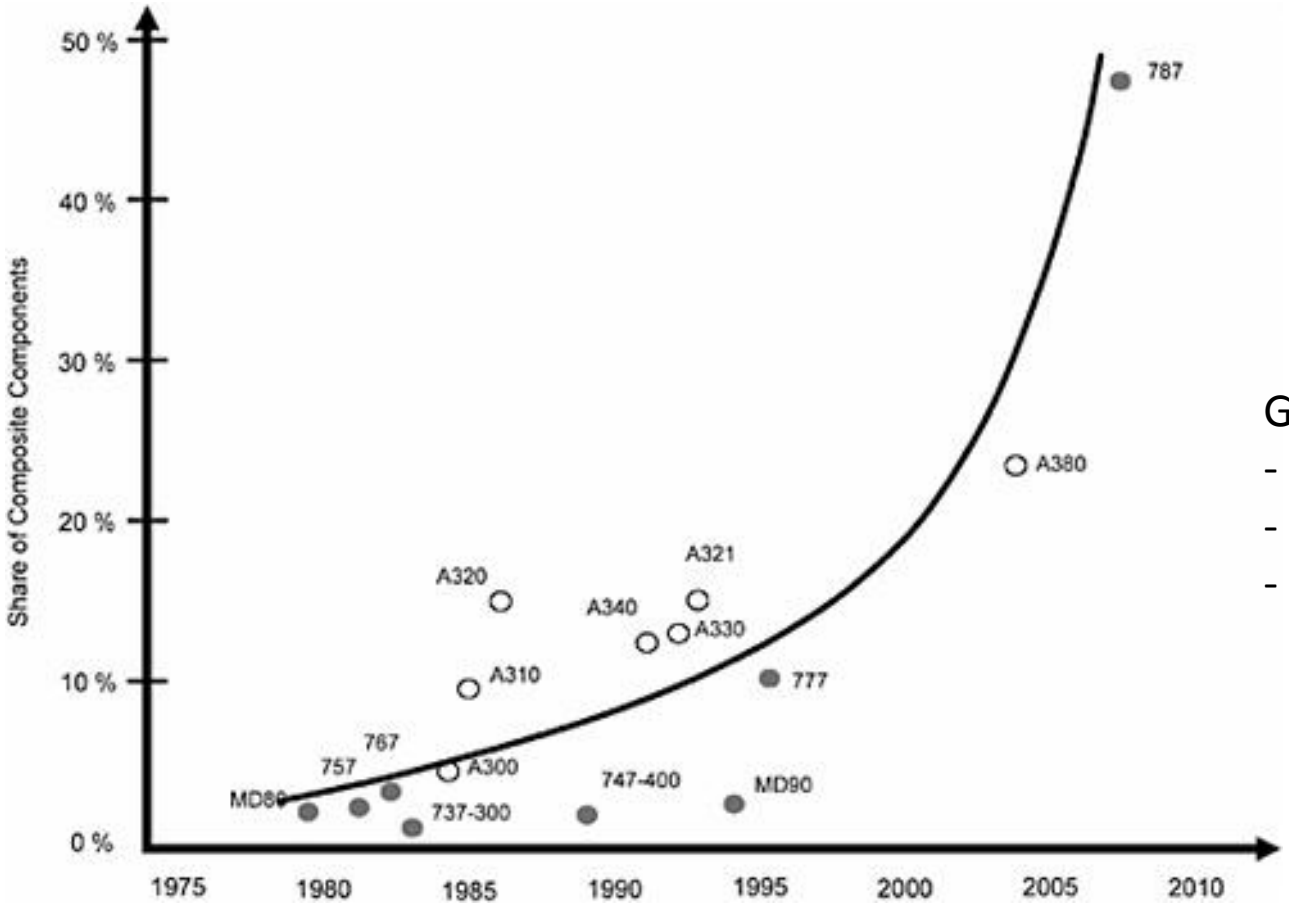
COMSOL CONFERENCE BOSTON 2012

Modeling the Squeeze Flow of a Thermoplastic Composite Tape During Forming.

