



Fundamentals for Modern Precision Slitting of Copper

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ENGINEERED SUCCESS



IWCC Legal Disclaimer

The purpose of this presentation is to guide programs benefiting the copper industry and to provide attendees with information to make independent business decisions.



Modern expectations for copper slitting:

- + More predictable and repeatable results
- + Tighter tolerance mult width
- + Reduced quality issues due to equipment and tooling limitations
- + Improved reliability & operating life of:
 - ◆ Equipment
 - ◆ Tooling



**The precision limits of a slitting system (Equipment + Tooling)
are highlighted by:**

- ◆ Brand new equipment
- ◆ Refurbished equipment
- ◆ Tooling, manufactured tolerance
- ◆ Tooling condition
- ◆ More demanding slitting application

Very Light Gauge Slitting





Common Issues

Equipment

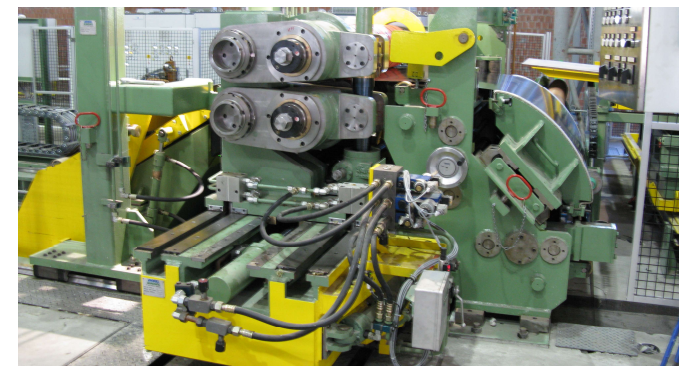
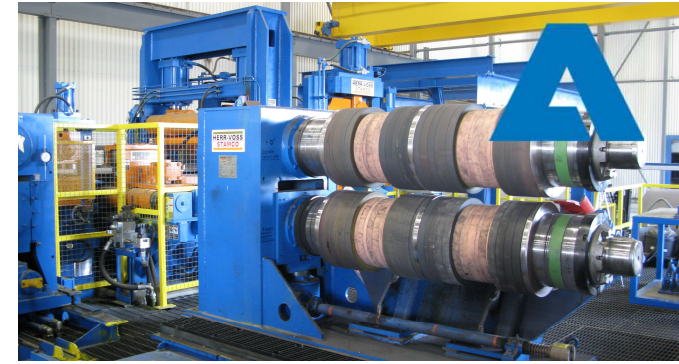
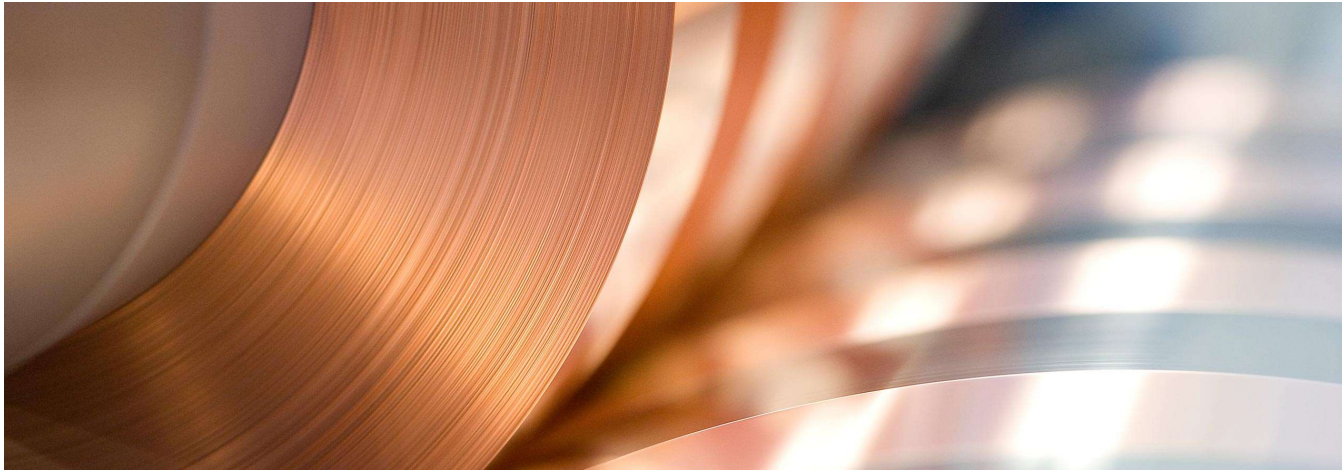
- Not designed for the application
- Worn arbors
- Worn or non-precision bearings
- Misalignment (Equipment or Process)
- Mechanical Damage
- Maintenance related issues
- Wear/Backlash in the knife gap adjustment assembly

Tooling

- Dirt or build up on tooling
- Nicks, scratches, or chips
- Out of tolerance due to wear
- Dull knives
- Worn stripper rings or bonded spacers

