APPLICATION OF EXO-TECHNOLOGY TO CIRCULAR SAWS for Secondary Processing of Wood & Wood Products
Background Concepts: Plate Thickness – Saw Stiffness

\[ D = \frac{Et^3}{12(1 - \nu^2)} \]

D: bending/flexural rigidity of the plate.
E: Young's modulus
\( \nu \): Poisson's ratio of the plate material
t: thickness of the plate

- If plate thickness increases from 1.00 mm to 1.10 mm, saw stiffness increases by 33%.
- In a normal, uncoated saw blade (not shown) if tip-to-body side clearance is 0.20 mm this means the kerf increase is from 1.40 mm to 1.50 mm.
- Which means that increasing the kerf by 7%, in this case, increases stiffness by 33%.
- With our coated saw blades (as shown) you can reduce the side clearance and take the 33% STIFFNESS INCREASE with NO KERF INCREASE!!

Reduced tip-to-body clearance for thicker plate, coated blade ➔ Wear Resistance and Thermal Management properties of coating protects saw plate.
Higher tool stiffness leads to:

• Less blade ‘wobble’ ~ lower “effective” kerf ~ lower cut deviation \(\Rightarrow\) improved cut precision.
• Greater resistance to lateral force \(\Rightarrow\) Fewer crashes \(\Rightarrow\) hence increased tool life.
• Possibility of additional re-tips and re-grinds \(\Rightarrow\) hence increased tool life.

• More uptime
• Improved cut quality
• Overall lower cost per cut

Background Concepts:
Plate Thickness – Saw Stiffness

Reduced tip-to-body clearance for thicker plate, coated blade \(\Rightarrow\)
Wear Resistance and Thermal Management properties of coating protects saw plate.
**Kerf reduction is desirable:**

- Less wastage of work-piece material $\rightarrow$ significant yield improvement.
- Lower power consumption.

**Kerf reduction drawbacks:**

- Mechanical integrity of the saw blade will be compromised if blade design is not beefed up.
- Compromised mechanical integrity and lower tool stiffness leads to:
  - Reduction in number of re-tips & re-grinds $\sim$ overall lower tool life.
  - Higher cutting deviation.
Coated Tool Geometry Considerations

KERF THICKNESS, $K_1 = K_2$

PLATE THICKNESS, $P_2 > P_1$ $\Rightarrow$ IMPROVED MECHANICAL INTEGRITY OF TOOL WHILE MAINTAINING KERF THICKNESS

TIP TO BODY CLEARANCE, $T-B_2 < T-B_1$

CASE 1

KERF THICKNESS, $K_2 < K_1$

PLATE THICKNESS, $P_2 = P_1$ $\Rightarrow$ MAINTAIN MECHANICAL INTEGRITY OF TOOL WHILE REDUCING KERF

TIP TO BODY CLEARANCE, $T-B_2 < T-B_1$

CASE 2
Coated Tool Geometry Considerations

- **REDUCE KERF THICKNESS**
  - REDUCTION OF TIP-TO-BODY CLEARANCE
  - KEEP PLATE THICKNESS UNCHANGED
  - DECREASE PLATE THICKNESS
  - NO REDUCTION OF TIP-TO-BODY CLEARANCE

- **RUBBING ACTION BETWEEN WORK PIECE & SAW BODY**
  - EXO
  - FRICTION \( \rightarrow \) HEAT GENERATION
    - ~ RAPID INCREASE IN TEMPERATURE OF SAW
  - PITCH / RESIN BUILD-UP ON SAW BODY & WORK PIECE

- **REDUCTION OF BLADE STIFFNESS**
  - LESSER NUMBER OF RE-TIPS & RE-SHARPENINGS
    - ~ REDUCTION OF BLADE LIFE
  - SAW BLADE RUN-OUT OR ‘WOBBLE’ INCREASES \( \rightarrow \) INCREASE IN CUTTING DEVIATION

- **DETERIORATION OF CUT QUALITY**

- **EXO**
INTRODUCTION TO EXO TECHNOLOGY
EXO FEATURES

• A proprietary inter-metallic nickel based coatings technology.
• Under development over the past 6 years - $50m in investment.
• Unique combination of properties ideally suited for cutting and wear-protection applications for tooling and industrial machinery wear parts & components.
  ➢ Hardness
  ➢ Toughness
  ➢ Lubricity
  ➢ Low coefficient of friction
  ➢ Surface topography
Immersion in Liquid $\Rightarrow$ non line of sight $\Rightarrow$ uniform coating thickness.

