Joining of Advanced Thermoplastics

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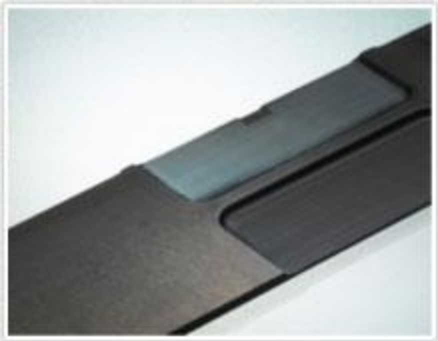
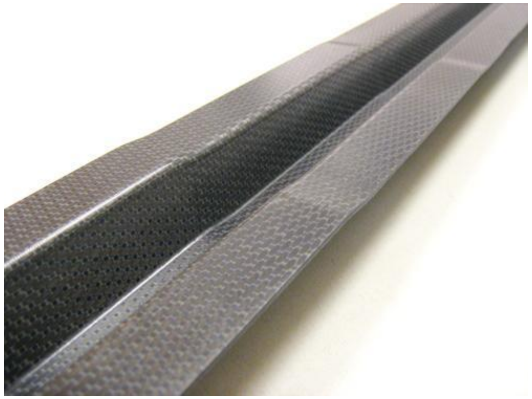
Thermoplastic Composites: Outline

- Lighter than metals, tougher than thermosets, can be welded and recycled



- Examples of joining approaches

- Bio-based composites
- Nano-reinforced composites
- High temperature thermoplastics