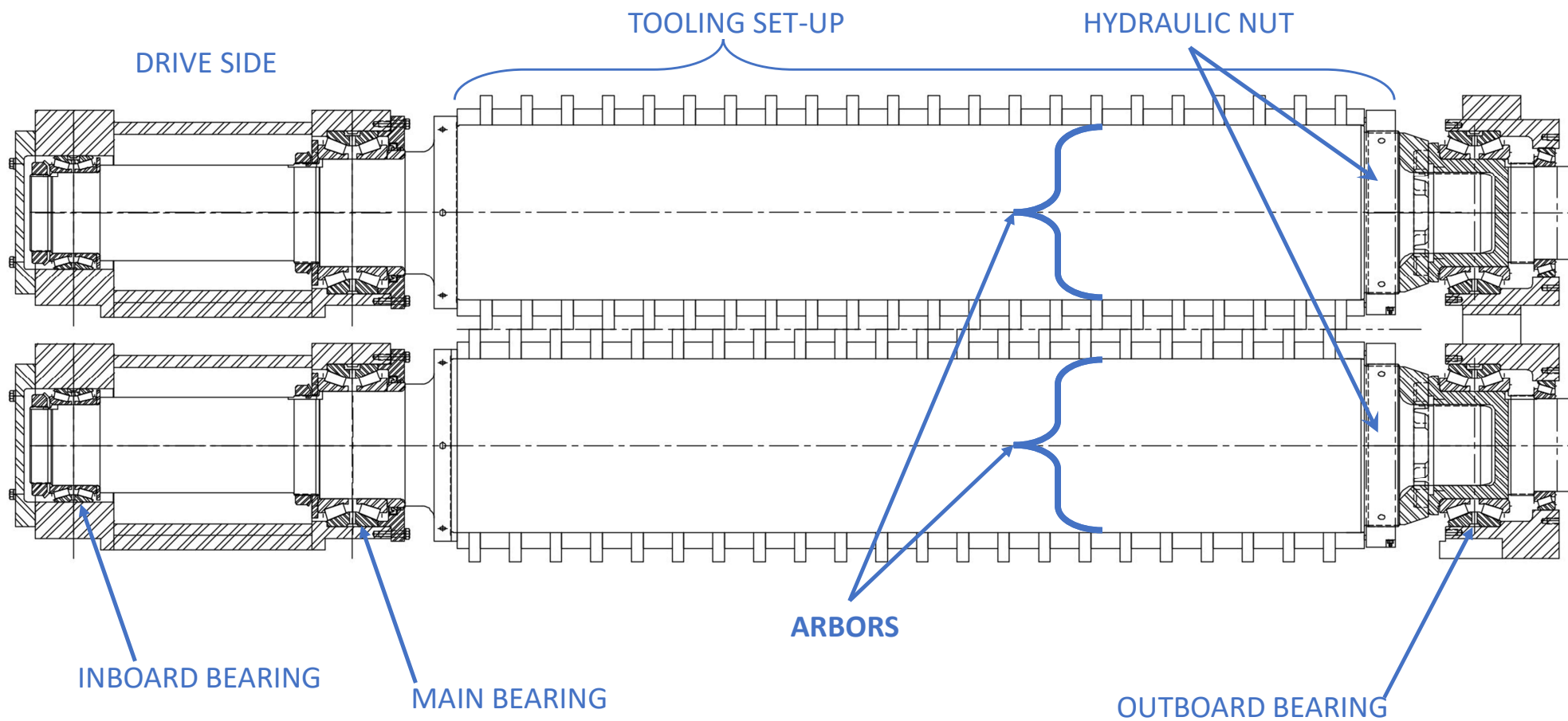


EQUIPMENT





SLITTER DESIGN





SLITTER DESIGN



CUSTOMER APPLICATION PARAMETERS

MATERIALS

GAUGES

STRENGTHS

WIDTHS

LINE SPEED/
PRODUCTION

NUMBER OF
CUTS



SLITTER DESIGN



OEM DESIGN

**CUSTOM ENGINEERED
PARAMETERS**



**PURCHASED COMPONENT
PARAMETERS**



SLITTER DESIGN

OEM DESIGN CUSTOM ENGINEERED PARAMETERS

DRIVETRAIN

Single Input – Internal Gearing

Dual Input – External Gear Reducer

ARBOR DESIGN

Deflection

Bearing Loads

Bending Stress

TOOLING

Surface Finish

Tooling Tolerance

Locking Mechanism



SLITTER DESIGN

OEM DESIGN

PURCHASED COMPONENT CONSIDERATIONS

DRIVETRAIN

Single Input – Internal Gearing

Dual Input – External Gear Reducer

BEARINGS

CLASS 0 - PRECISION

CLASS 2 - STANDARD

OTHER

Locking
Mechanism

AUTOMATED
HYDRAULICS

HIGH
PRESSURE NUTS

STANDARD
PRESSURE NUTS



TAPERED ROLLER BEARING – PRECISION CLASS IN RELATION TO VERTICAL KNIFE GAP



INCH	METRIC	RADIAL RUN-OUT
4	K	.002" (0.051mm)
2	N	.0015" (0.038mm)
3	C	.0003" (0.0076mm)
0	B	.00015" (0.00381mm)
00	A	.000075" (0.001905mm)
000	AA	.000040" (0.001016mm)

0.010" Thick Material = 9-11% Vertical Gap
.0009"-.0011" = **.0002"** Difference (**Class 0 Precision**)