Arthur Levy, Gilles Philippe Picher Martel and Pascal Hubert
McGill University - Montreal

Excerpt from the Proceedings of the 2012 COMSOL Conference in Boston

Composite Materials



Good specific properties:
- Strength
- Stiffness
- Low Weight

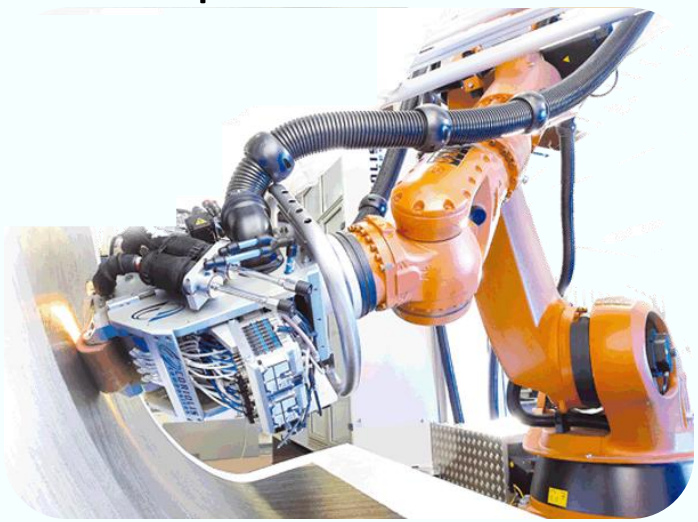
Source, EADS

Example of Huge part

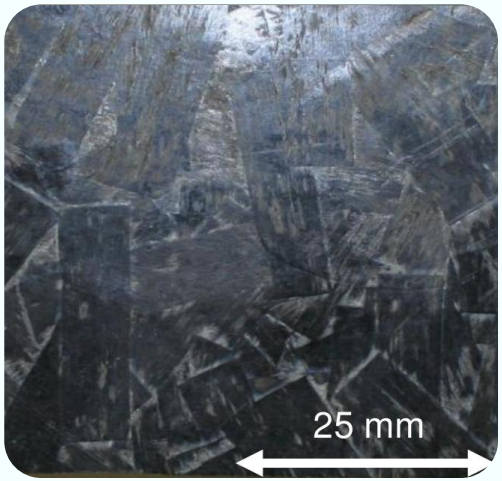
➡ Autoclave or oven curing is expensive or even impossible

