Iowa State University

Department of Agricultural and Biosystems Engineering

Tool Life Comparison between Servo and Pneumatic Ultrasonic Welders for cutting Polylactic Acid

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Presentation overview

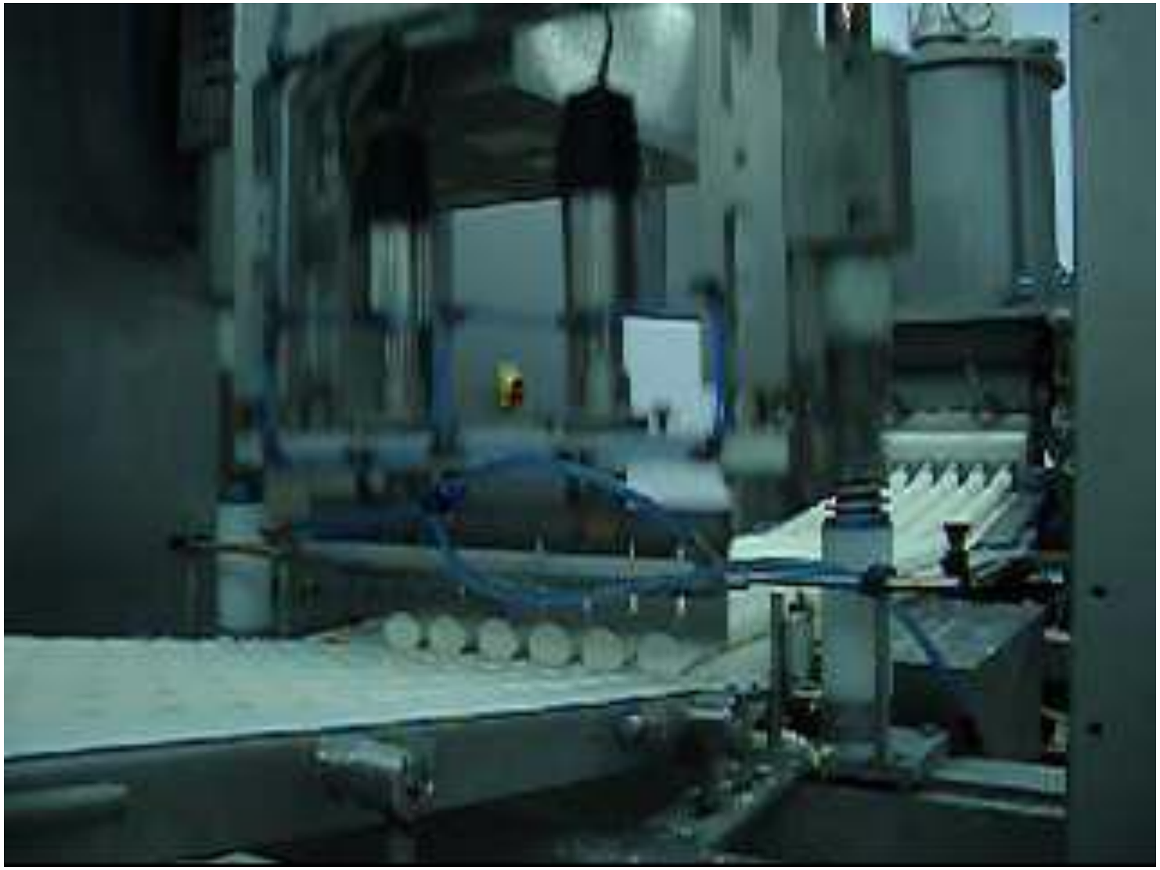
- Back ground of US cutting
- Applications
- Process
- Goal
- Experimental
- Results
- Conclusions

Background

- Ultrasonic cutting
  - +Fast
  - +Clean cuts
  - +No residual build up
  - -Costs