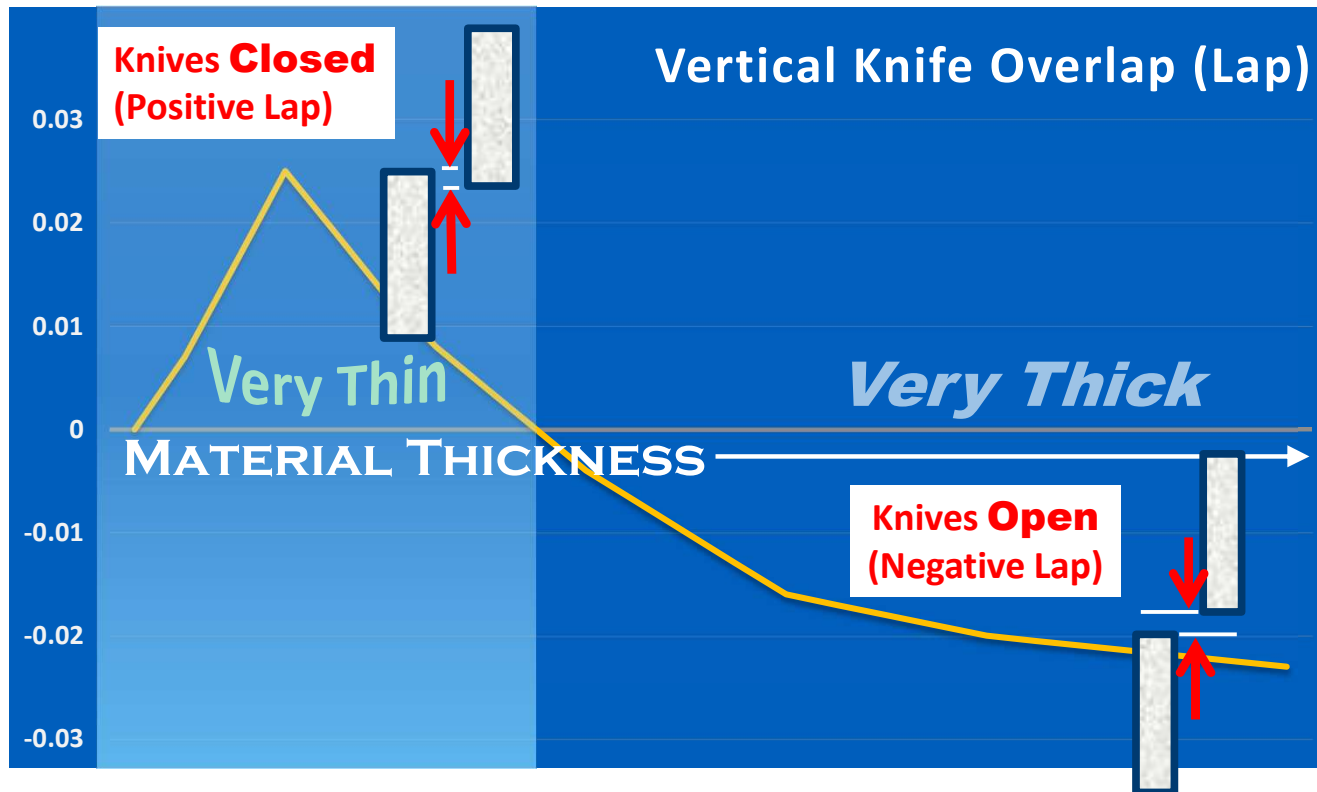
0.100" Thick Material = 9-11% Vertical Gap
.009"-.011" = **.002"** Difference (**Class 2 Standard**)



VERTICAL KNIFE CLEARANCE



Only sink the knives enough to make the cut





ARBOR DEFLECTION IMPACT ON VERTICAL KNIFE CLEARANCE

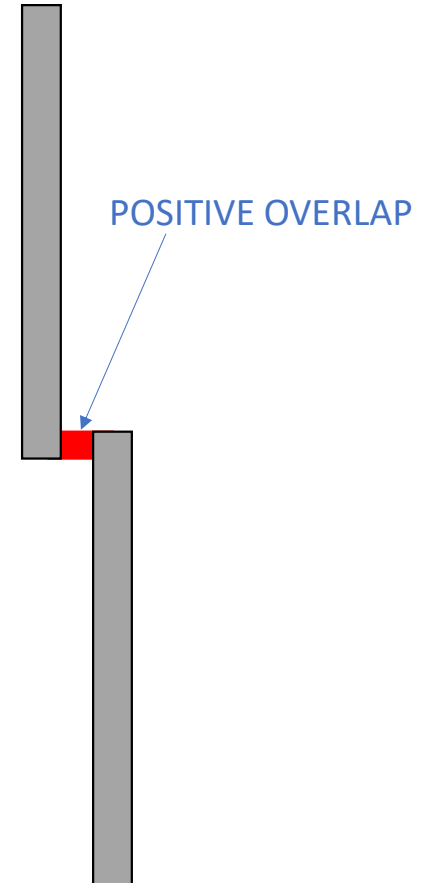


Main Contributing factors to Deflection:

- Gauge (Thickness²)
- Arbor Diameter
- Bearing Span

0.010" Thick Material = +0.005" Overlap
Deflection limited to ~10% Material Thickness = 0.001"
14 Cuts - 6.00" Arbors
36 Cuts - 8.00" Arbors

0.100" Thick Material = +0.011" Overlap
Deflection limited to ~10% Material Thickness = 0.010"
4 Cuts - 6.00" Arbors (3.5X Less)
8 Cuts - 8.00" Arbors (4.5X Less)





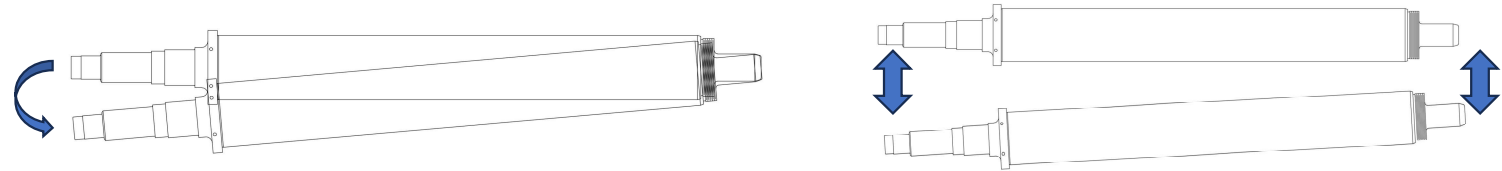
ARBOR DEFLECTION & MAINTENANCE IMPACT ON HORIZONTAL KNIFE CLEARANCE



- Arbor End Play



- Arbor parallelism



- Other issues: Pass line/idler roll set up





SLITTER TOOLING



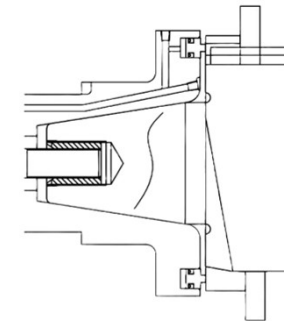
Knives



Spacers + Rubber Stripper Rings
OR
Bonded Spacers



Hydraulic Lock Nuts
OR
Automated Hydraulic Lock System





Slitter Knife Considerations



- Key Dimensions
 - Outer Diameter
 - Inner Diameter
 - Keyway (if any)
- Knife Thickness vs. Material Thickness
 - 3:1 ratio for non-ferrous material & medium carbon steels
 - Example:*
 - *Maximum slit material thickness of 0.125"*
 - *Minimum knife thickness should be 0.375"*
- Knife Material
- Surface Finishes
- Manufacturing Tolerances



Slitter Knife Considerations



Knife Material (tool steel)

Performance characteristics:

- Wear resistance

vs.

- Toughness (not needed for copper)

Copper: Favor wear resistance

High chrome tool steel.

- ◆ High hardenability
- ◆ High polish-ability



Slitter Knife Considerations



Surface Finishes

Smooth & Highly polished to resist material build up

- Precision Plus
 - 4 Ra & semi-reflective polish
- Precision Plus Plus ← Recommended for copper
 - 2 Ra & Mirror polish

Manufacturing tolerances

- Precision Plus
 - + / - 0.000040" millionths
- Precision Plus Plus ← Recommended for copper
 - + / - 0.000020" millionths

