ROLE OF FRICTION IN THE THERMAL DEVELOPMENT OF ULTRASONICALLY CONSOLIDATED CONTINUOUS FIBER REINFORCED METAL MATRIX COMPOSITE TAPE

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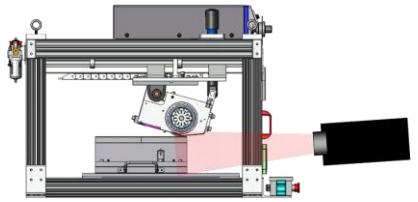
INTRO

- Ultrasonic consolidation has the ability to make metal matrix composite parts
- MMC's offer exceptionally high stiffness and strength
- Low temperature welding process (10-30% T_{melt})
- Underlying science is not well understood
- Lack of process maturity
- Bonding mechanisms are temperature dependent
- Need to quantify thermal development

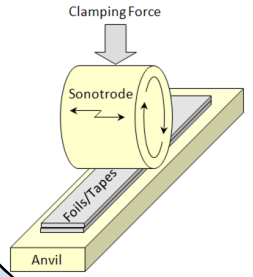


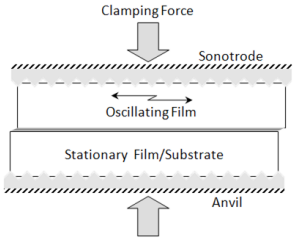
PROCESS DESCRIPTION

Process Components
- Sonotrode
- Foils/Tapes
- Anvil

Bonding Mechanisms
- Plastic Deformation
- Diffusion

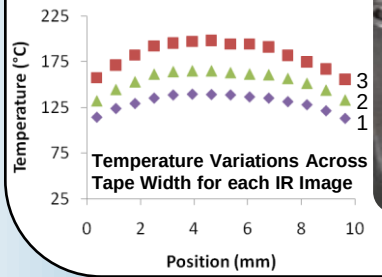
- Clamping Force, F_a
  - Seats knurl pattern
  - Brings material in contact
- Sonotrode Rotation, s
- Sonotrode Oscillation, λ
  - Friction
    - Removes asperities
    - Oxide dispersal
    - Heat generation
  - Plastic deformation

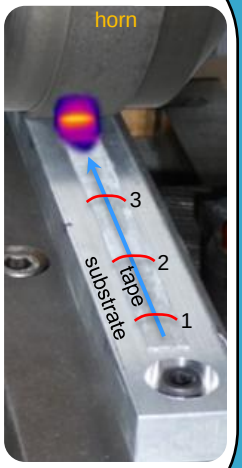




TEMPERATURE MEASURMENT

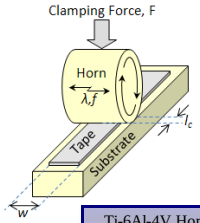
- Infrared Camera
  - Front mounted, 6° angle
  - Temperature dependent ε
- Sampling Rate, 4 Hz
- Temp across width at nip point recorded
- Temperature contours can then be averaged
  - Vertically – avg T across width
  - Horizontally – avg T along length



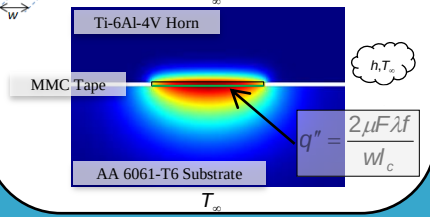


IR image overlay
Contour lines in red

THERMAL MODEL

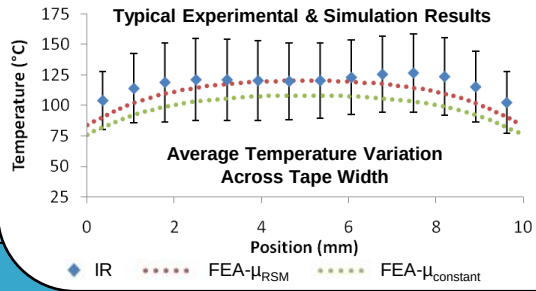


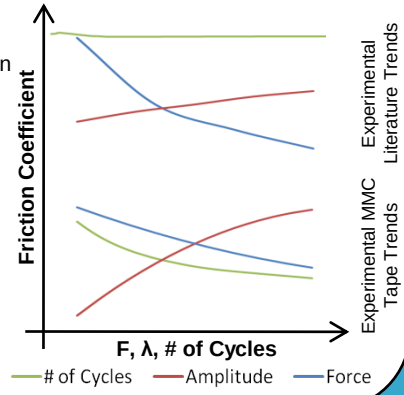
- Fixed T at top and bottom boundaries
- Free convection on all edge boundaries
- Frictional heat flux applied at slip interface



MODEL VALIDATION

Friction coefficient determined empirically and validated experimentally
- Constant μ – $\mu_{constant}$, less accurate, easier to obtain
- Variable μ – μ_{RSM}, depends on welder parameters





RESULTS & CONCLUSIONS

- Temperatures measured across tape width at horn-tape nip point
- Temperature Predictions via FE model
  - Constant μ → 15% Average Error
  - Empirical, parameter dependent μ → 7% Average Error
- Trends in parameter dependent μ correlate to trends in literature

ACKNOWLEDGEMENTS

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