Thermoplastic Composites

Tape Placement

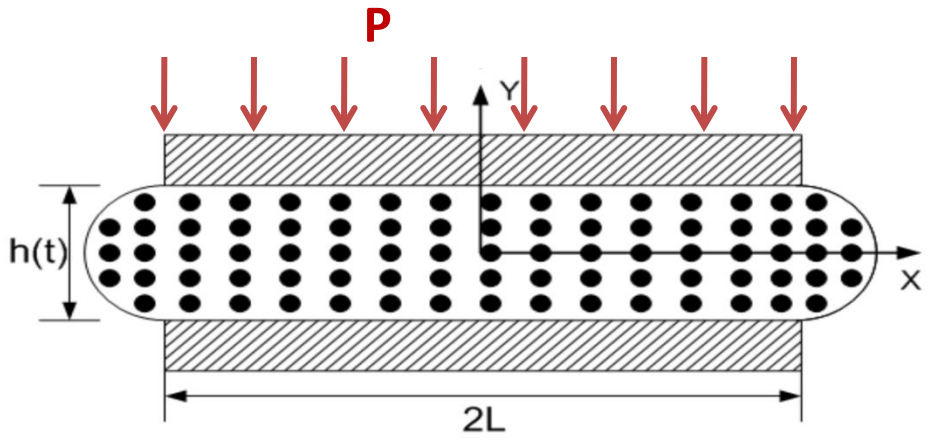


Press Forming



⇒ No need for Cure

From the Tape to the Part

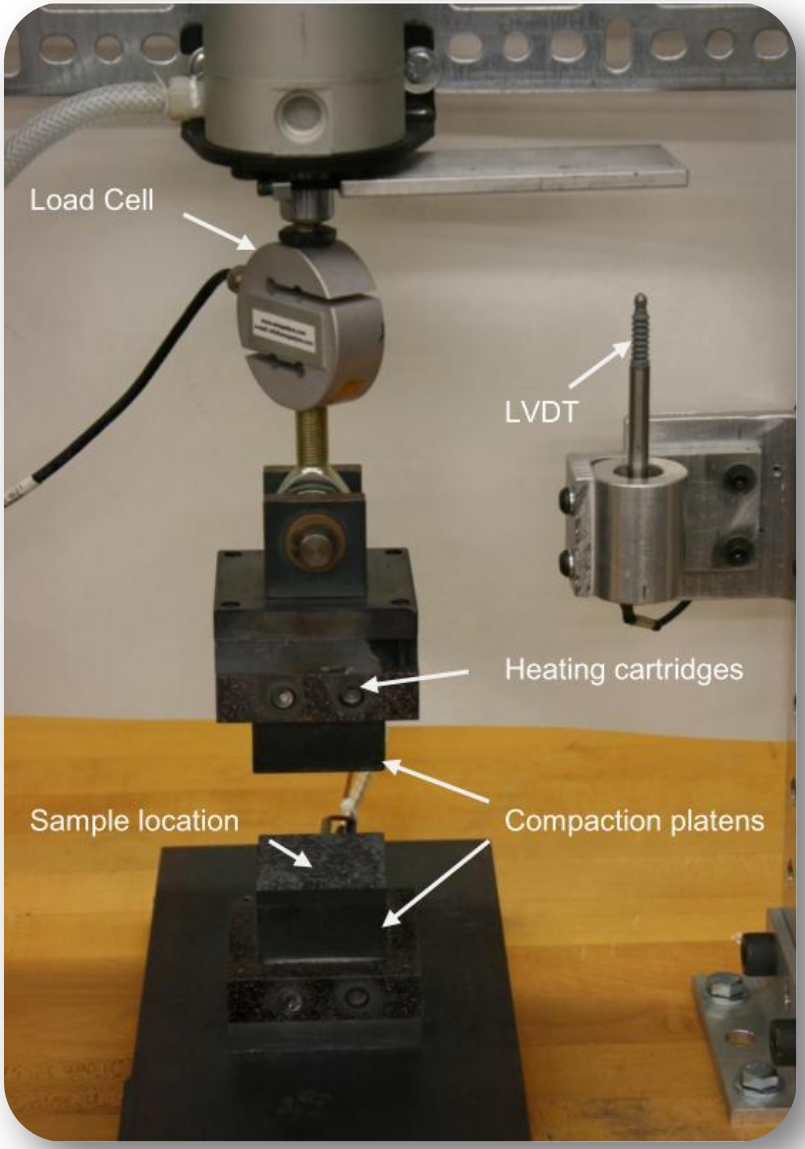


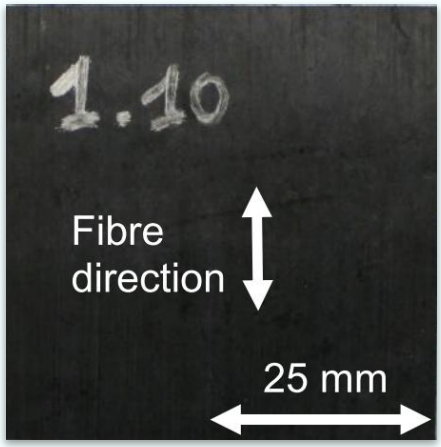
Goal : understanding the effect of pressure and temperature on the forming.
Methods : modeling the squeeze flow of a single tape.