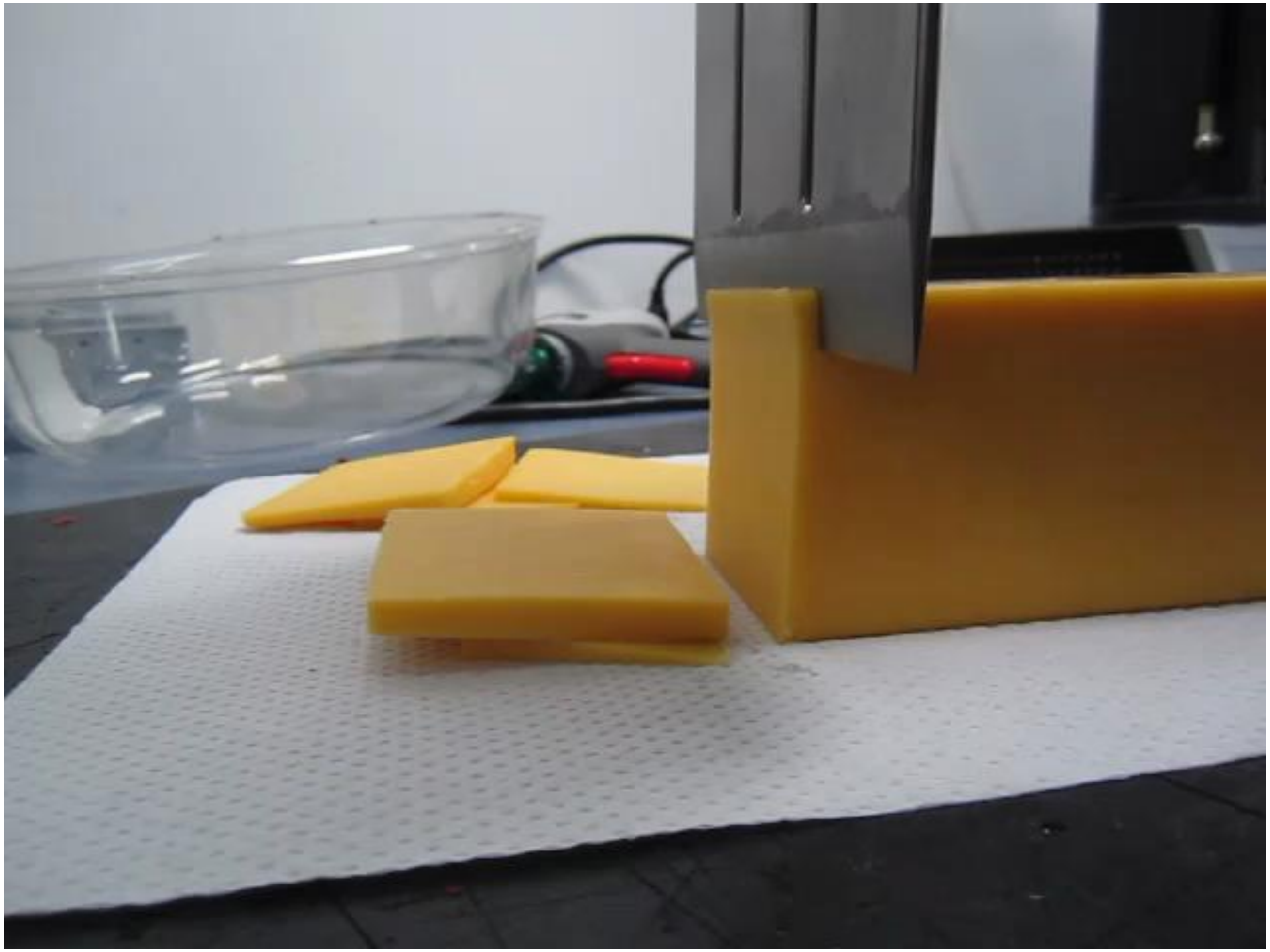
Background

- Food cutting



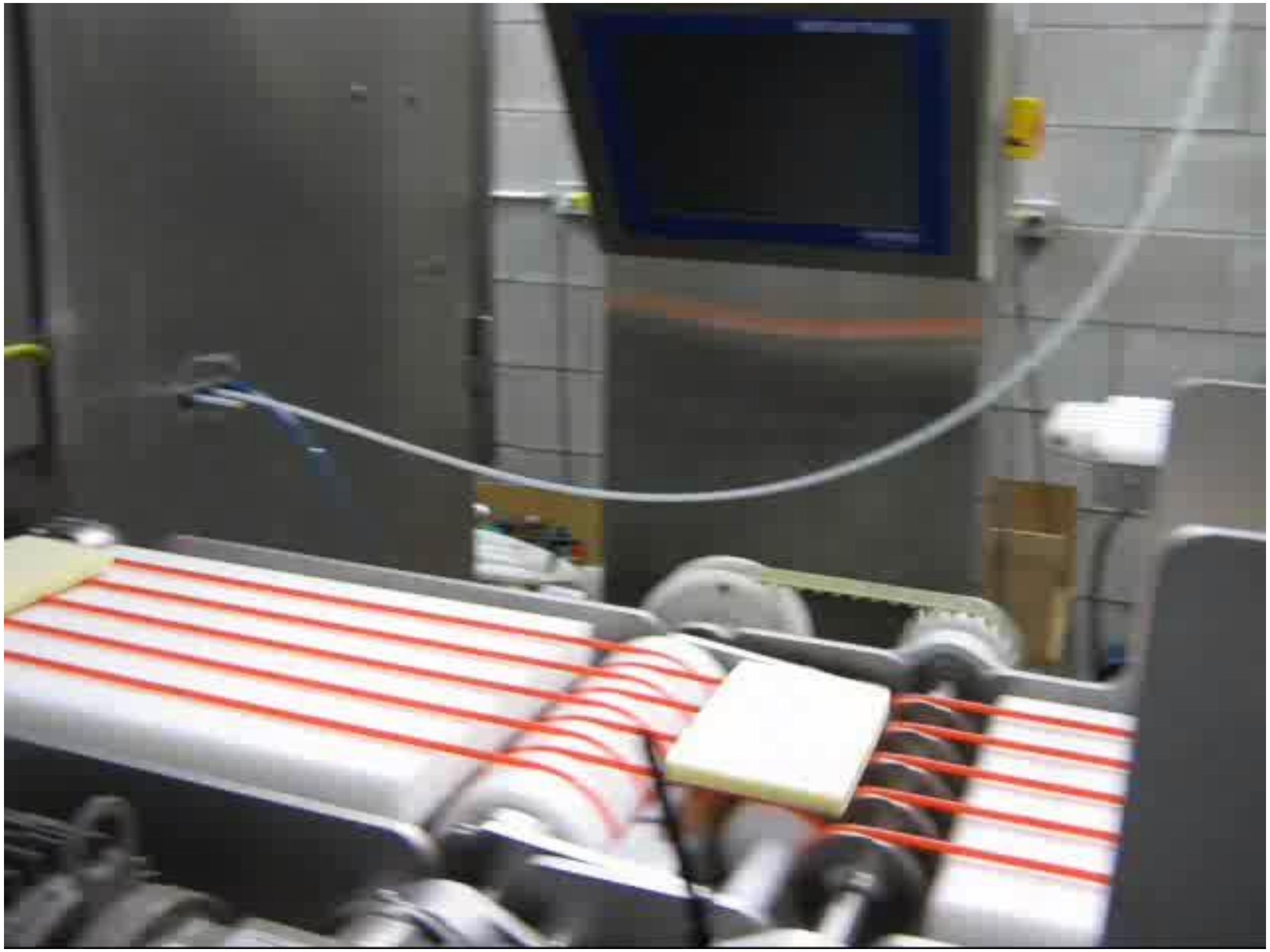
Branson Ultrasonics

Background



Branson Ultrasonics

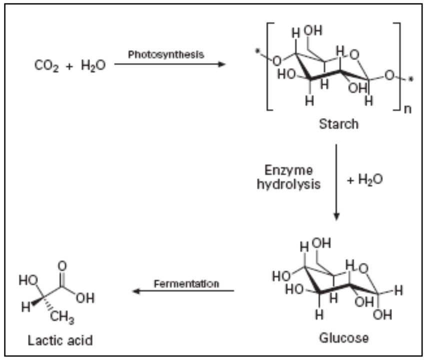
Cheese cutting



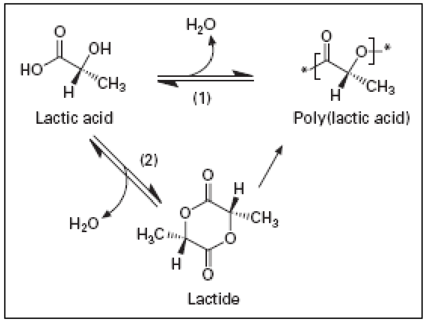
Branson Ultrasonics

Background

Process to prepare polylactic acid[d]



Polymerization of PLA[d]



[a]

[b]

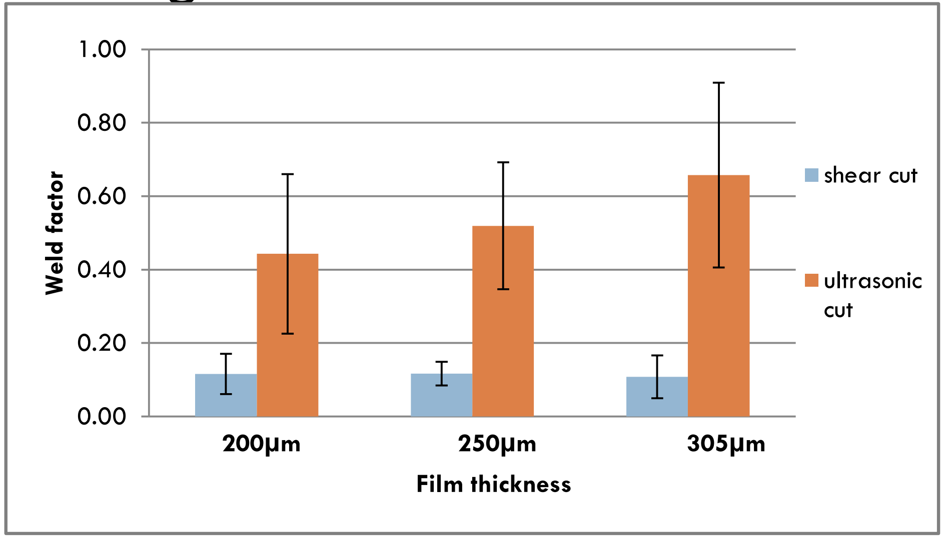
[c]

Polylactic acid – Properties[d]	
σ - Tensile strength	70 MPa
E - Modulus of Elasticity	3.6 GPa
ρ - Density	1.25 g/cm^3
MW - Molecular weight	100 – 300 kDa

[a] - www.japancorp.net
[b] - www.sillyjokes.co.uk
[c] - www.greenerdesign.com
[d] - Biodegradable and sustainable fibres, Farrington, Lunt, Davies, Blackburn

Background

Cutting welded PLA



Weld factor = σ/σ_0

σ - measured force

σ_0 - base material strength

Welding parameters:

- Branson 2000, time mode
- gain 2.66:1 (booster and sonotrode)
- amplitude = 48 $\mu m_{p\text{-}p}$
- weld time 0.2 s
- static force = 178 N

Cutting parameters:

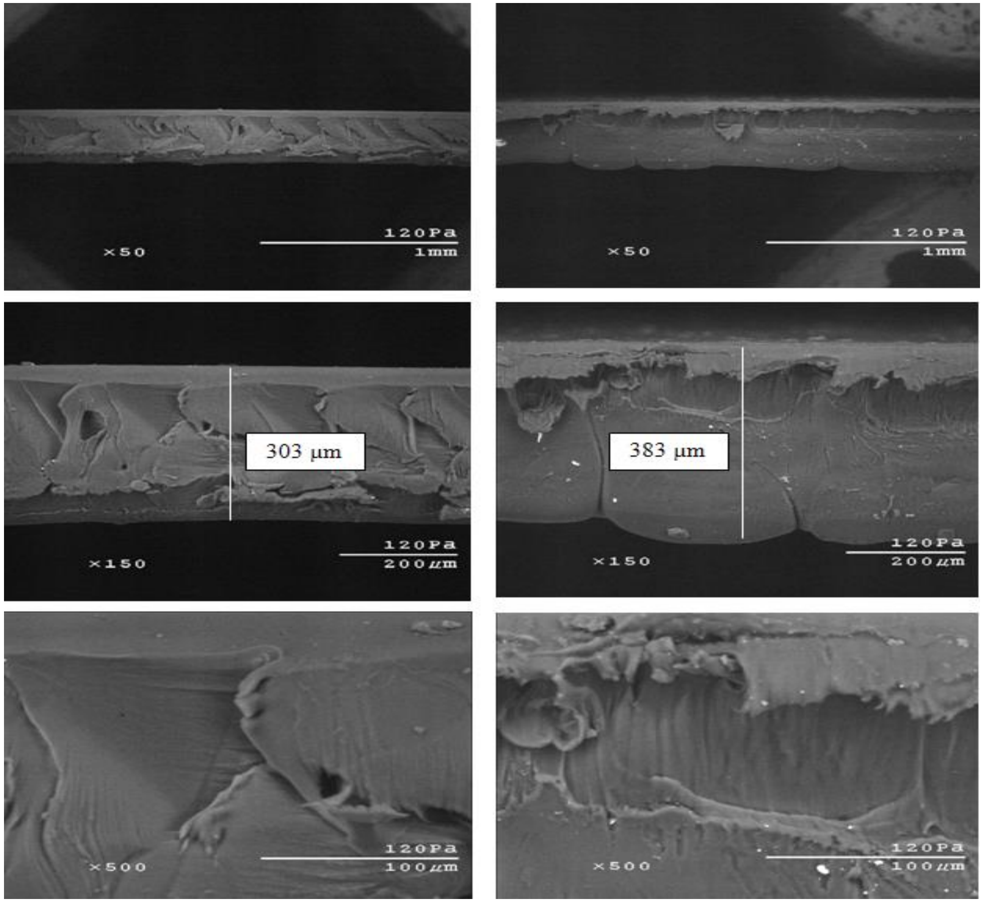
- Branson 2000, ground detect mode
- amplitude = 48 $\mu m_{p\text{-}p}$
- static force = 178 N

- Cutting melts and solidifies films in overlap area
- Additional ‘welding’ increases shear strength