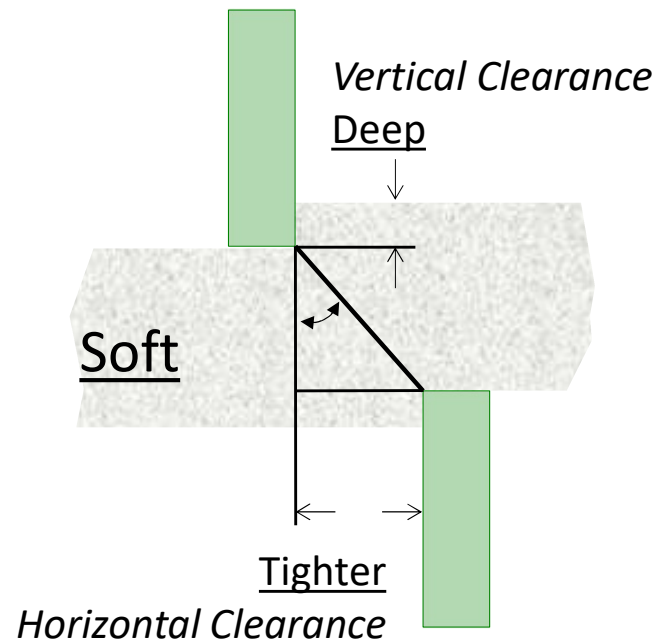


SLITTER TOOLING SET-UP

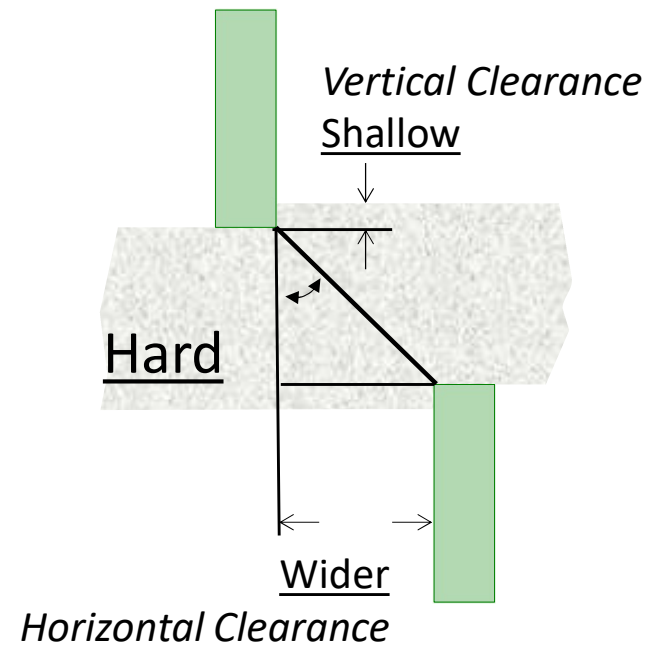


Material Properties vs. Cut Geometry

Copper



Steel





SLITTER TOOLING TOLERANCE





SLITTER TOOLING TOLERANCE



ASKOedge Desktop Client

Machine: Machine -1635 mm | Head: Head 1 | Slitter Setup: Slitter Setup | Setup Orientation: Shoulder | View: Horizontal | Configuration: Slitter Head | Head Length: 1635.000 mm

Maximum Mult Width: 1560.000 mm

VIEW DATA | VIEW BUILD

Order Information

Order Number: .254 mm Copper - Setup # 1

Job Number: Setup # 1

Order Description:

Coil Information

Material: Copper | Coil Width: 1219.000 mm

Coil Weight: 0.000 kg | Material Thickness: 0.254 mm

Tensile Strength: 262 MPa | Clearance Percent: 0.000 %

Builds	Ordered Width (mm)	Built Width (mm)	Quantity	Inboard Knife	Inboard Clearance (mm)	Outboard Clearance (mm)	Outboard Knife	Slitter Mult	
Spacer	304.80	304.80	4	10	0.02	0.02	10	Green and Blue Slitter Mult	
	0.00	0.00	0	None	0.00	0.00	None	None	

Subscription ANDRITZ

8 columns selected | Width used 1226.20 | Remaining width 0.00 | Remaining weight 0.00 | Coil yield 100.02% | Version 1.11.2

Flat rolled copper
Master coil width: 1219.2 mm (48")
Material thickness: 0.254 mm (0.100")
Tensile strength: 262 MPa (38 ksi)
Build width: 304.8 mm (12.00")
Mult Quantity: 4

Inboard Clearance (mm): 0.02



SLITTER TOOLING TOLERANCE



ASKOedge Desktop Client

admin

Setup Machine -1635 mm Head Head 1 Slitter Setup Slitter Setup Setup Orientation Shoulder View Horizontal Configuration Slitter Head Head Length: 1635.000 mm

Maximum Mult Width: 1560.000 mm

VIEW DATA VIEW BUILD

Outboard clearance: 0.02mm
The TOP arbor is misaligned 0.1

Inboard clearance: 0.02mm

24.00mm 304.80mm 284.76mm

Spacer 4 mm Spacer E - 2.1 mm Spacer 24 mm Knife 10 mm Spacer - Bonded Green 10 mm Spacer 80 mm Spacer - Bonded Green 20 mm Spacer 80 mm Spacer - Bonded Green 20 mm Spacer 80 mm Spacer A - 2.6 mm Spacer C - 2.2 mm Spacer - Bonded Green 10 mm Knife 10 mm Spacer 64 mm Spacer 16 mm Spacer - Bonded Blue 20 mm Spacer 64 mm Spacer 16 mm Spacer - Bonded Blue 20 mm Spacer 64 mm Spacer 16 mm Spacer A - 2.6 mm

Spacer 4 mm Spacer 2 mm Spacer 32 mm Spacer H - 2.02 mm Knife 10 mm Spacer 80 mm Spacer - Bonded Blue 20 mm Spacer 80 mm Spacer - Bonded Blue 20 mm Spacer 80 mm Spacer A - 2.6 mm Spacer D - 2.16 mm Knife 10 mm Spacer - Bonded Green 10 mm Spacer 80 mm Spacer - Bonded Green 20 mm Spacer 80 mm Spacer - Bonded Green 20 mm Spacer 64 mm Spacer 16 mm Spacer A - 2.6 mm Spacer C - 2.2 mm Spacer - Bonded Green 10 mm

34.02mm Inboard clearance: 0.02mm 284.76mm Outboard clearance: 0.02mm 304.80mm

Subscription	Ordered Width (mm)	Built Width (mm)	Quantity	Inboard Knife	Inboard Clearance (mm)	Outboard Clearance (mm)	Outboard Knife	Slitter Mult.	
	304.80	304.80	4	10	0.02	0.02	10	Green and Blue Slitter Mult	✗
	0.00	0.00	0	None	0.00	0.00	None	None	✗

8 columns selected Width used 1226.20 Remaining width 0.00 Remaining weight 0.00 Coil yield 100.02% Version 1.11.2

