MODELING OF THE AUTOMATIC THERMOPLASTIC TAPE PLACEMENT (ATP) PROCESS

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**PROCESS PRINCIPLE**

Two steps, out-of-autoclave, composite forming process.

- **Step 1**: Automatic placement of successive thermoplastic prepreg tape
- **Step 2**: Followed by consolidation under vacuum

**Goal**: Understand the link between process parameters and final quality of the laminate.

**Method**: Modeling and simulation of the main material and process physics

**EXISTING CDS SIMULATION TOOL INCORPORATES MULTI-PHYSICS ATP MODEL**

- Consolidation Model
  - Squeeze flow 
  - Void growth
  - Adhesion of substrate
  - Laser and differing

- Temperature simulation (t, z) steady state

- Coupled bonding analysis
  - Laser and Spring
  - Intimate contact

- Chemical analysis
  - Crystallization
  - Degradation

**IMPROVEMENT OF THE CODE**

- **Optimization**: rewritten in Matlab
  - Use of vectors and matrices
  - Use of built-in routines (linear algebra, Runge Kutta, optimization)
  - CPU speed improvement: ~5 times faster

- **Process Adaptation**: to simulate EADS industrial head
  - Laser heating
  - Thermal contact resistance between layers
  - Highly deformable silicone roller. Solving the finite deformation using FEA

- **Embedding** of the code in an optimization framework

**ONGOING WORK PROCESS OPTIMIZATION**

Maximize process throughput for a given required quality
- Maximize head speed
- Consider quality improvement over multiple passes

**Parameters**: Velocity
**Cost function**: maximize velocity
**Constraint**: Good bonding
No degradation
Low void fraction

**FUTURE WORK**

Modeling the second step of consolidation under vacuum.

We first need to understand the physical phenomena that allow a reduction of voids.

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