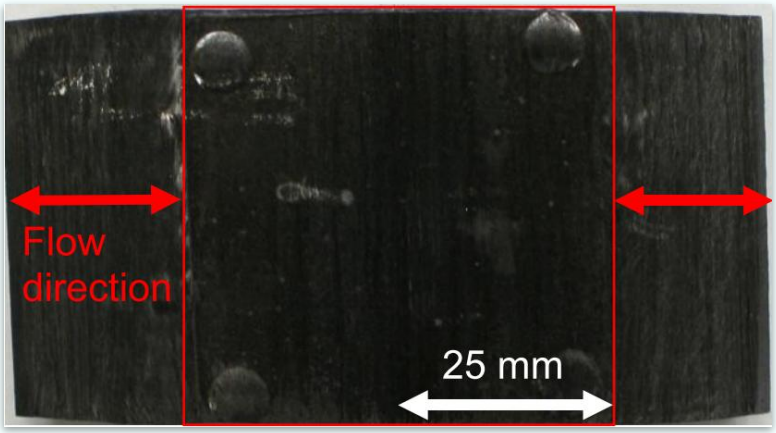
Outlines

- Experiment
- Modeling
- Implementation in COMSOL
- Results
- Discussion

Experiment



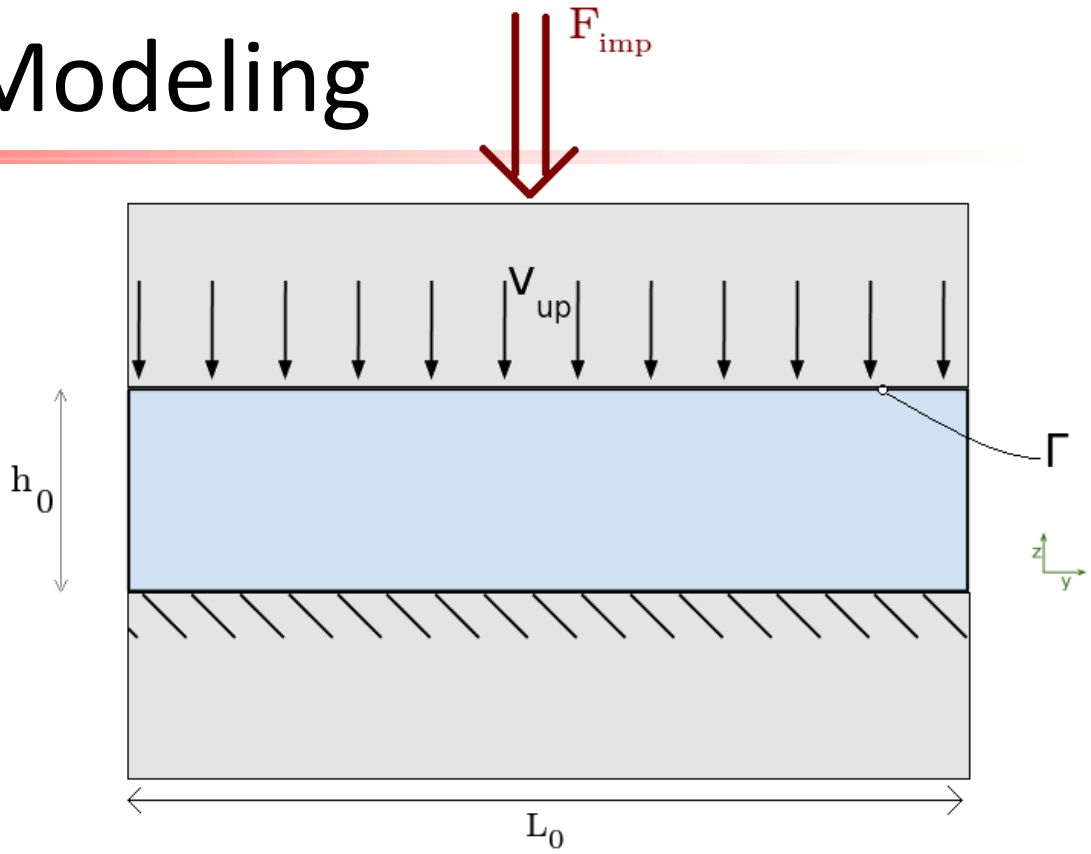




Picher Martel and Hubert 12

Modeling

2D modeling (plane strain)



Heat Transfer (T)

Conduction, transient

→ 2D Finite element resolution

Fluid flow, incompressible (u,v,p)

Non Newtonian Fluid (Carreau, literature)
Inertia Negligible
Large deformation

→ Lubrication assumption → Analytical resolution. (1D p, v=0) Shuler and Advani 96

→ 2D Finite element resolution

COMSOL – modules used

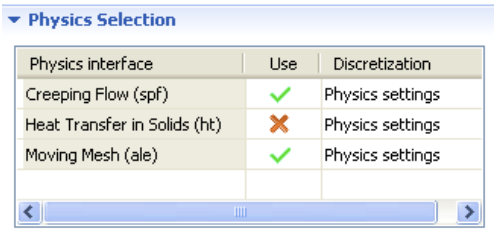
Heat transfer in Solids
Transient Conduction