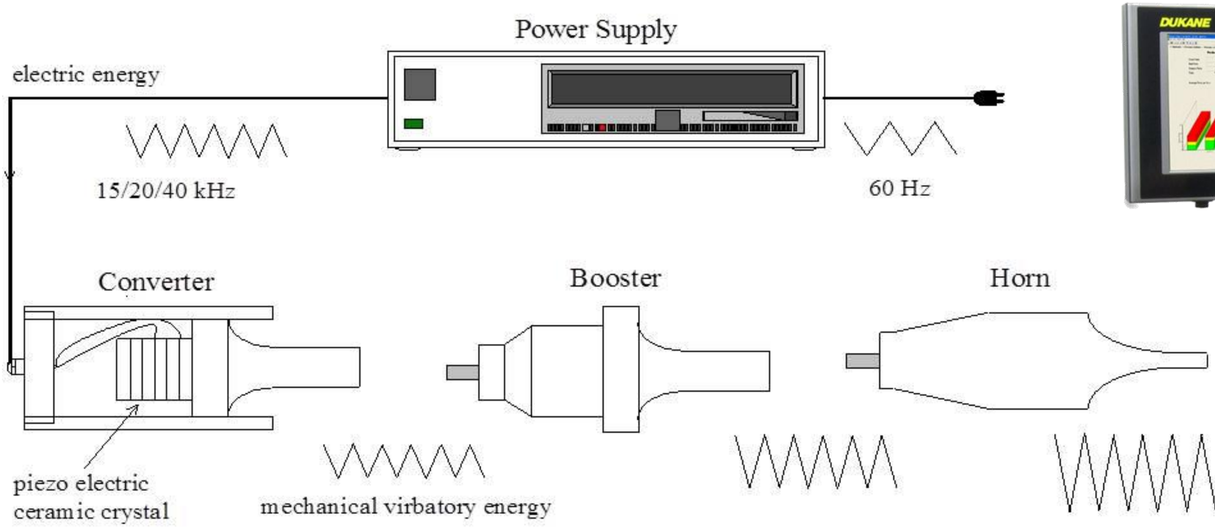


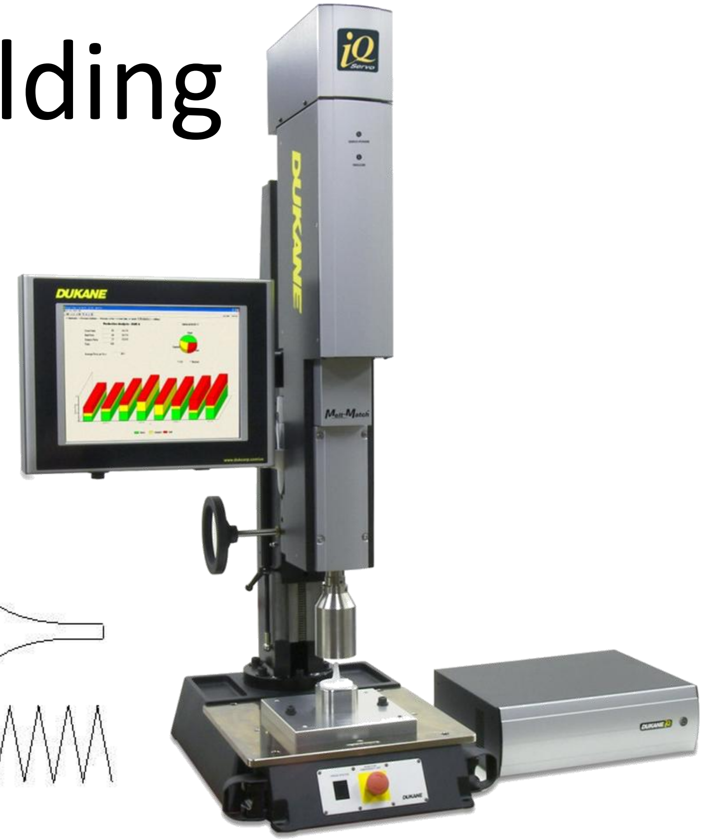
Joining of Engineering Thermoplastics

MATERIAL	WELD ZONE (^{o}C)
• Polyether-ether ketone (PEEK)	380-400
• Polyphenylene sulfide (PPS)	220-280
• Polyetherimide (PEI)	250-280
• Polethersulfone (PES)	200-250
• Polyamides (PA)	250
• Polyesters (PET, PBT)	150-180

- Reinforcement levels can be 0-60 volume percent.

Ultrasonic Welding

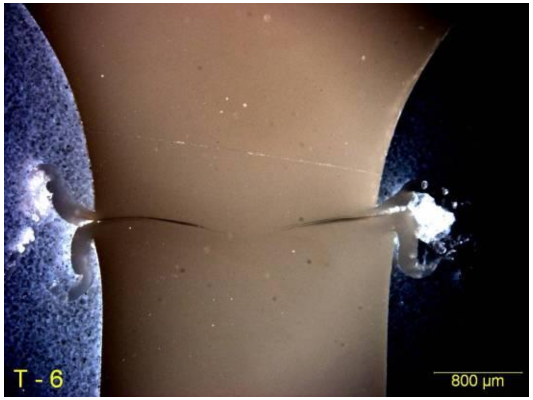




- Power Supply: Converts standard AC power to 15- to 40-kHz
- Converter/Transducer: Converts electrical energy from power supply into high frequency vibrations by the cyclic expansion of piezoelectic ceramic elements
- Booster: The vibration produced by the piezoelectric transducer is transmitted to the horn through the booster
- Horn/Sonotrode: Transmits the linear vibrations to the workpiece

Ultrasonic Welding

- <u>Advantages</u>
  - Very fast process
  - Advanced, modern equipment with sophisticated control and monitoring features
  - Ideal for small to medium size parts
  - Versatility
  - Can be automated
  - No foreign material required at interface
- <u>Disadvantages</u>
  - Requires specific joint designs
  - Overall sensitive process
  - Some geometry and material limitations
  - Requires tight dimensional tolerances of molded parts
  - Ultrasonic horn must be tuned
  - Known to damage internal



Introduction - Biocomposites

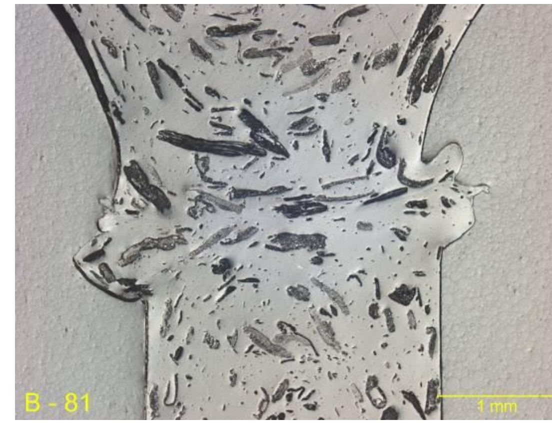
- Biocomposites
  - Formed by the addition of natural, reinforcement fibers to a traditional or bio-based resin
  - Biodegradability is dependent on the matrix material and filler materials