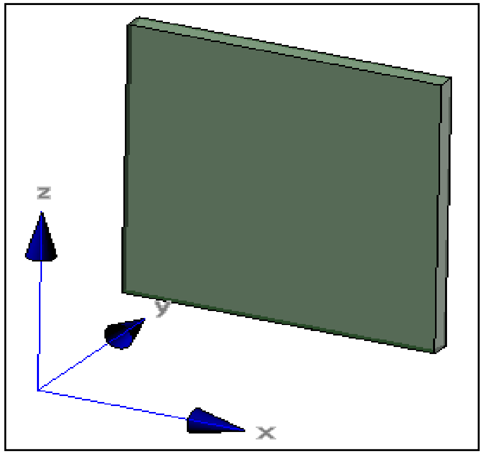
Background

Shear Cut

Ultrasonic Cut



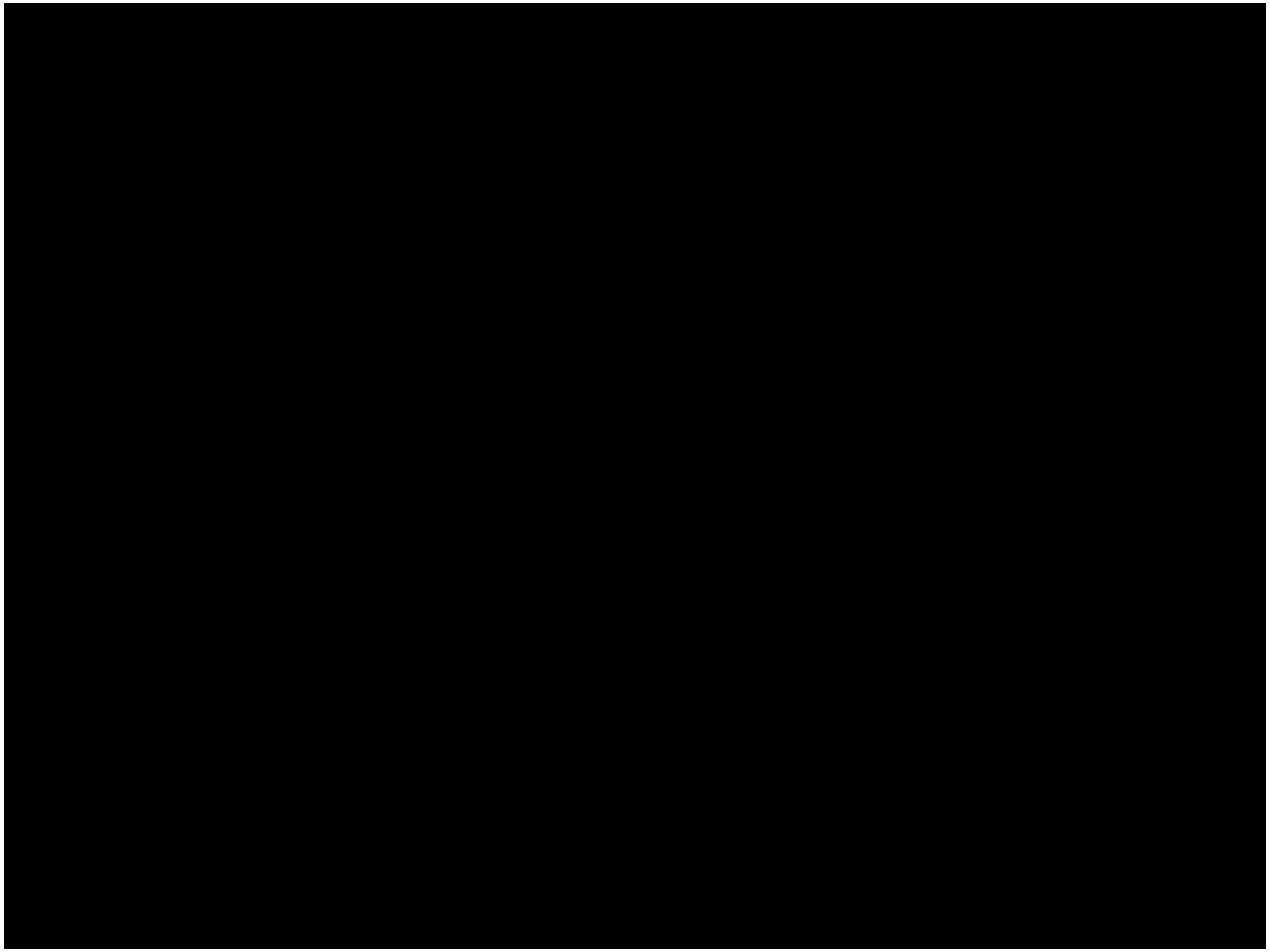
Sample orientation during SEM imaging x-y plane



Ultrasonic cutting leaves a more homogeneous and "smooth" surface.