Solved first,
independently:
for t=0:1000

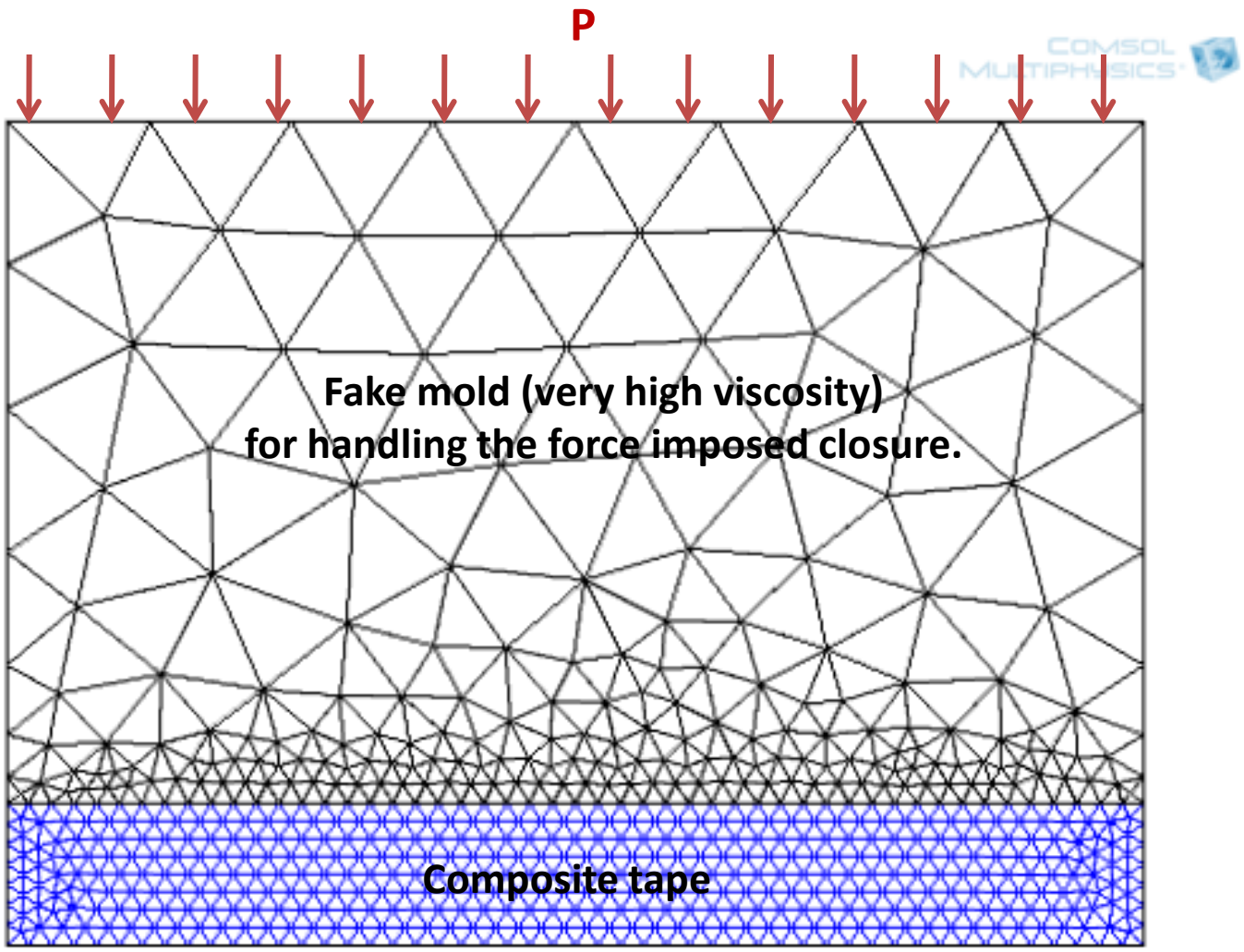
Fluid Flow (laminar)
Carreau Viscosity

Solved then,
together:
for t=0:150

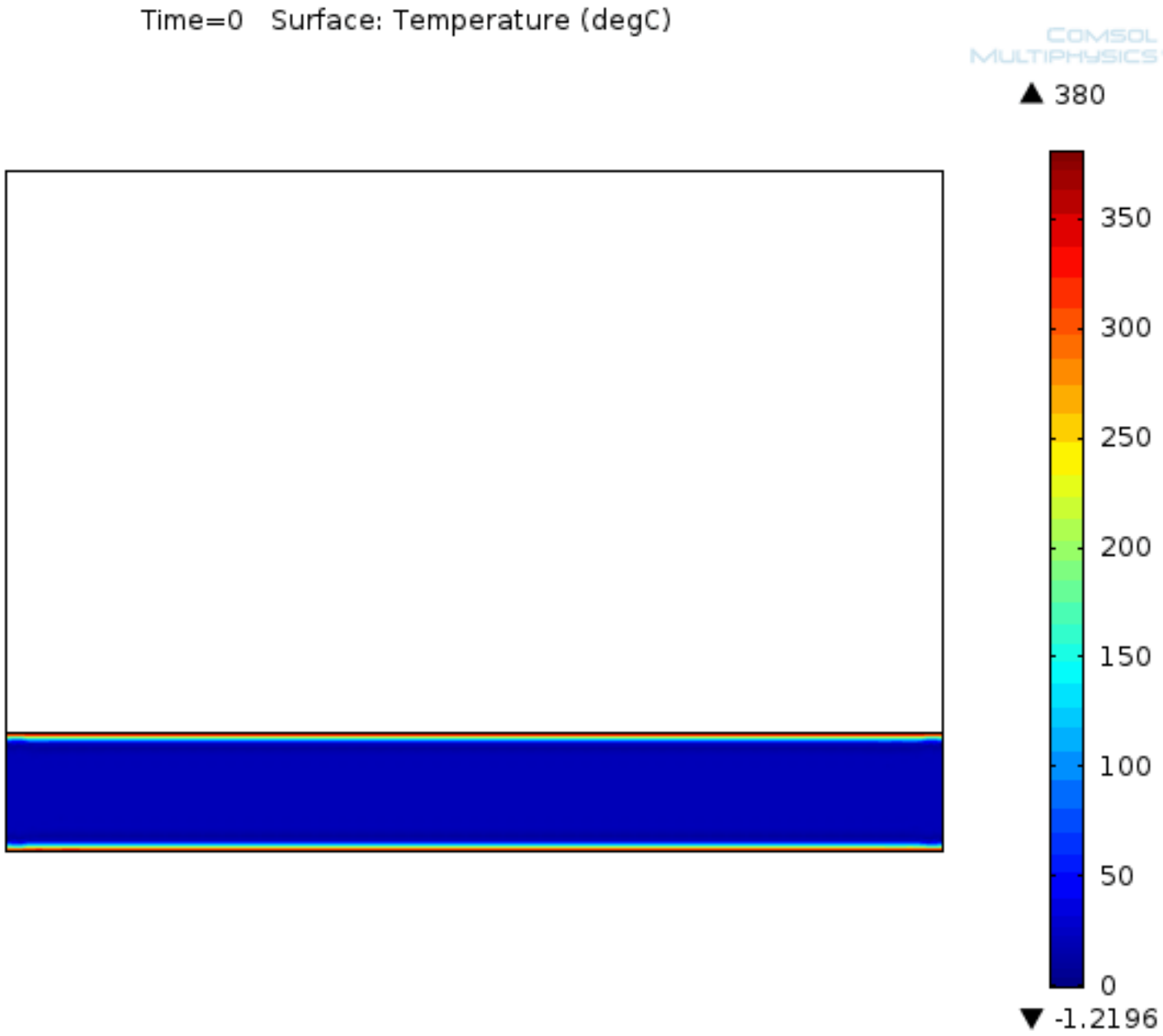
Moving Mesh ALE



COMSOL – Fluid flow specificity

