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_{\text{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, \lambda
  - Friction
    - Removes asperities
    - Oxide dispersal
    - Heat generation
  - Plastic deformation

TEMPERATURE MEASUREMENT

- Infrared Camera
  - Front mounted, 6° angle
  - Temperature dependent \varepsilon
  - 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

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 \mu = \mu_{\text{constant}}, less accurate, easier to obtain
- Variable \mu = \mu_{\text{RSM}}, depends on welder parameters

RESULTS & CONCLUSIONS

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

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