Material accumulation because of melting and solidifying.

Background



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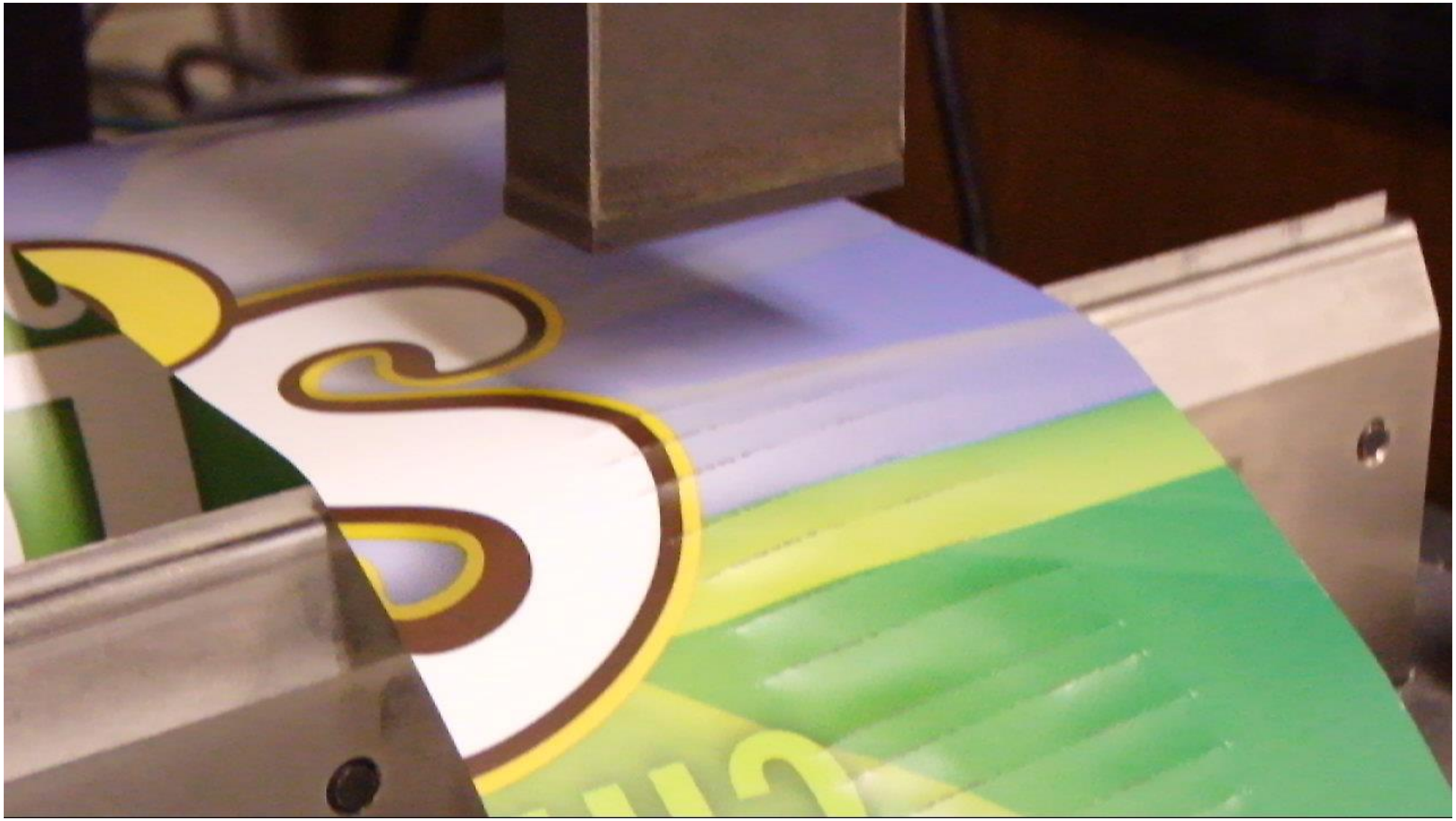
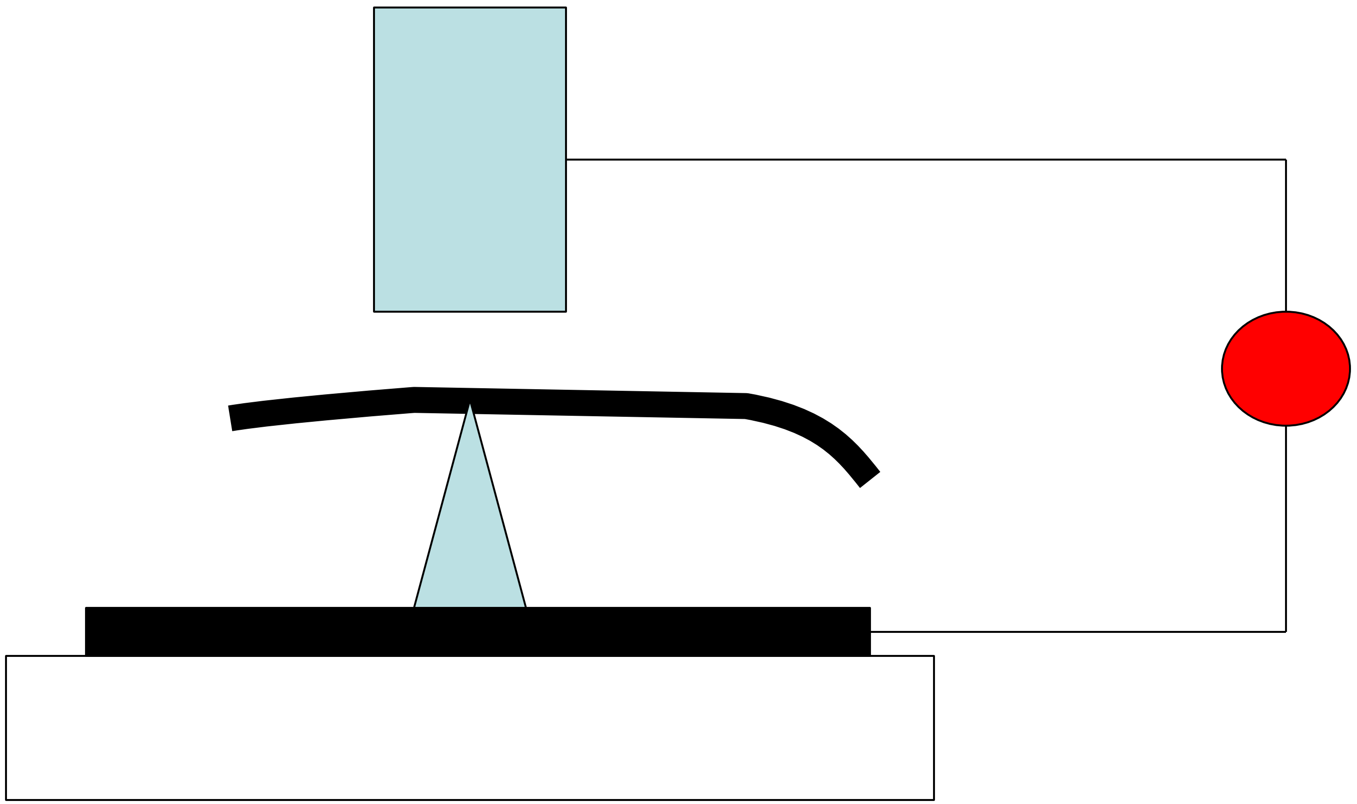
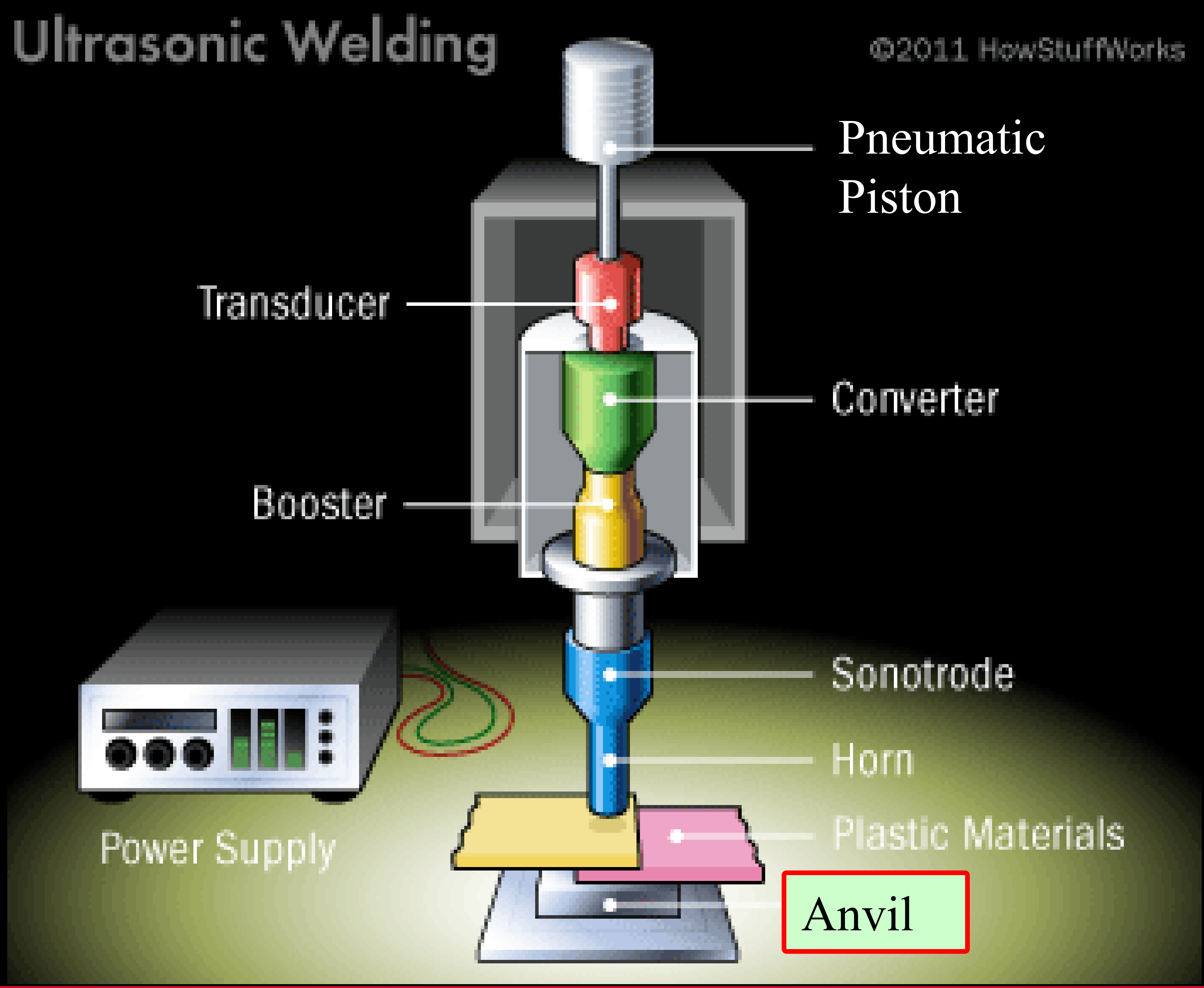