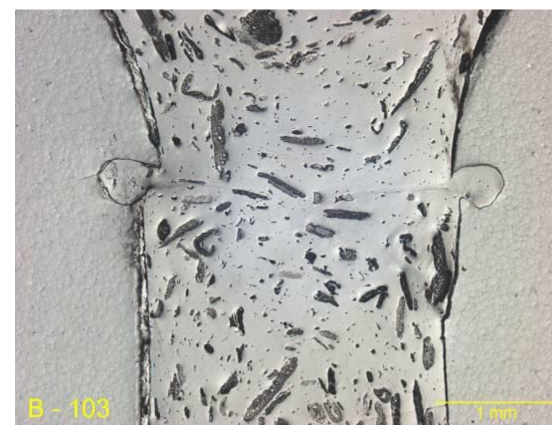
- Natural fibers
  - Commonly derived from plants
  - Examples: flax, hemp, switch grass, wheat straw, and wood fibers

Wheat Straw Biocomposites

- Wheat straw-reinforced PP: Better mechanical properties compared to other natural fibers
  - Weight savings of approximately 10 percent
  - Increased dimensional stability
  - Less energy used in manufacturing due to lower machine temperatures
  - Lower carbon footprint - produces 1.30 kilograms less of carbon dioxide per kilogram of product based on Ford's analysis

- AgriPlas^{TM} BF20H-31
  - 20% wheat straw fiber-filled PP biocomposite
  - Used in the Ford Flex 3rd row bin and lid





Nanoclay Composites

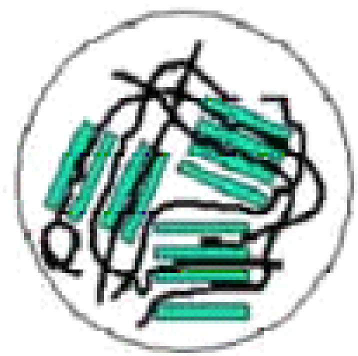
- Advantages
  - With little increase in density, many properties can be improved:
    - decreased permeability to vapors such as gasoline
    - higher thermal stability and can be flame retardant
    - greater tensile strength and modulus
  - less expensive than co-polymers
- Disadvantages:
  - lower toughness
  - ***poor weld strength!!!***
- Applications:
  - Medical Equipment
  - Battery Jars
  - Food & Beverage Storage
  - Fuel Tanks

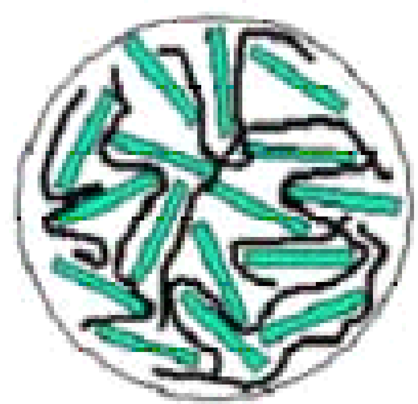
Nanoclay Composites

•Polymer matrix systems in which nanosized clay reinforcing phase particles are dispersed in the matrix