- Low Temperature ($> 200^\circ\text{F}$) $\Rightarrow$ no tool distortion or reduction of bulk tool hardness.
- Fast Deposition rate $\sim 20$ microns/hr (0.0008 in/hr).
EXO TECHNOLOGY FEATURES

NOT A LINE-OF-SIGHT PROCESS

- Complicated geometry components can be coated with a uniform coating thickness. No edge build-up.
- Through holes and cavities can be coated to a tight tolerance finish.
WIDE RANGE OF COATING THICKNESS POSSIBLE

- Depending upon application – typical 10 microns (0.0004 in.) to 100 (0.004 in.) microns. Possible: 800 microns (0.032 in.)
- If coating is used in a sacrificial mode, there is substantial thickness to wear through – so a prolonged component life is possible.
MICROSTRUCTURE & TOPOGRAPHY

- Large surface area to dissipate heat.
- Low sliding contact area minimizes friction forces.
The material has inherently low coefficient of friction. This property coupled with the unique surface topography, gives coated surfaces a high degree of lubricity, making them ideally suited for SLIDING / ADHESIVE WEAR & GALLING application.

LOW COEF. OF FRICTION / HIGH LUBRICITY

EXO TECHNOLOGY FEATURES

LOW COEF. OF FRICTION / HIGH LUBRICITY

- The material has inherently low coefficient of friction. This property coupled with the unique surface topography, gives coated surfaces a high degree of lubricity, making them ideally suited for SLIDING / ADHESIVE WEAR & GALLING application.

EXO TECHNOLOGY FEATURES

- VALVE SEATING & VALVE TRUNION
- EXTRUSION SCREW & BARELL
- EXO GUIDE-PADS FOR LUMBER MILL SAW GANGS
- EXO GREASE-LESS GUNS
- LINER HANGERS
UNIQUE SURFACE TOPOGRAPHY

- Large surface area to maximize heat dissipation from the surface
  - Cooler temperatures $\Rightarrow$ better mechanical stability of tools (especially thin bodied) and components.
  - Modified heat-signature.

EXO TECHNOLOGY FEATURES
WEAR RESISTANCE

- Adequate hardness, that can be tailored over a range of 900 – 1400 Knoop, depending upon the application.

Note: HRC 67 = HK 900
EXO TECHNOLOGY FEATURES

MECHANICAL INTEGRITY

• Excellent bonding to most surfaces
• Bending & Impact resistance

BENDING DEFORMATION
(survives 180° bend test)

TENSILE BOND
> 70 MPa
(> 10,000 psi)
(exceeds test ability)

IMPACT
(no delamination)
TESTING EXO-TECHNOLOGY ON CIRCULAR SAWS
TESTING PROTOCOL

- SAW BLADES MANUFACTURED BY STS ➔ 180 mm DIAMETER, 1.35 mm KERF, 1.10 mm PLATE, TIP-TO-BODY CLEARANCE: 0.006”

- WORK PIECE MATERIAL: RED OAK

- MEASURE AMPERAGE DRAW, DYNAMIC RUN-OUT AND TOOL TEMPERATURE AS A FUNCTION OF LINEAL FEET OF WOOD STRIPS CUT BY THE SAW.
Cutting 1½” Red Oak

- Resin Build-up
- Cut Deviation
- Blade run-out

900 linear feet – uncoated
1500 linear feet - coated

Resin Build-up

Blade run-out

Cut Deviation

Uncoated Coated

900 linear feet – uncoated
1500 linear feet - coated

Cut Deviation

Blade run-out

Uncoated Coated
Cutting Test Data

Amperage Draw on 0.006" Side Clearance Blades

- 30% lower Current draw

Nodular surface topography ➔ Low sliding contact area minimizes friction forces.