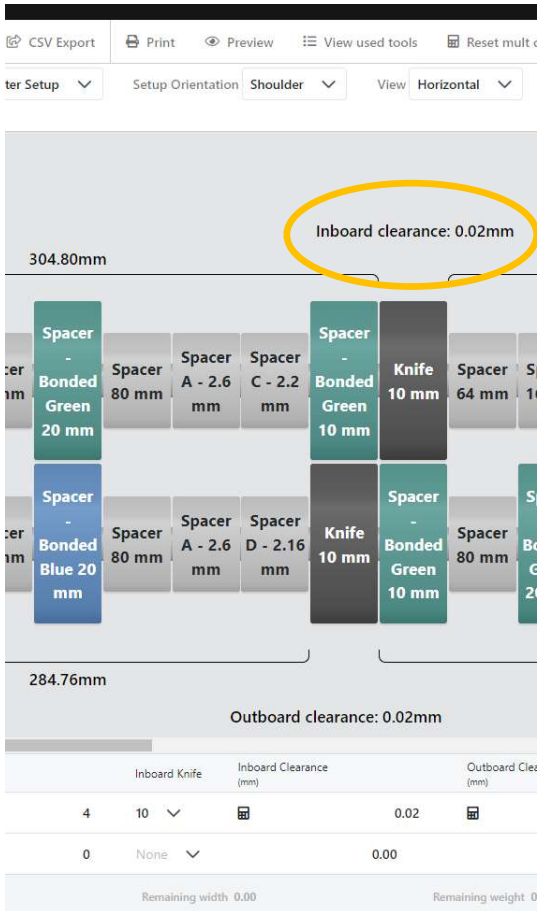


SLITTER TOOLING TOLERANCE



Example 1, Gauge

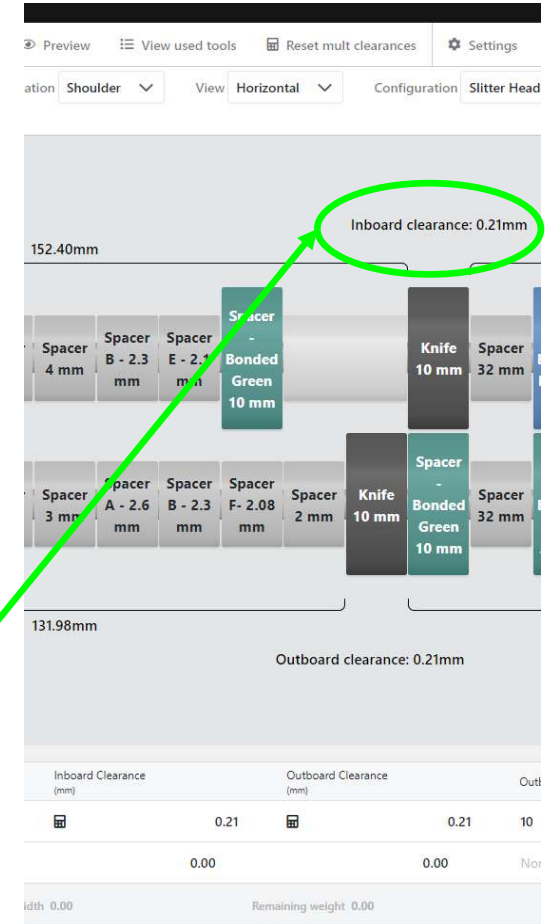
Master coil width: 1219 mm (48")



Material thickness: 0.254 mm (0.010")
 Tensile strength: 262 MPa (38 ksi)
 Build width: 304.8 mm (12.00")
 Mult Quantity: 4
 Horizontal Clearance: 0.02 mm (.0008")

VS.

Material thickness: 2.540 mm (0.100")
 Tensile strength: 262 MPa (38 ksi)
 Build width: 152.4mm (6.00")
 Mult Quantity: 8
 Horizontal Clearance: 0.21 mm (0.008")





SLITTER TOOLING TOLERANCE



Example 2, Tensile Strength

Master coil width: 1219 mm (48")

Export CSV Export Print Preview View used tools

Slitter Setup Setup Orientation Center View Horizontal

Outboard clearance: 0.001in

Inboard clearance: 0.001in

Quantity	Inboard Knife	Inboard Clearance (in)
14	0.375	0.001
0	None	0.000

45.750 Remaining width 2.250

Material thickness: 0.254 mm (0.010")
 Tensile strength: 262 MPa (38 ksi)
 Build width: 82.55mm (3.250")
 Mult Quantity: 14
 Horizontal Clearance: 0.0254 mm (.001")

VS.

