Thermo Mechanical Analysis of Composite Material Exposed to Fire

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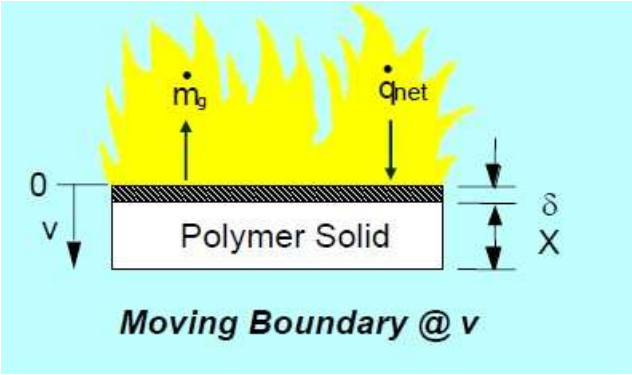
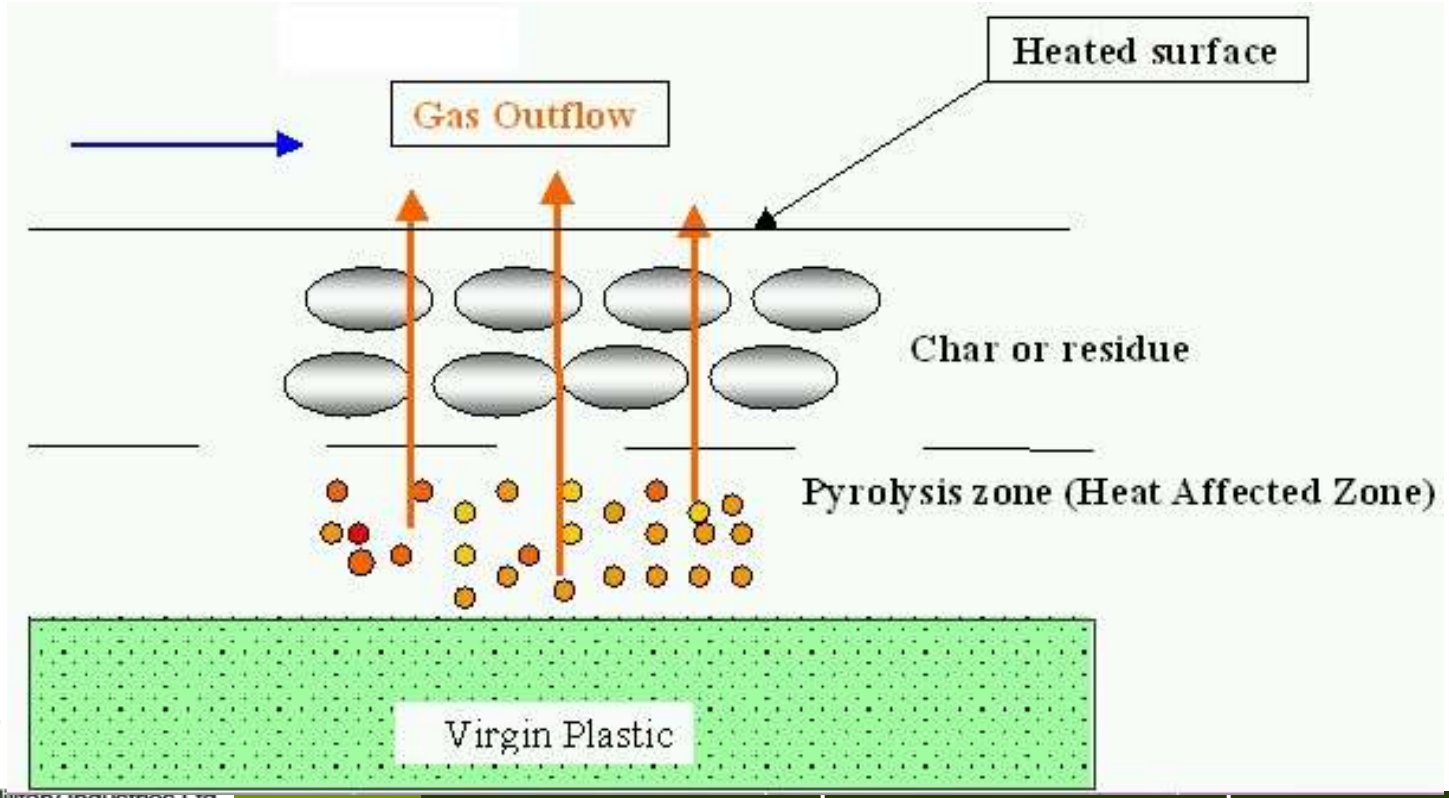
Problem Description

This paper presents thermo-mechanical models for predicting the strength of polymer laminates. The models assume that one side of a laminate beam is evenly heated at a constant radiant heat flux. Calculation of the fire resistance demands determination of temperature distribution in the cross-section and analysis of mechanical responses of the structure exposed to increased temperature.