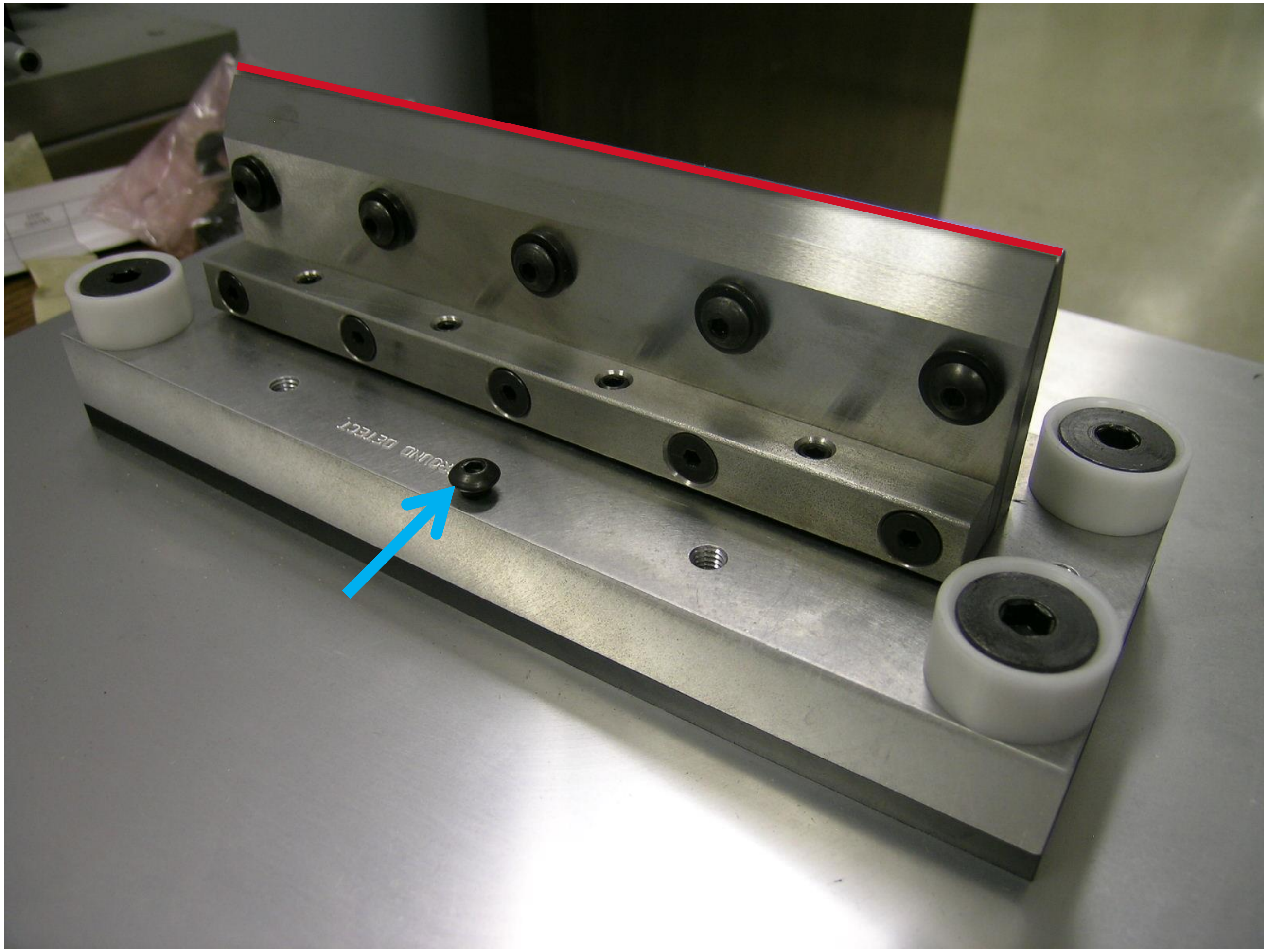
Background



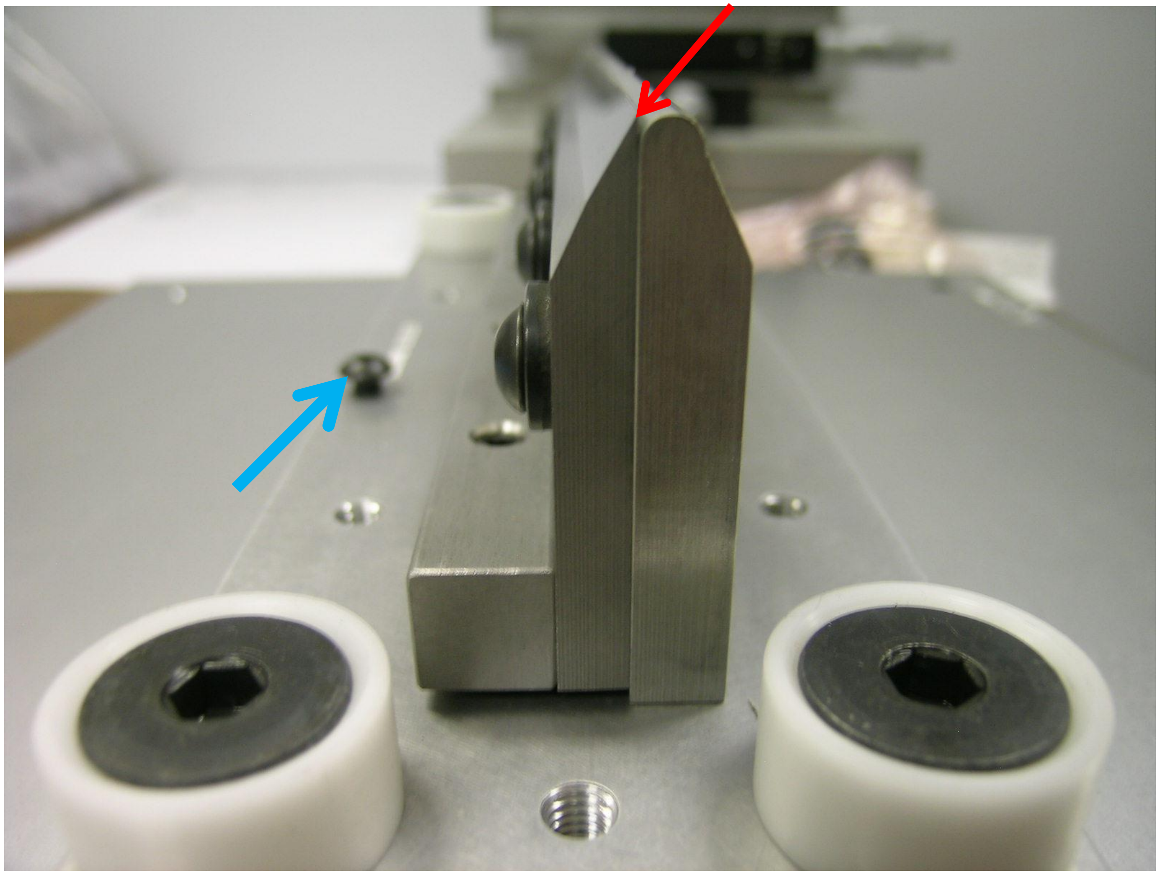
Dukane

Photo from Biopolymers & Biocomposites Research Team Press Release


Ultrasonic Welding
©2011 HowStuffWorks
Pneumatic Piston
Transducer
Converter
Booster
Sonotrode
Horn
Plastic Materials
Anvil
Power Supply



Fixture



Fixture from the side

Cutting Material

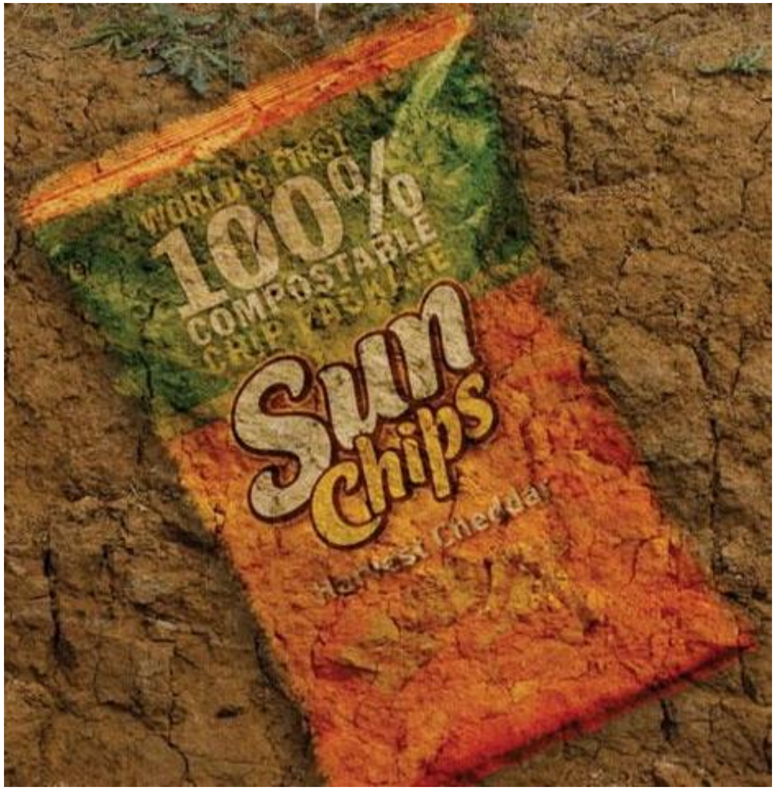


Photo courtesy of Packaging World

- Polylactic Acid (PLA)
- Bioplastic made from corn starch
- Can biodegrade under certain conditions
- Difficult to recycle

Ultrasonic Cutting

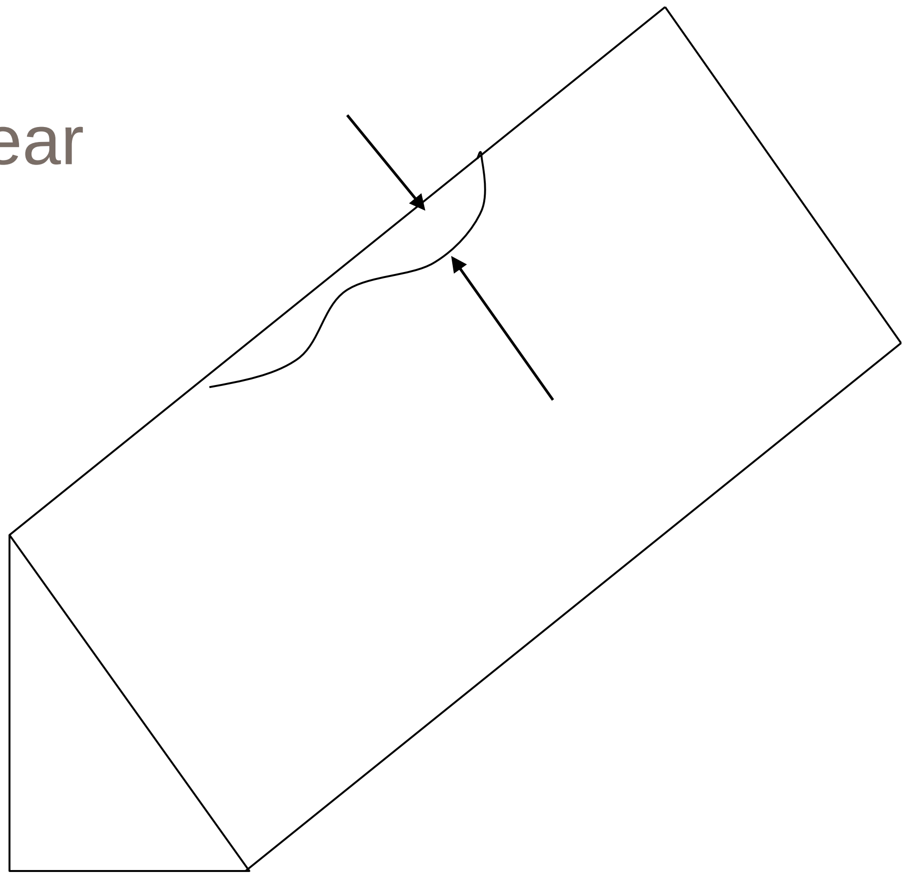
- Pneumatic
  - Ground detect
  - Horn/anvil make contact
- Servo
  - Accurate force/distance
  - Stop before contact
- Cutting edge
  - Anvil
  - Aluminum

Ultrasonic Cutting

- Pneumatic
  - Used as process profile
    - Force
    - Velocity
    - Pre-trigger
- Servo
  - Matched pneumatic by programing
    - Force
    - Velocity
    - Pre-trigger