Material thickness: 0.0254 mm (0.010")
 Tensile strength: 483 MPa (70 ksi)
 Build width: 82.55mm (3.250")
 Mult Quantity: 14
 Horizontal Clearance: 0.0381 mm (0.0015")

CSV Export Print Preview View used tools Reset mult c

Setup Orientation Center View Horizontal Configurati

Outboard clearance: 0.0015in

Inboard clearance: 0.0015in

Inboard Knife	Inboard Clearance (in)	Outboard C (in)
14	0.375	0.0015
0	None	0.000

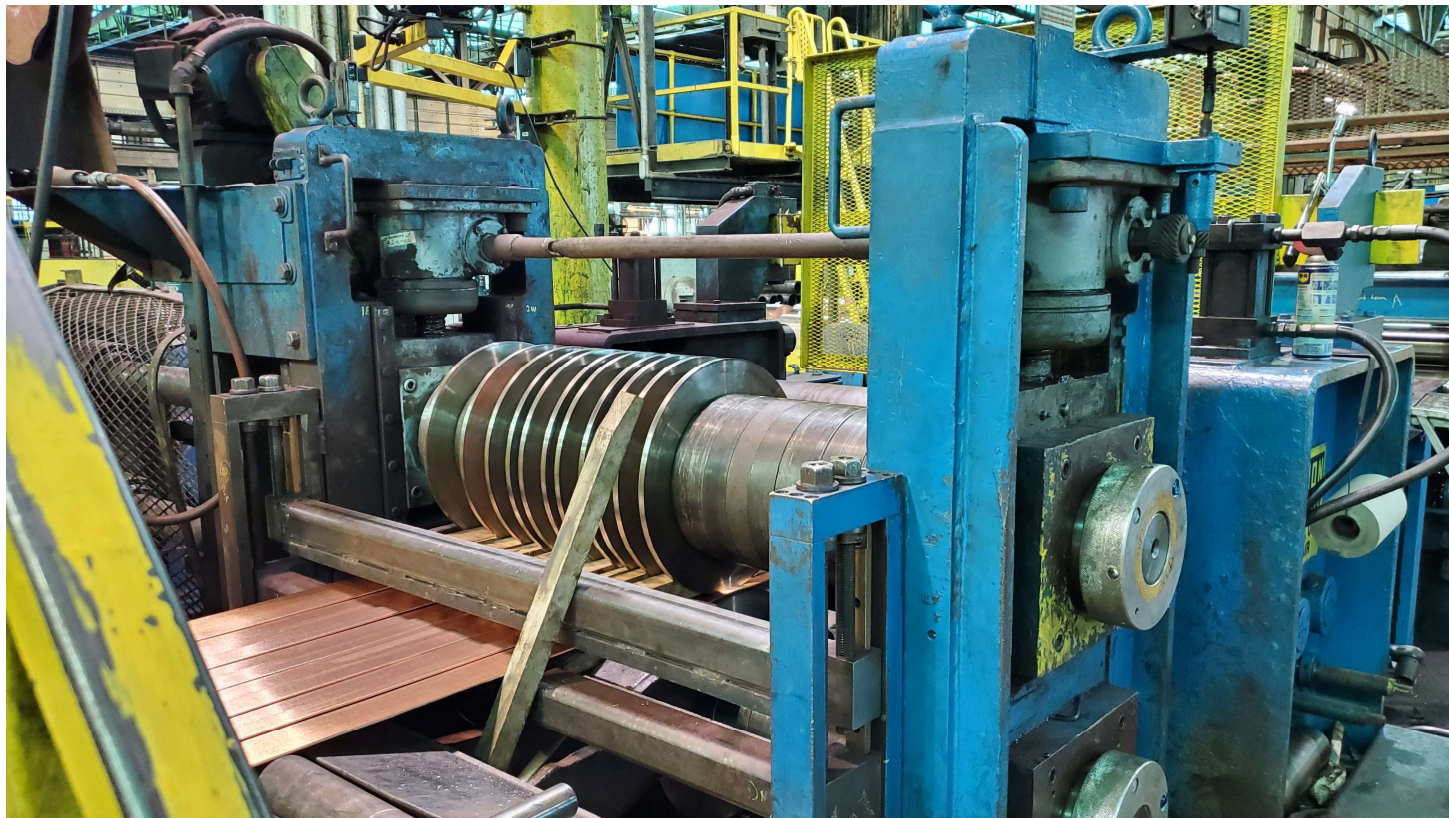
Remaining width 2.250 Remaining weight 0.0



