High Speed Circular Sawing

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Outline of Presentation

• Results of studies aimed at increasing mill throughput:
  a) “Sub-Critical” high blade speed study
  b) “Super-Critical” high blade speed study

• Effect of speed on blade stiffness
  “Critical Speed” concept

• Factors that influence cutting accuracy
Details of Laboratory Cutting Tests

- Climb cutting
- Variable blade and feed speed
- Variable depth of cut and position of cant.
- Cants made up of boards to minimize effect of wood variation.
- High accuracy laser probes used to monitor wood surface after the cut

Details of guided saw and height of cant with respect to the saw

Teeth fully buried in cut
Laser probes used to measure surface deviation on cut board
Laser plots of cut profiles at top and bottom of cant

From these plots we determine averages and standard deviations of the cut board profiles and use these to quantify cutting accuracy.

20thou = 0.50mm

Mill Studies
Sub-Critical High Speed Mill Study

Current Mill Parameters:
- Saw Dia. 0.40m, 36 Teeth
- Saw Plate 2mm
- Blade Speed 2770rpm
- Feed Speed 1.4m/s
- Critical Speed >4000rpm

Aim:
- To determine the effect of increased blade and feed speed on cutting accuracy.

Effect of Blade Speed on Surface Deviation for Feed Speed of 1.6m/s
Comparison of Two “Identical” Blades
Comparison of Mean Deflection for Three Different “Identical” Blades

Mean Deflection at Top of Cant for Different Speeds (Averaged Results for all Blades)
Summary: Sub-Critical Speed Cutting

- As speed is increased blade stiffness does not reduce.
- For a fixed feed speed, increased blade speed reduces bite and cutting forces.
- Reducing side clearance also reduces cutting forces but must ensure that blade rubbing does not occur.
- Effect of blade heating at rim is to reduce the critical speed.
- If the blades are not flat cutting accuracy may be significantly reduced.

Super-Critical High Speed Mill Study

Existing Situation

- The mill runs stainless 0.43m dia circular saws with 2mm plate and with 40 teeth. The saws run at 3400 rpm with feed speeds as high as 2.0m/s in a climb cutting mode.
- The mill has two double arbor lines each with a maximum depth of cut per saw of 125mm. The wood is predominantly fir.

Aim of Study

- The aim of this study is to assess the possibility of:
  a) increasing recovery by decreasing blade thickness and running 1.5mm or 1.75mm saws;
  b) increasing throughput by running saws faster and thus increasing feed speeds for the same bite.
Measurement of Cutting Accuracy

- Cants were positioned such that blade was not fully imbedded in cut.
- In this case the blade displacement could be measured directly above the cut.

Cutting Response: Different Blade Speeds

- 3400 rpm
- 4200 rpm
- 4400 rpm
- 5400 rpm

.43m dia. saws with 2.0mm plate
Effect of Speed on Standard Deviation for Constant Bite (0.43m, 2.0mm saw)

No sign of critical speed response (4400rpm)

Standard Deviation Difference Between [2.0mm;3400;2.0m/s;0.8mm] and 1.7mm Blades

No sign of critical speed response (3400rpm)
Standard Deviation Difference Between [2.0mm;3400;2.0m/s;0.8mm] and 1.5mm Blades

No sign of critical speed response (3000rpm)

Summary: Super-Critical Speed Cutting

- Blade stiffness is not reduced at the lowest critical speed. In some cases successful cutting has taken place by running between 2nd and 3rd critical speeds. This conclusion is only valid for small saws. Say, 0.5m or less.

- A number of Canadian mills operate saws in the supercritical speed range.

- In general our fundamental understanding of the supercritical speed behaviour of saws is not well developed.
Quote from One of My Reports

- In all the mill cases investigated it was found that (in the lab) increased feed speeds could be obtained, without significant reduction in cutting accuracy, by increasing the blade speeds above existing mill levels.
- In a number of cases washboarding occurred. However, in each case, it was found that the washboarding could be eliminated by changing the blade speed.
- It was found that the cutting accuracy of the blades were adversely affected in a significant manner if the blades were not flat.

Effect of Speed on Blade Stiffness

- Concept of Critical Speed
- Role of Blade Heating
- Role of Cutting Forces
Critical Speed Concept

- If we apply a constant sideways force to a blade the magnitude of deflection will depend upon the blade speed.
- This displacement will be a maximum when the blade is rotating at its critical speed.
- It is not possible to cut with collared saws near to, at, or above the critical speed.

Video up next
The Critical Speed Phenomena

• Critical Speeds
  – occur at rotational speeds where a blade natural frequency is zero
  – depend on saw diameters, tensioning, temperature distribution, and thickness
Effect of critical speed instability?

- Critical speed instability is a vibrational effect which causes dynamic instability and poor saw cuts
Role of Blade Heating

- Heating the rim of the saw more than the eye will reduce blade stiffness. Thus, gullet spillage, blade rubbing, and tooth friction will increase blade deflections.

- Rim heating reduces the blade critical speed and thus limits blade speeds.

- ( Heating the eye more than the rim will increase blade stiffness. This idea has been tried in active control systems that used induction heaters to provide the necessary temperature gradient).
Effect on Blade Flexibility of Heating Rim more than the Eye

Note that at higher speeds smaller temperature difference is required to increase flexibility.

Role of Cutting Forces

- The larger the cutting forces the larger the blade displacements.
- Cutting forces depend upon:
  a) wood species
  b) moisture content
  c) bite
  d) kerf width (side clearance)
  c) tooth sharpness
- They do not have a strong dependency on blade speed itself
Conclusions

• Understanding the basics will help in the determination of optimal sawing parameters.

• There is a potential for mills to operate at higher speeds than are presently used.

• Current bearing design limits the maximum speed in most mills.

• It should not be assumed that what is recorded in the lab will be recorded in the mill.

• Results obtained in the laboratory are best viewed as a guide for mill tests.