Ultrasonic Cutting

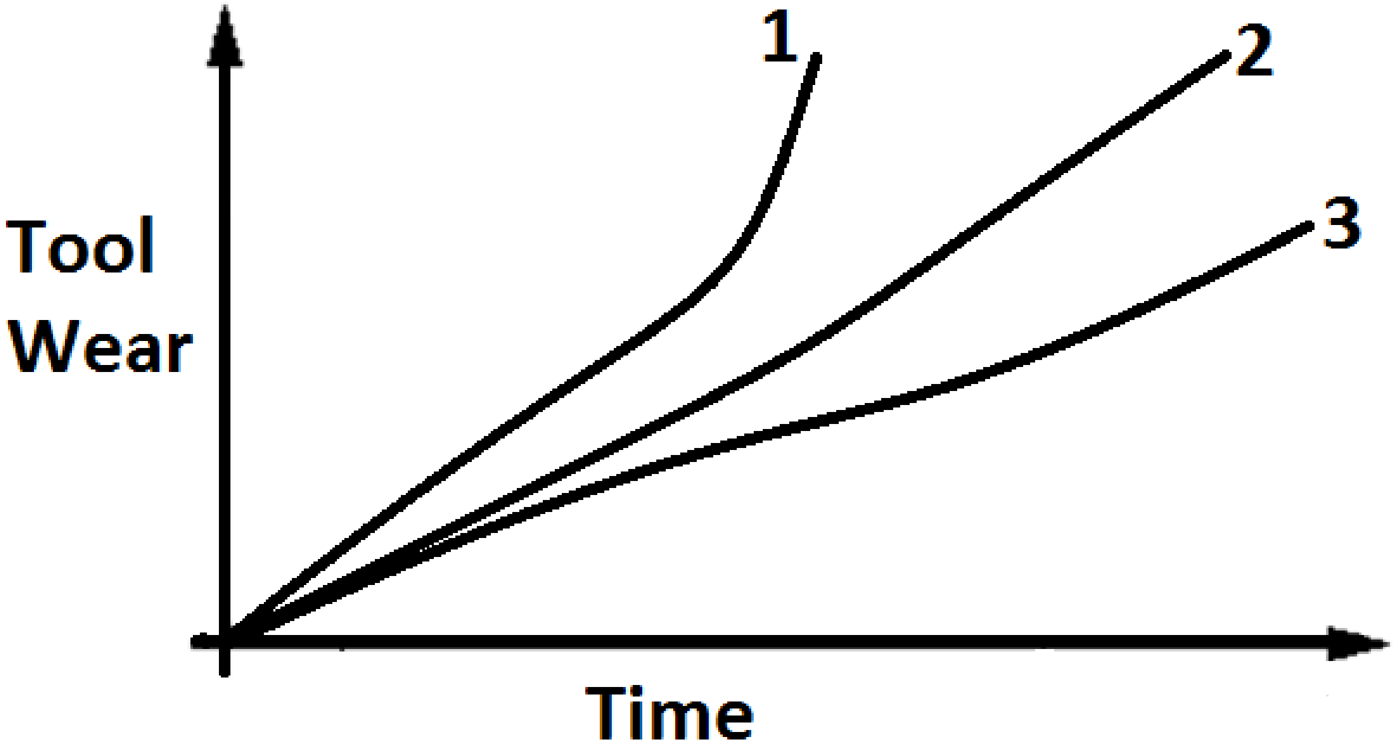
- Measurement of wear
- 3x



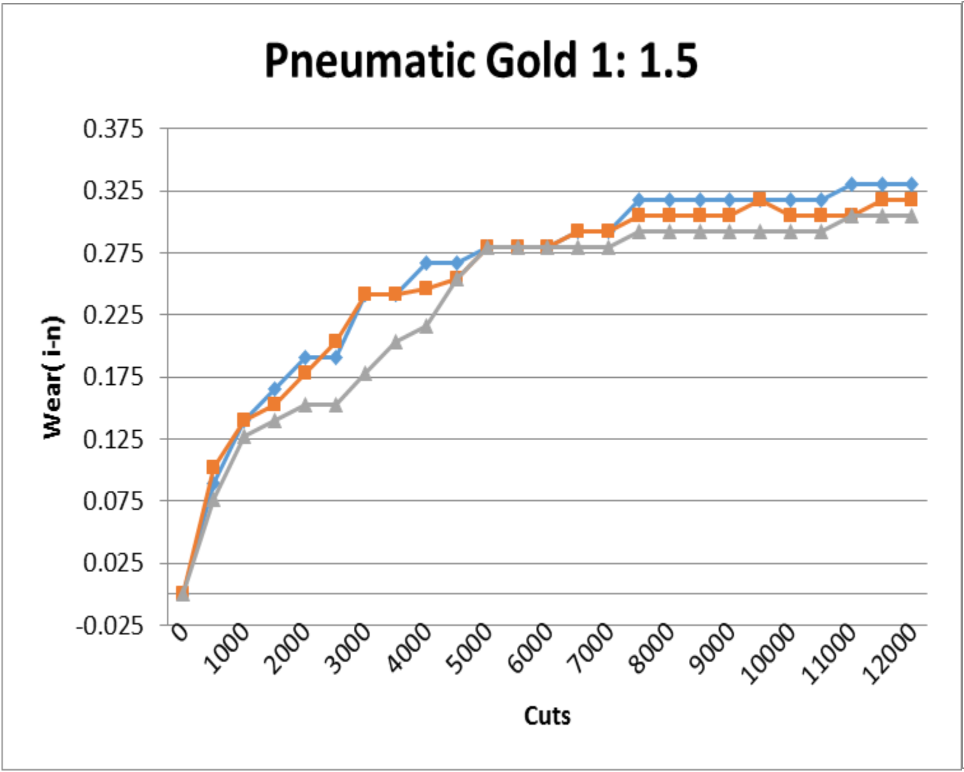
Comparison between Servo and Pneumatic

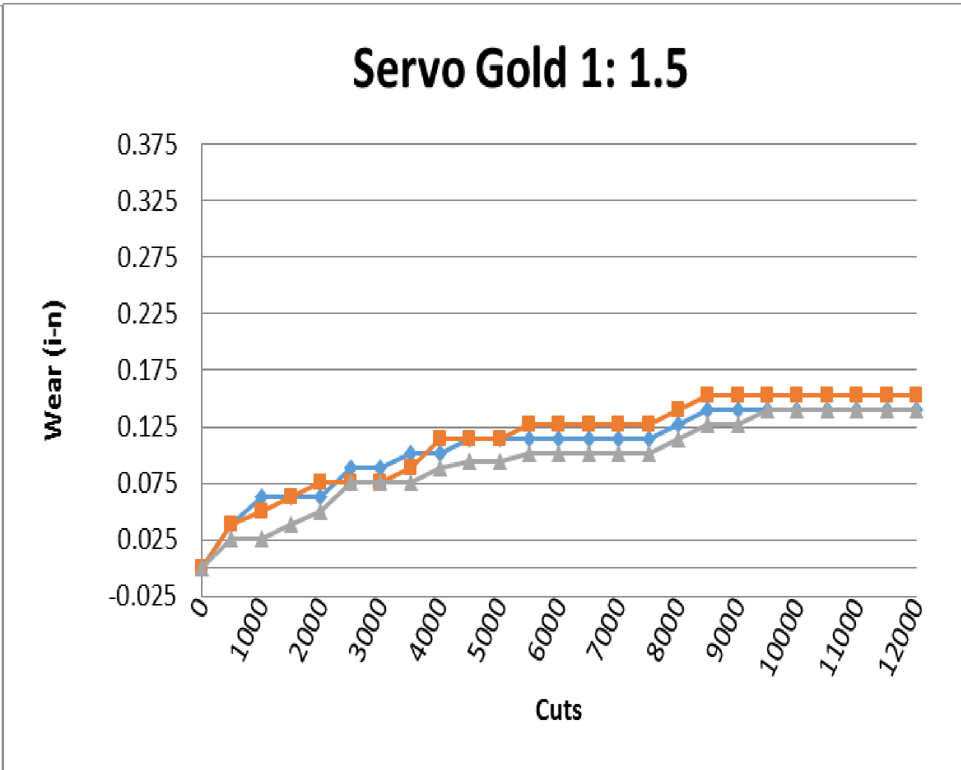
- standard pneumatic has ground-detect
- servo system has a closed-loop position control

