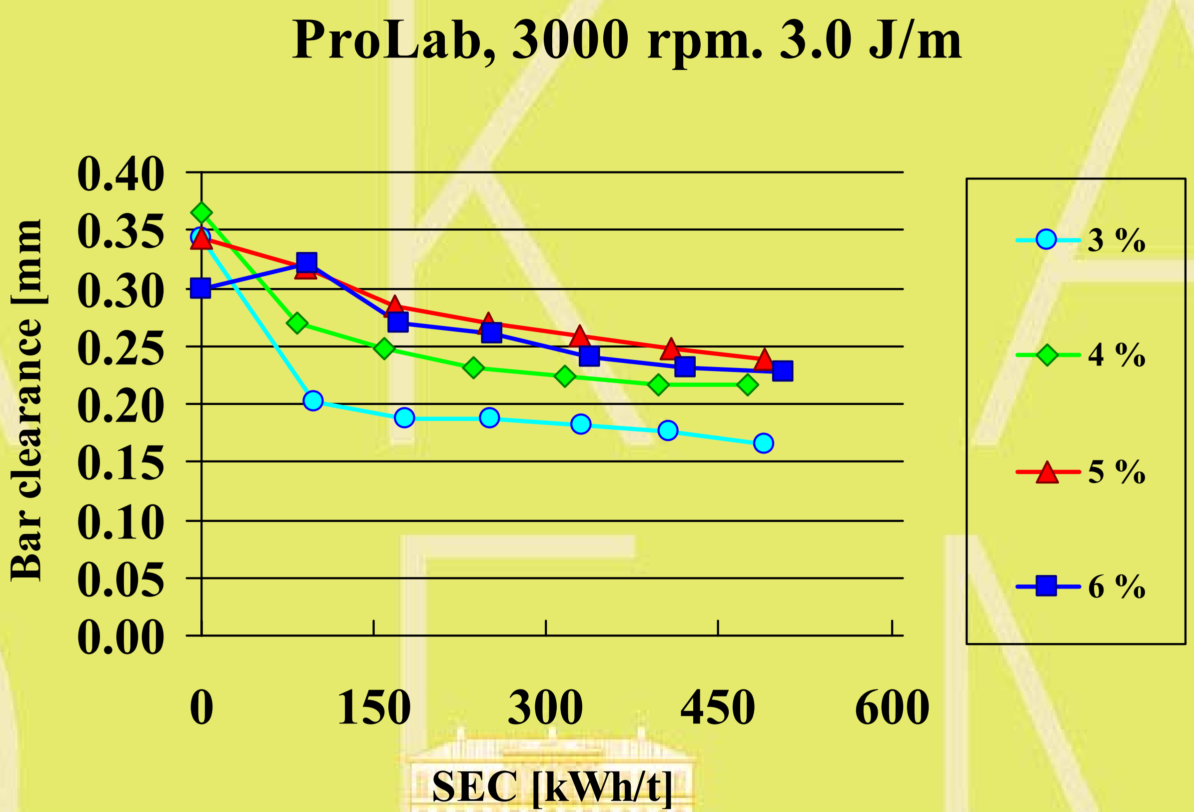
Results

- The minimum bar clearance required for refining energy transfer ($P_{tot}>P_0$)



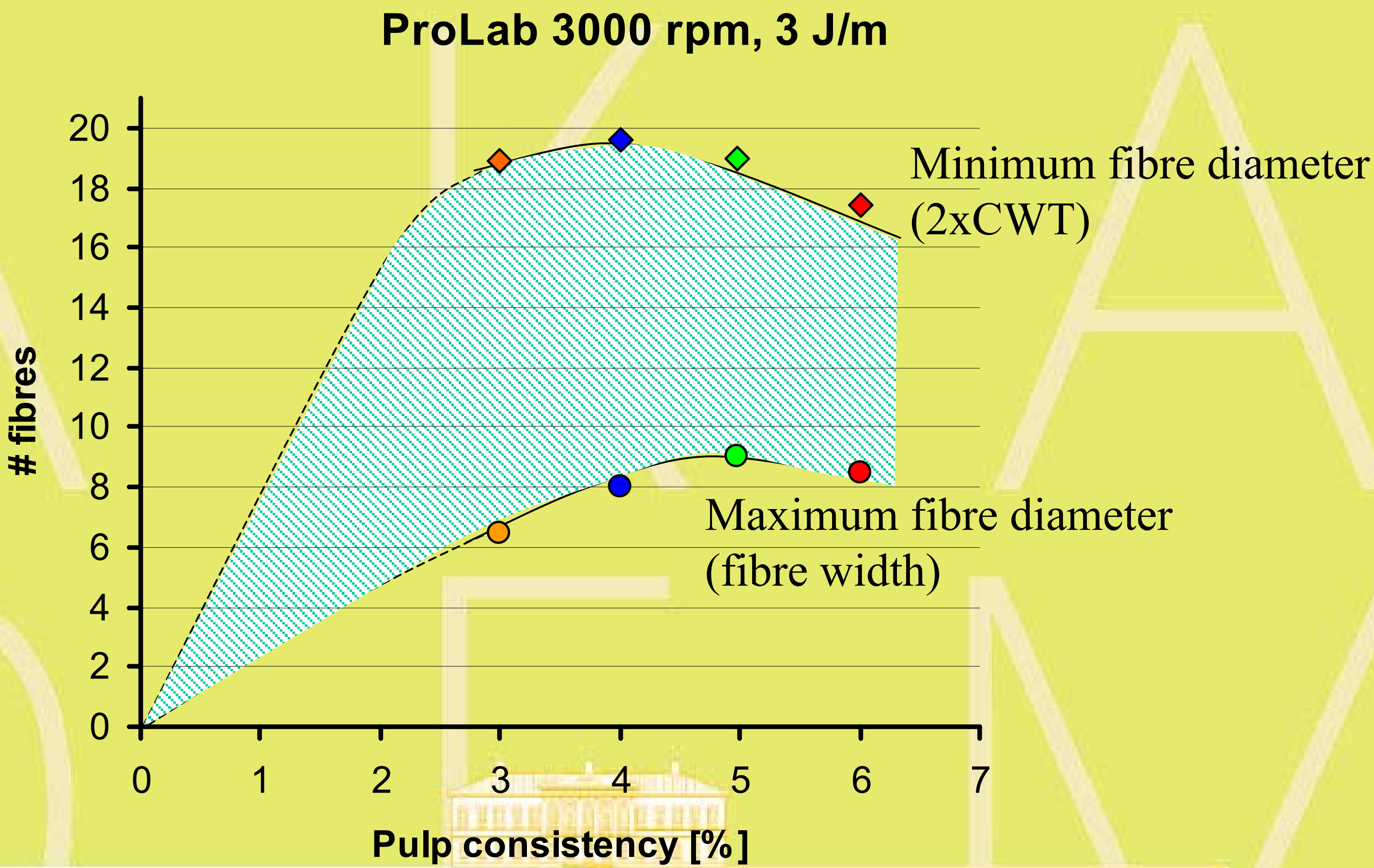
Results

- SEC *vs.* bar clearance (floc size)
  - Smaller bar clearance at decreasing consistency



Results

- Number of fibres between bars



Conclusions

- Idling power increased with consistency
- Refiner loadability increased with consistency
- The critical bar clearance
  - Increased with consistency (>2% cons.)
- 5-20 fibres between rotor and stator bars depending on consistency

Acknowledgements

PaPSaT and the Research Institute of the Åbo Akademi University Foundation are gratefully acknowledged for financial support