•At least one dimension is in the nanometer range

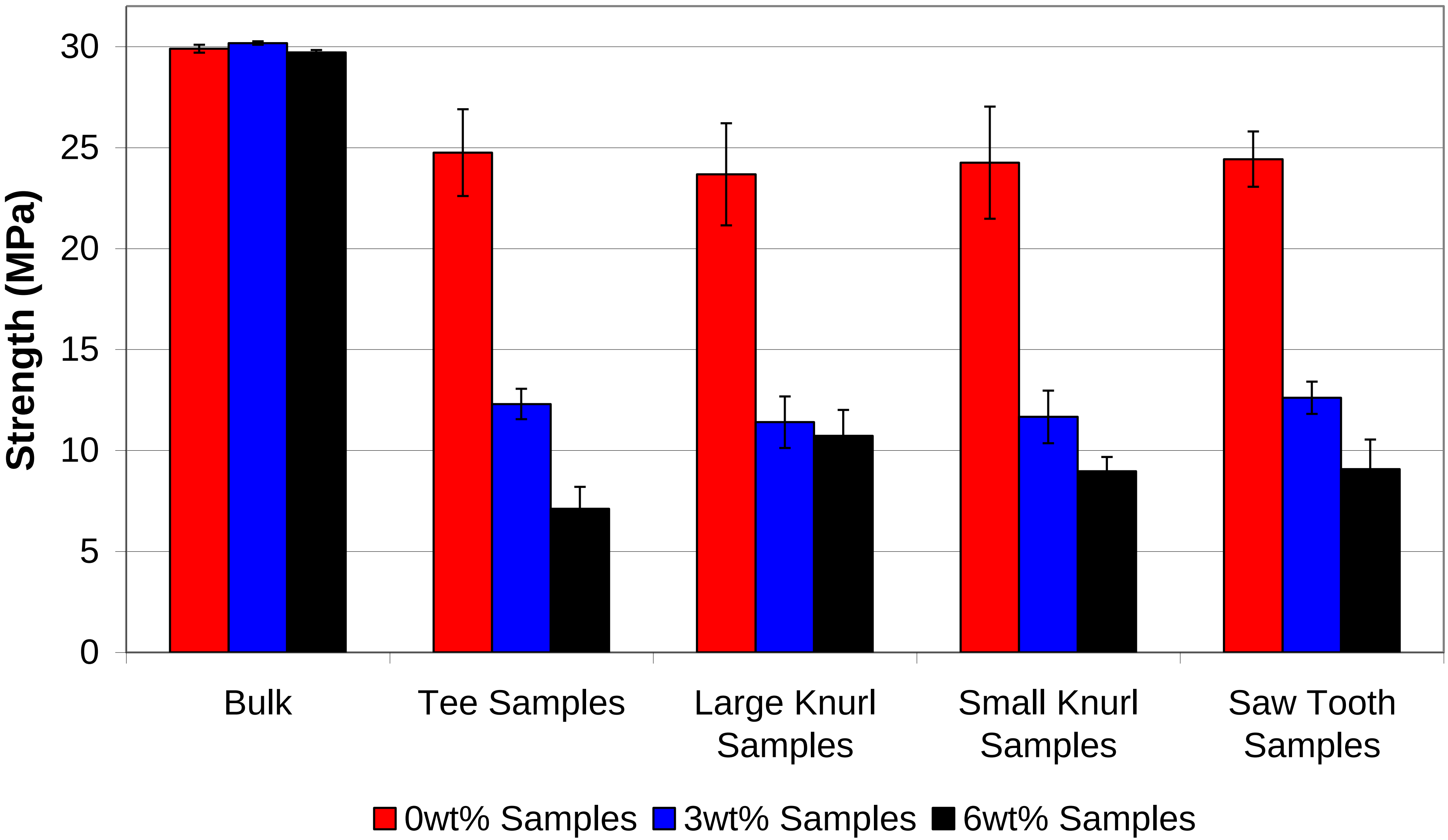
- Two typical achievable microstructures:
  - intercalated nanocomposite
    - Polymer resin in-between the layers of clay platelets
    - Their stacking order is retained
    - Not as desirable for strength applications
  - exfoliated nanocomposite
    - Clay layers are individually dispersed in the host polymer matrix
    - As the extent of exfoliation increases, more clay particle surface area comes into contact with polymer resin





National Research Council Canada:
http://www.nrc-cnrc.gc.ca/highlights/2003/0307nanocomp_f.html

Example of varying joint design



High T Thermoplastic Composites

PPS – glass fabric composite fixed wing leading edge --- on Airbus A340 and A380

Carbon Fiber re-inforced PEEK for aircraft wing

induction welded with PEEK resin as bonding agent

Thermoplastic Composites Summary

- A wide variety of bio, nano, and high temperature thermoplastic composites commercially available
- Opportunities for lightweighting and enhancing environmental sustainability
- In order to realize full potential, advanced joining processes are essential