SLITTER TOOLING



Yesterday's
Technique





SLITTER TOOLING TOLERANCE



Today's Technique

Spacers + Rubber Stripper Rings



Bonded Spacers

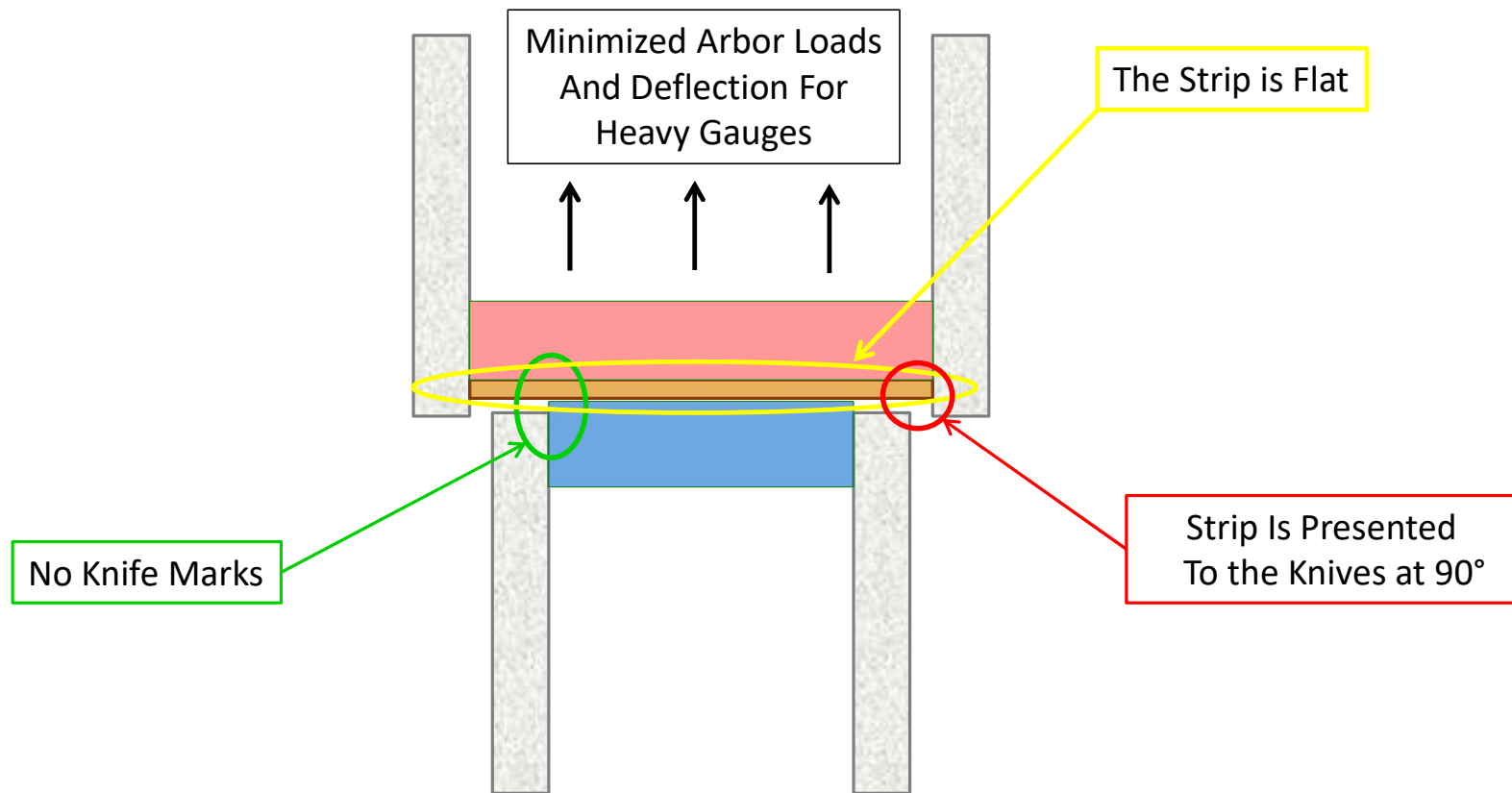




SLITTER TOOLING TOLERANCE



Proper Stripper Ring Practice





Slitter Stripper Ring Considerations



Ferrous material
Stripper ring sizing

<u>Material Thickness</u>	<u>MALE</u>	<u>FEMALE</u>
.020" to .055"	+.020" to +.030"	.000" to -.010" under knife OD
.056" to .090"	+.020" to +.030"	-.055" to -.065" under knife OD
.091" to .125"	+.020" to +.030"	-.090" to -.100" under knife OD
.126" to .180"	+.020" to +.030"	-.125" to -.140" under knife OD
.181" to .250"	+.020" to +.030"	-.180" to -.200" under knife OD

VS.

Copper material
Stripper ring sizing

<u>Material Thickness</u>	<u>MALE</u>	<u>FEMALE</u>
.001" to .015"	+.010"	even with knife OD
.016" to .035"	+.010	-.020" under knife OD
.036" to .060"	+.020" to +.030"	-.035" to -.045" under knife OD
.061" to .090"	+.020" to +.030"	-.060" to -.070" under knife OD
.091" to .125"	+.020" to +.030"	-.090" to -.100" under knife OD
.126" to .180"	+.020" to +.030"	-.125" to -.140" under knife OD
.181" to .250"	+.020" to +.030"	-.180" to -.200" under knife OD



Arbor Locking Mechanism



Yesterday's Technique

Mechanical Spanner Nuts

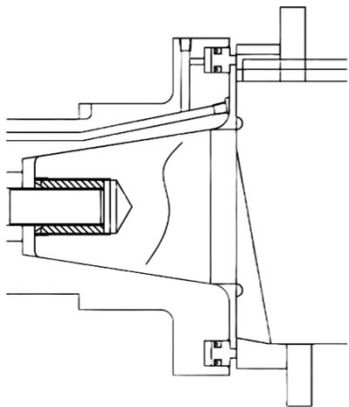
- Squareness problems
- Uneven pressure
- Difficult to mount
- Thread damage
- Hammer damage



Today's Technique

Automated Hydraulics & High Pressure Hydraulic Nuts

- Uniform loading
- No thread damage
- Easy to tighten





**Precision Slitting of copper
is best achieved with a holistic approach that includes:**

- ◆ Equipment design
- ◆ Tooling tolerances
- ◆ The processing line's actual capabilities
 - ◆ Condition of the incoming material

Thank you!

Grazie, धन्यवाद , Danke, ありがとう , Gracias, Merci

What questions do you have?