Tool Life



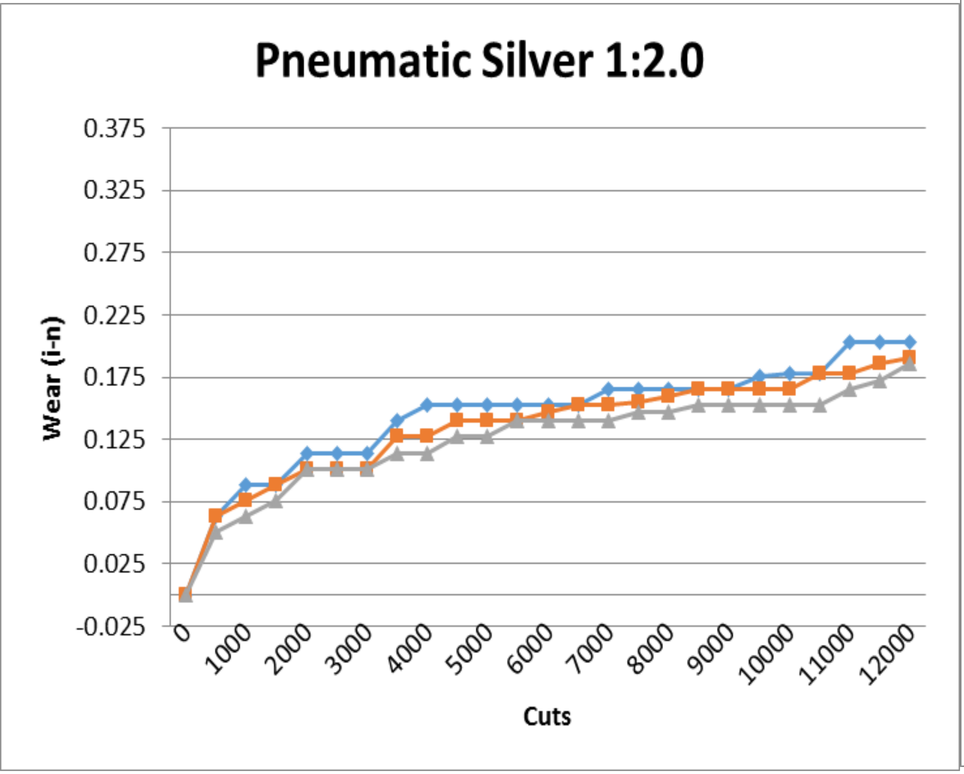
Tool Wear

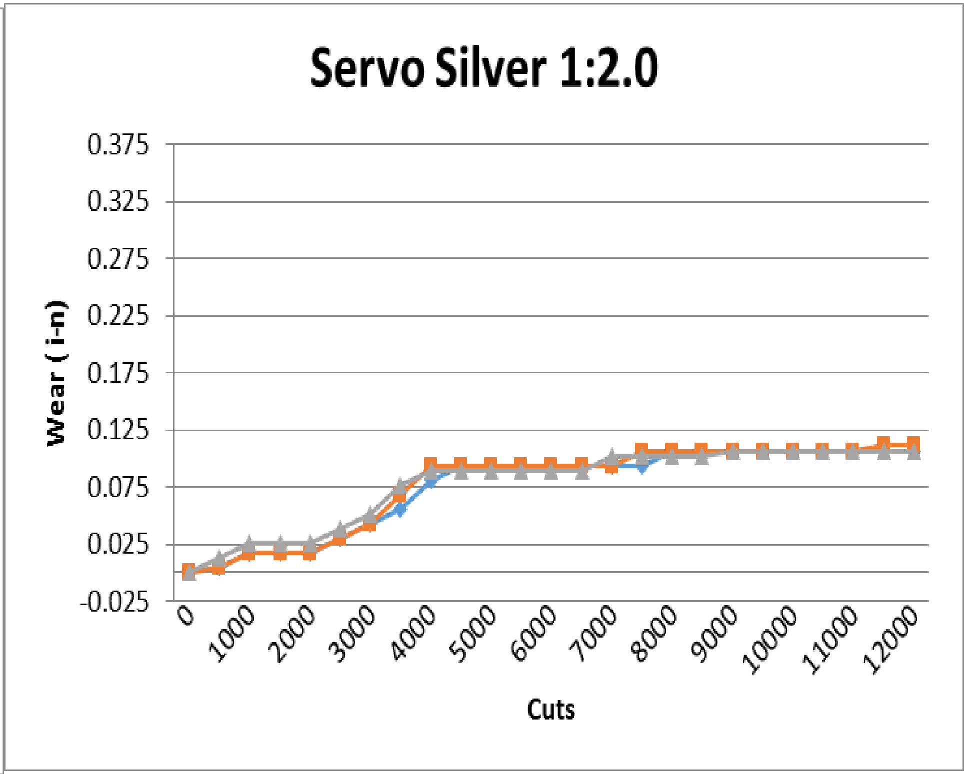




Wear is in units of mm

Pneumatic Tool Wear

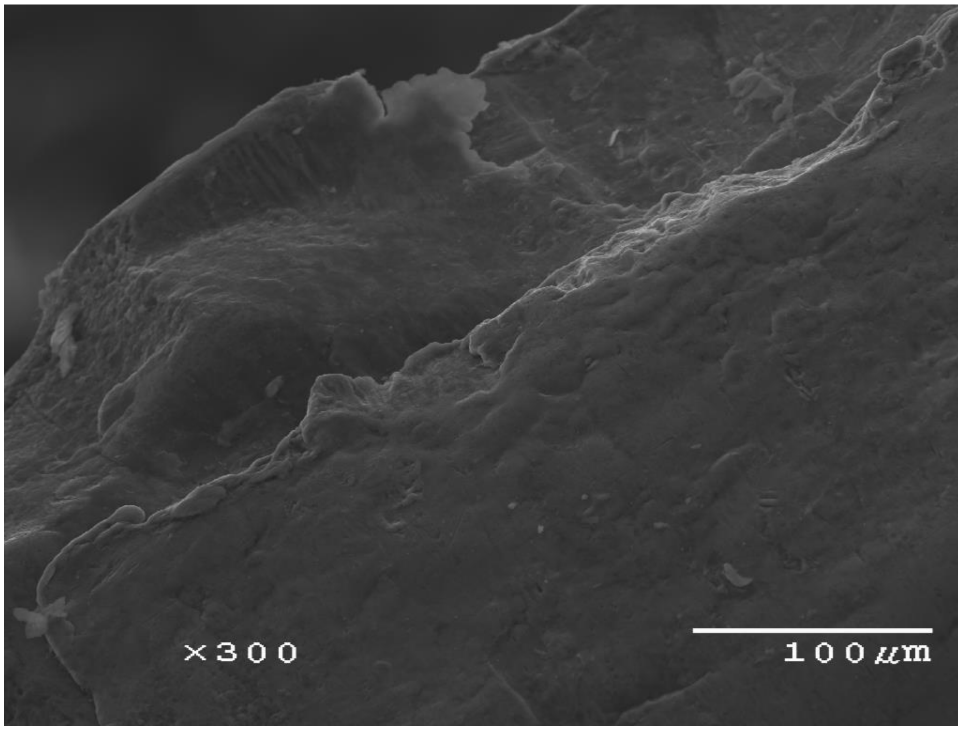


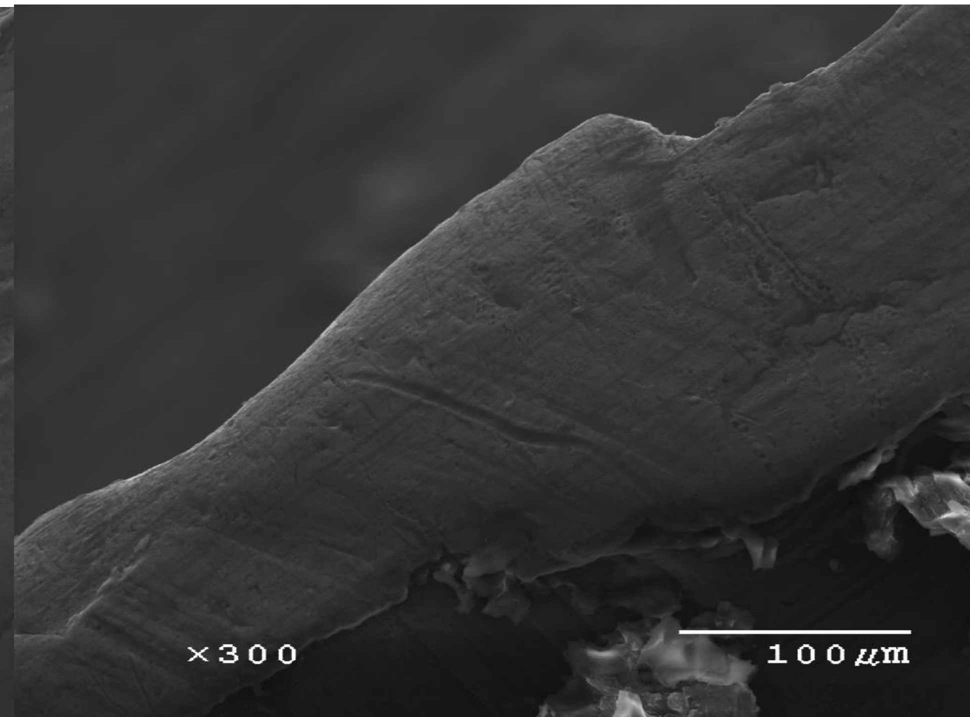


Wear is in units of mm

Center of Blade

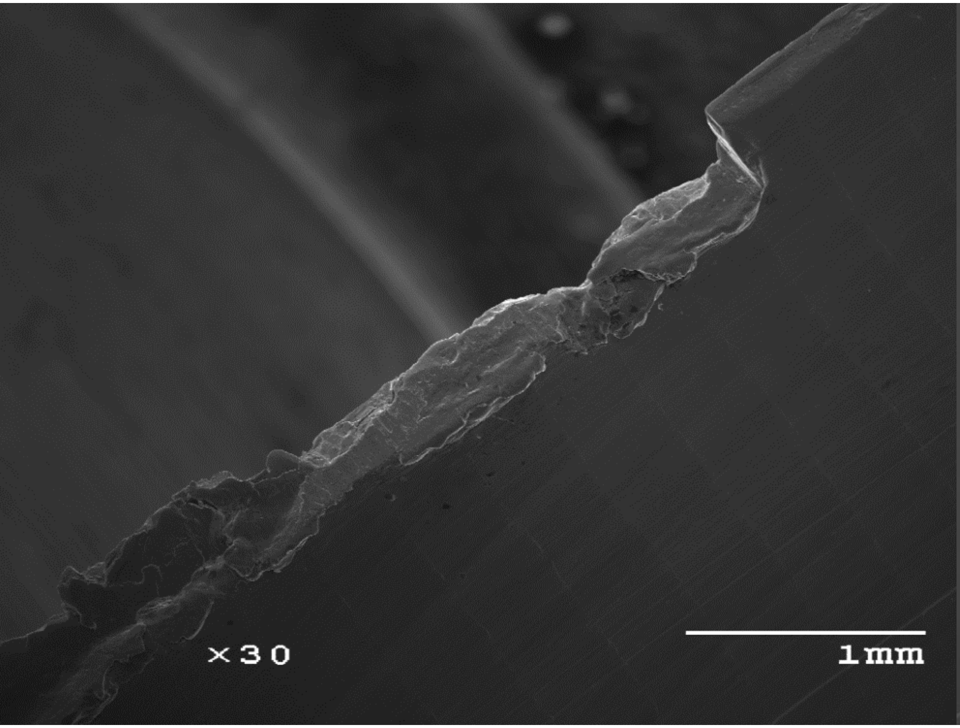
- Pneumatic
- Servo

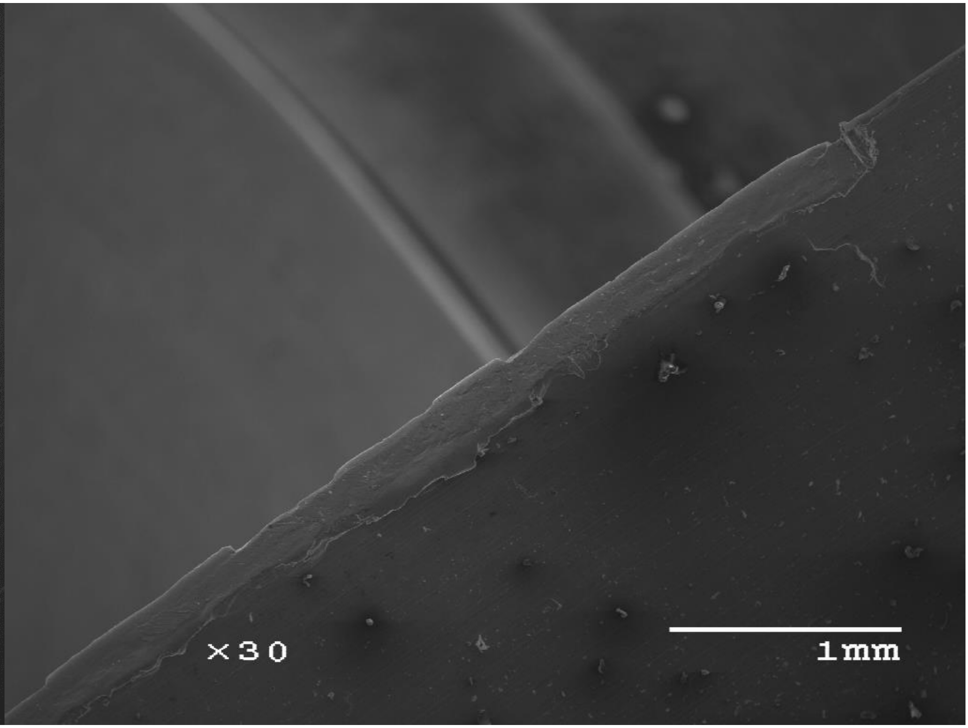




Edge where horn hits

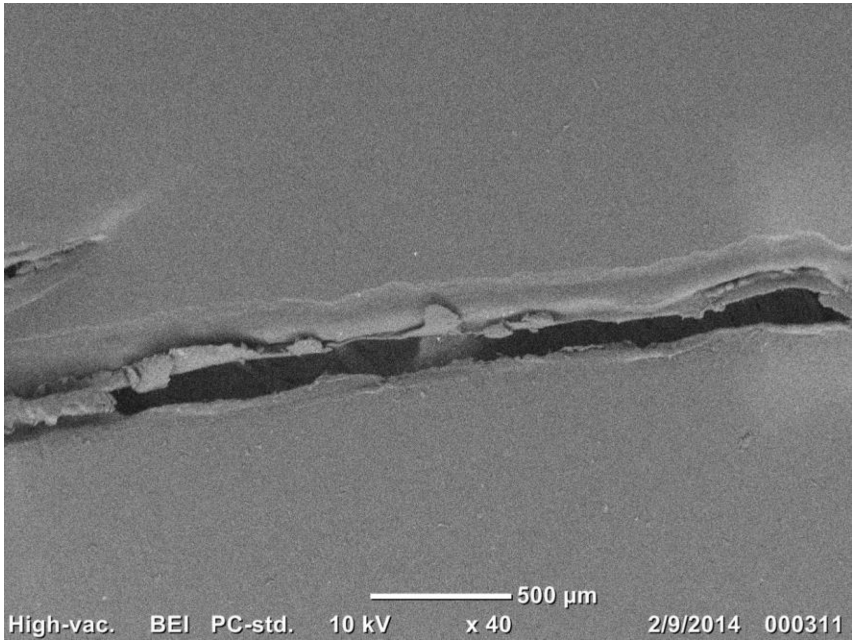
- Pneumatic