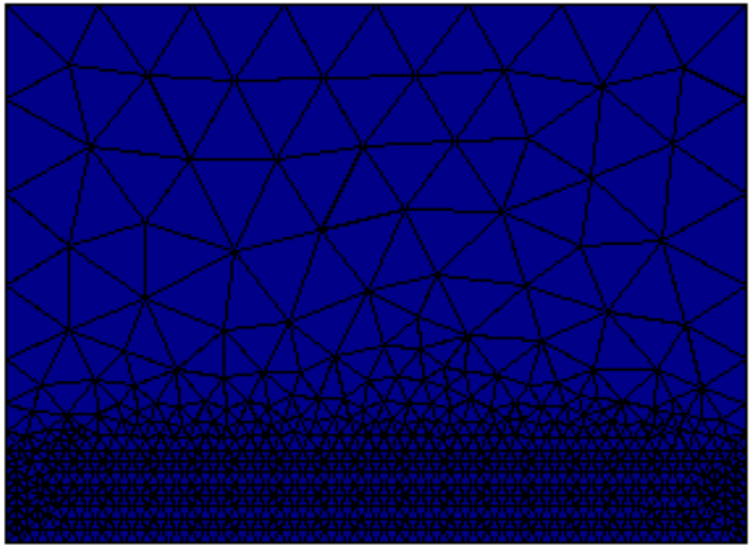


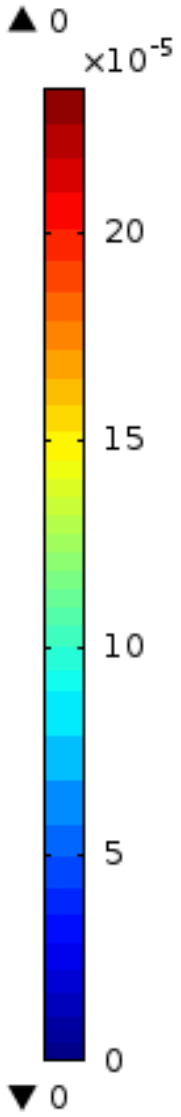
Results – Heat Transfer



Results – Squeeze Flow

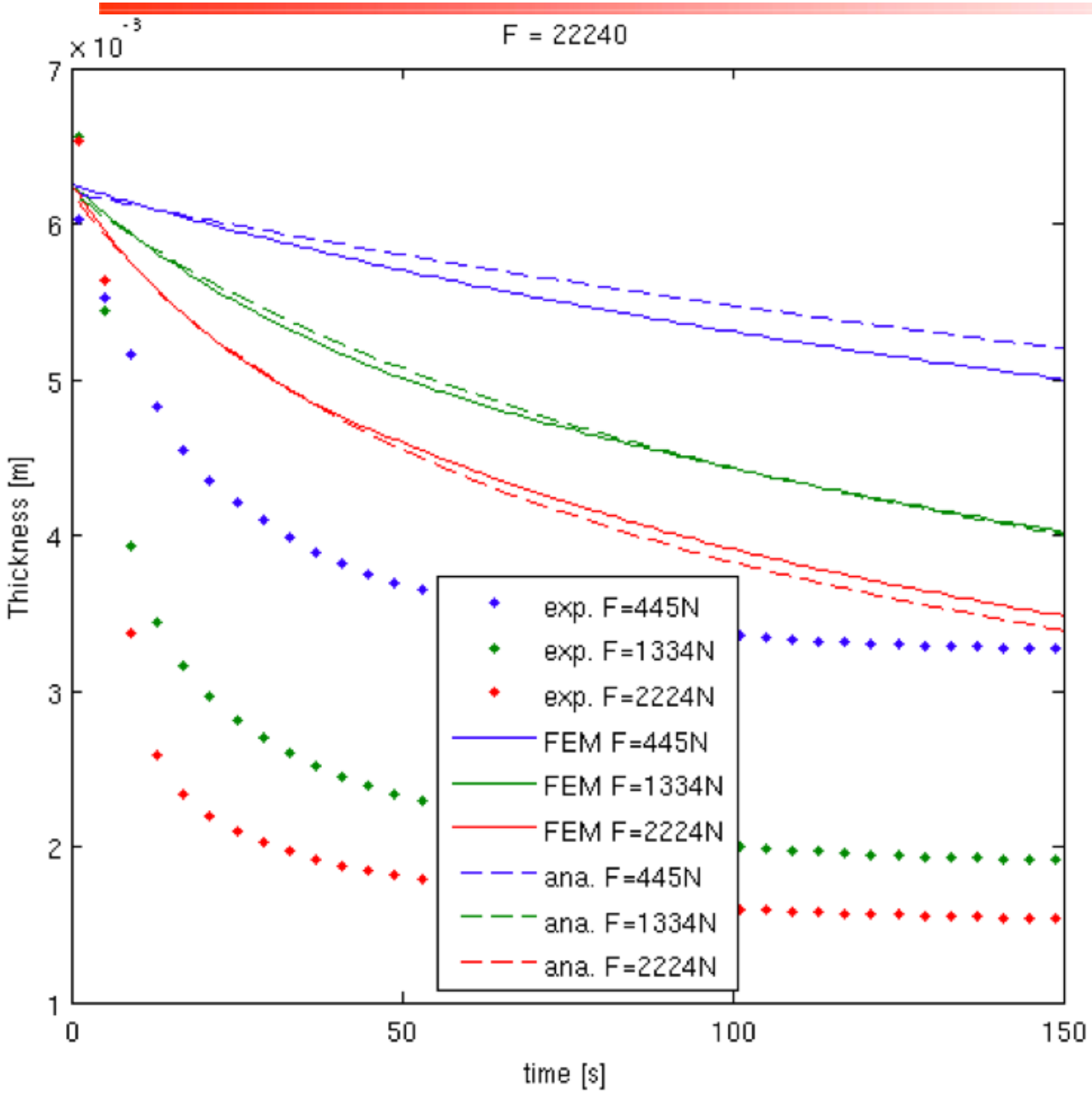
Time=0 Surface: Velocity magnitude (m/s) Mesh: Quality
Arrow Line: Velocity field (Spatial)





F = 2224N

Discussion



Experimental Data : Obtained with an in-house setup [Picher Martel & Hubert 2012]

Finite Element Data : Presented COMSOL results

Analytical Data : obtained using lubrication assumption and solving the ODE in MATLAB [Schuler & Advani 1996]