20% lower amperage for coated saws ➔ lower Horse Power & Energy requirements
Cutting Test Data

Temperature on 0.006" Side Clearance blades

Temperature (F)

Lineal feet

- **EXO**
- **Uncoated**

200°F Lower temp.

Nodular surface topography ➔ Large surface area ➔ higher heat dissipation rate.

Significantly lower temperature for coated saw.
Cutting Test Data

Runout on 0.006” Side Clearance blades

- Lower temperature of coated blade → improved mechanical integrity
- Significantly lower axial run-out for coated saw
Less Pitch / Resin build-up on coated saws

Pitch on coated saws less adherent and easily removable
HEAT DISSIPATION FROM COATED SURFACES

Thermograph of coated blade

At 800 lineal ft (195°F) At 2800 lineal ft (193°F) At 3200 lineal ft (350°F) Blade failed at this point

Thermograph of uncoated blade

At 1200 lineal ft (257°F) At 1600 lineal ft (346°F) Blade failed at this point

Coated blades run twice as long before they reach the same temperature as an uncoated blade.

Heat transfer away from cutting edge more effective with coated blade.

Coated Saw

Un-coated Saw
External Testing (NCSU) – Cutting loads

CNC Router Set-up

Industry standard side clearance for this type of cutting conditions is 0.012”. Coated blades; 0.006" tip to body side clearance. Cutting load ~ RMS milli-volts from 3-axes force dynamometer.

<table>
<thead>
<tr>
<th>Species</th>
<th>Coated</th>
<th>Uncoated</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDF (blade set 1)</td>
<td>3.57</td>
<td>5.18</td>
<td>31.1%</td>
</tr>
<tr>
<td>MDF (blade set 2)</td>
<td>1.63</td>
<td>2.36</td>
<td>30.9%</td>
</tr>
<tr>
<td>Particleboard</td>
<td>3.57</td>
<td>5.18</td>
<td>31.1%</td>
</tr>
<tr>
<td>Pine</td>
<td>7.05</td>
<td>11.67</td>
<td>39.6%</td>
</tr>
</tbody>
</table>
Thermal Characteristics – HP draw

Temp after 5 min at 7200 RPM

<table>
<thead>
<tr>
<th>Disk</th>
<th>HP draw</th>
<th>% Change</th>
<th>Ave Temp</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncoated</td>
<td>0.89 hp</td>
<td></td>
<td>142° F</td>
<td></td>
</tr>
<tr>
<td>Coated, unpolished</td>
<td>0.47 hp</td>
<td>-49%</td>
<td>102° F</td>
<td>-40° F</td>
</tr>
</tbody>
</table>

- Improved heat dissipation from coated surface.
- Lower friction forces on coated surface ➔ lower Horse Power draw.
Conclusions of recent external testing

- Tool temperature - reduced by 40 degrees
- Horse-Power draw - reduced by 49%
- CNC Cutting loads – reduced by 30-39%
- Accelerated Acid Wear Test – wear reduction of 50%

- **EXO** saws generate lower cutting forces vs uncoated saws. This translates into:
  - Lower HP draw
  - Lower tool temperature

- Reduction of friction due to **EXO** provides reduction of heat, drag and wear – significant value driver for a diverse range of wood and metal working products.
**PROPERTIES OF EXO treated tools and components**

**EXO treated tools dissipate heat more effectively – hence remain cooler over a longer period of time**

- Improved mechanical stability
- Less resin or work-piece material build-up
- Improved cut quality
- Lower ‘operating’ kerf ~ Less cutting deviation

**EXO treated tools and components have excellent lubricity**

- Material has an inherently low coefficient of friction.
- Unique surface topography minimizes contact surface area and hence leads to lower friction forces.
- Lesser heat generation than uncoated saws
- Lower cutting forces and power requirements → reduced energy consumption
- Significantly reduced lubrication consumption
Thank You!

For further details please contact:

Dr. Rajiv Ahuja
President
UCT Forestry

W: (772) 872-7119
C: (248) 202-1177

rahuja@uctcoatings.com

www.uctforestry.com
7825 SW Ellipse Way
Stuart, FL 34990 USA