- Servo



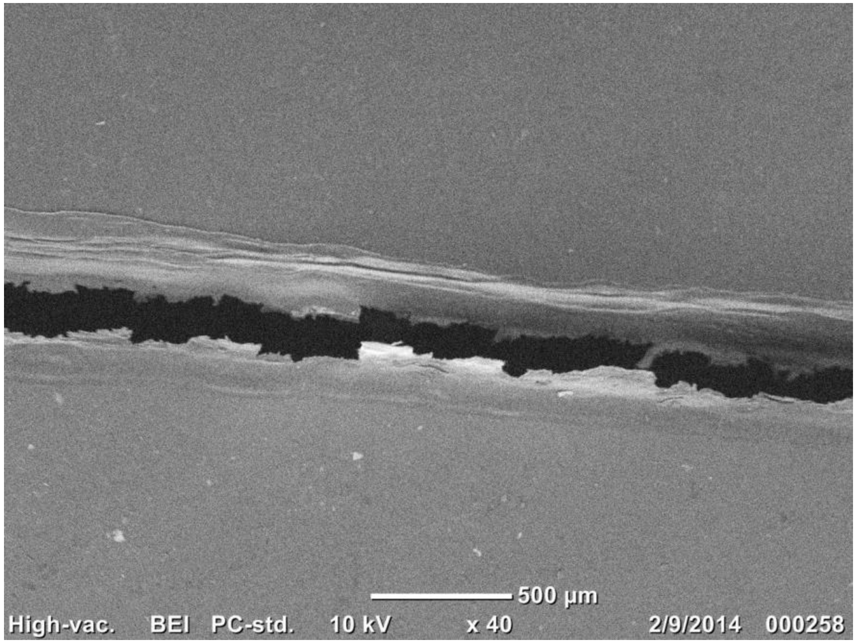


Start of Cutting

Pneumatic

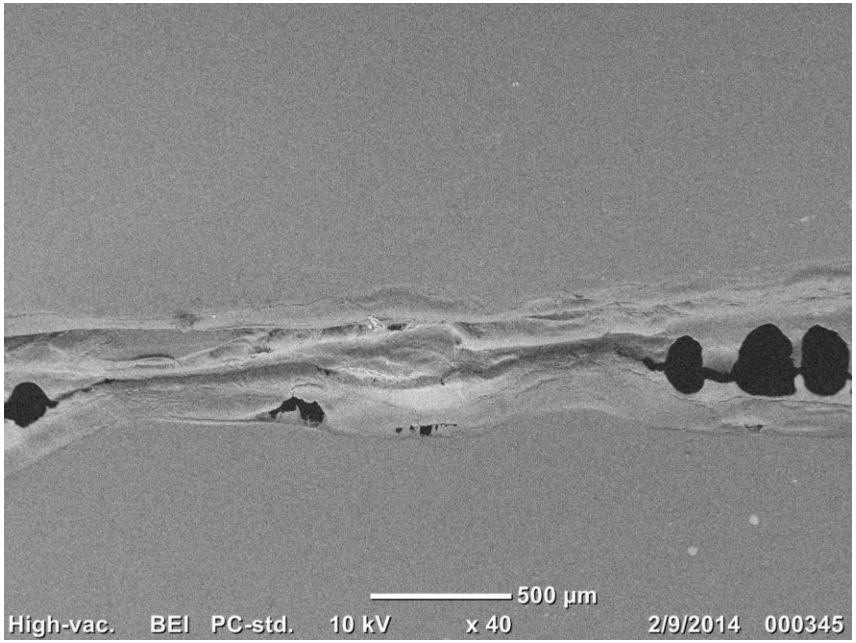


Servo

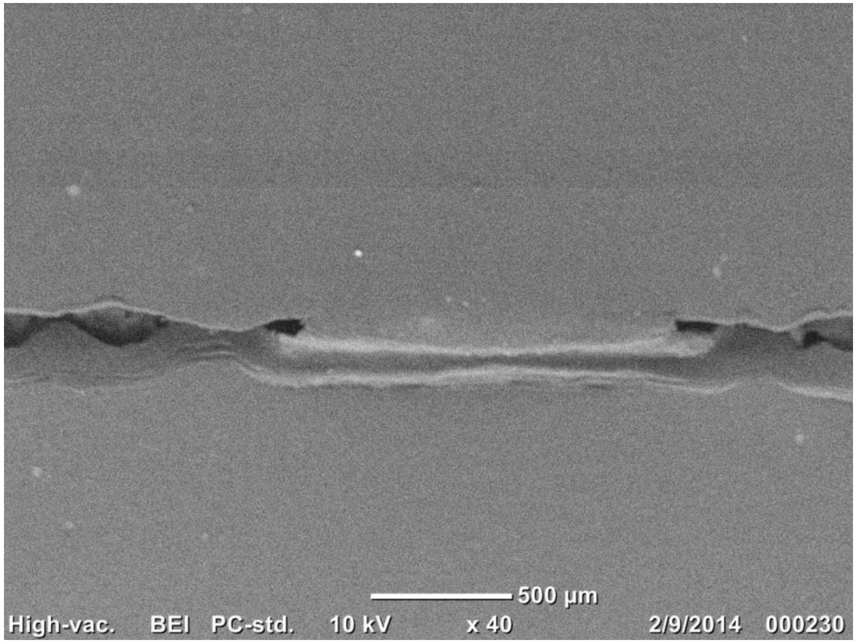


After 12000 cuts

Pneumatic



Servo



Conclusions

- Servo cutting has less tool wear compared to ground detect
- Servo cutting appears to produce better cuts compare to ground detect

Thanks

Dukane Ultrasonics

Branson Ultrasonics

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