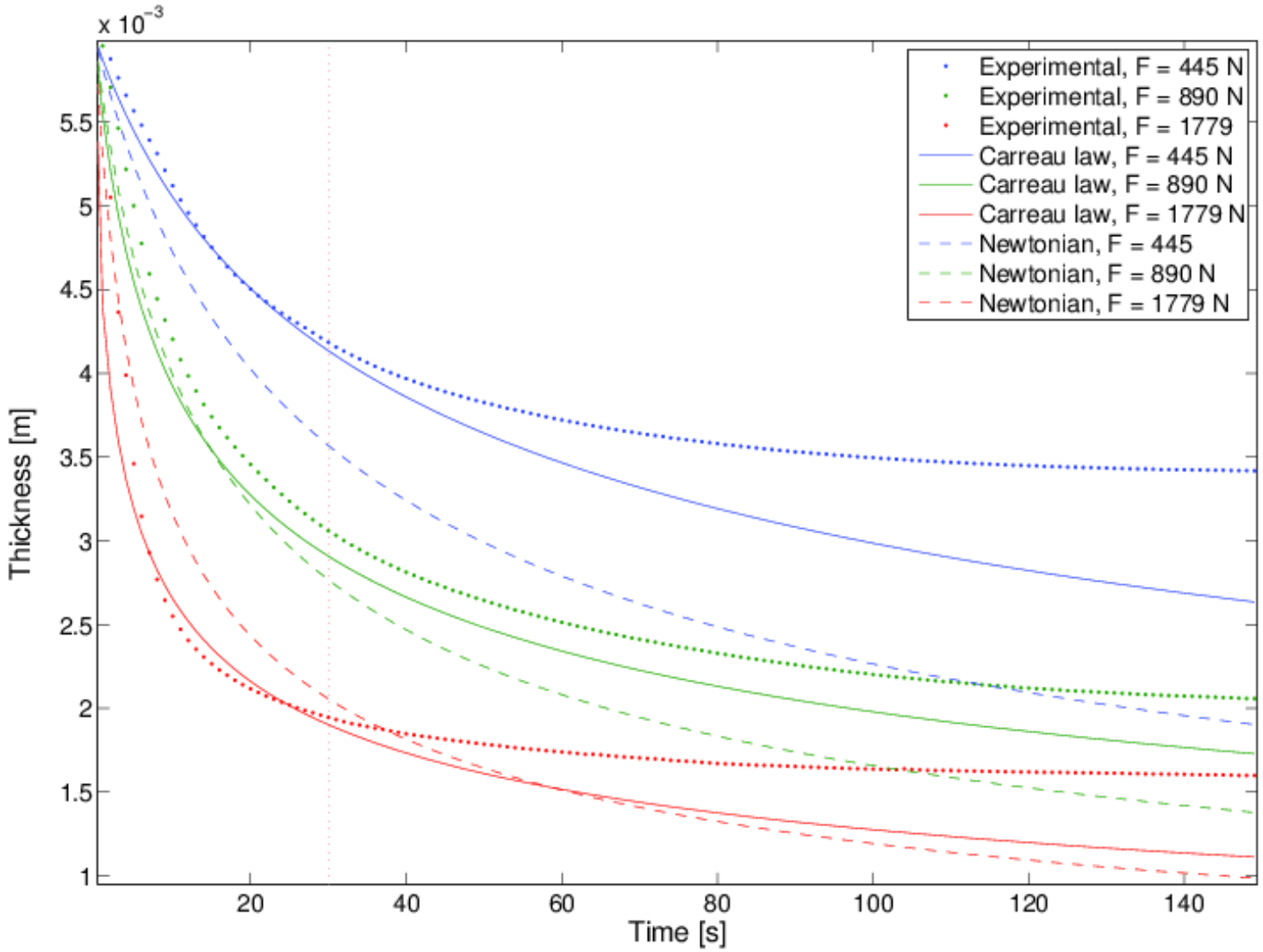
Conclusion & Future Work

Heat Transfer is fast : isothermal assumption makes sense.

Analytical and FEM solution correlate. Lubrication assumption is valid.

Experimental data are NOT recovered. Additional work is needed on:

- Behavior (not fluid ?)
- Modeling (slippage ?)


x 10^-3
Thickness [m]
Time [s]
Experimental, F = 445 N
Experimental, F = 890 N
Experimental, F = 1779
Carreau law, F = 445 N
Carreau law, F = 890 N
Carreau law, F = 1779 N
Newtonian, F = 445
Newtonian, F = 890 N
Newtonian, F = 1779 N