Composite degradation process

As the composite is heated, the original virgin material pyrolyzes and yields a pyrolysis gas, and a porous residue, which for most materials of interest is a carbonaceous char.



Calculation phases

The proposed approach is divided into three simulation parts:

1) The FDS model is utilized. The FDS model generates a solution of several state variables, such as temperature and recession rate.

2) COMSOL heat transfer module was used in order to compute the temperature profiles for the composite through their thickness using the heat flux or surface temperature results from the FDS model. The surface recession rate is specified with a moving mesh boundary condition enabled through the "Moving Mesh" (ALE).

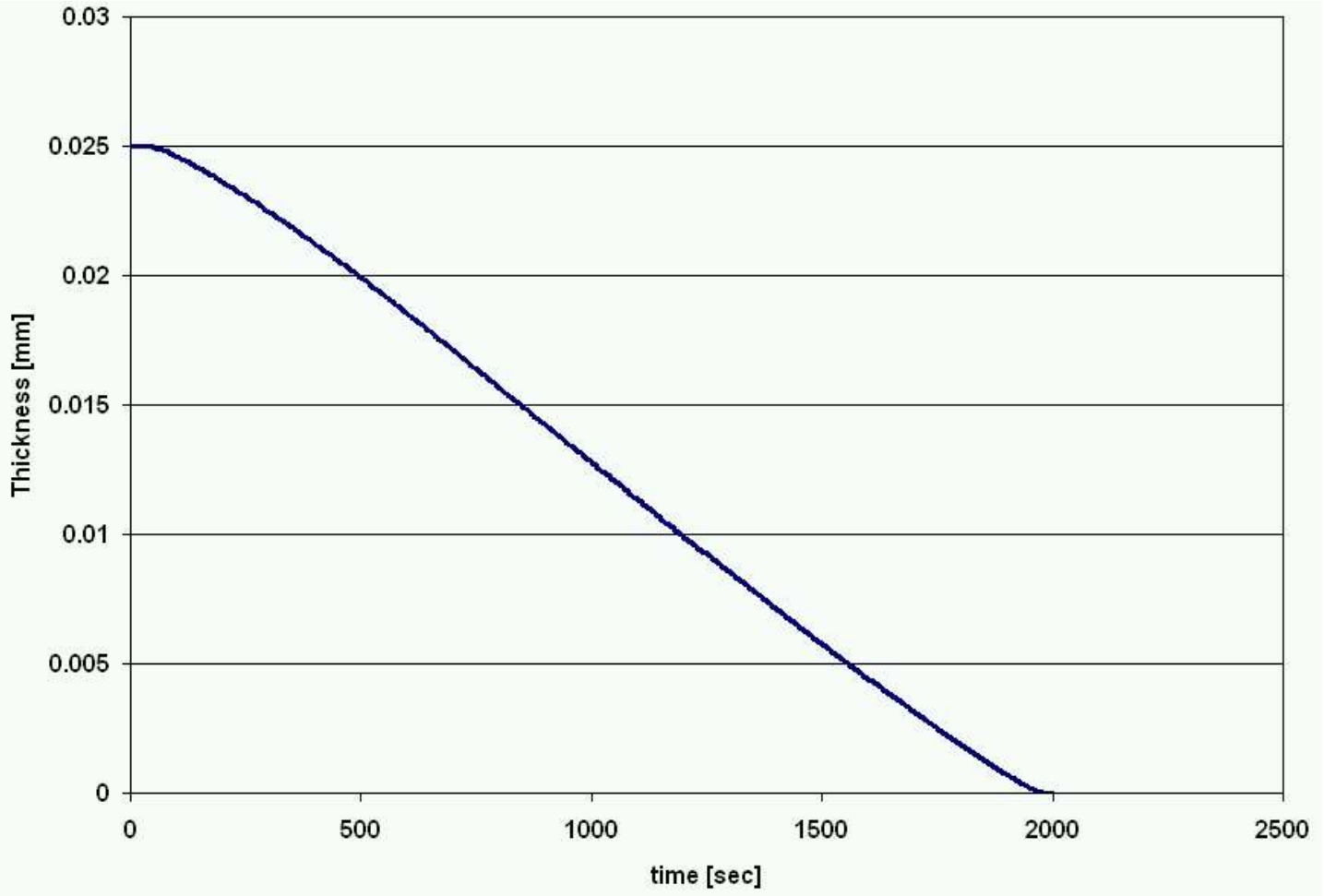
3) Finaly, the mechanical properties of the composite were evaluated.

Modeling Regressing Surface with COMSOL

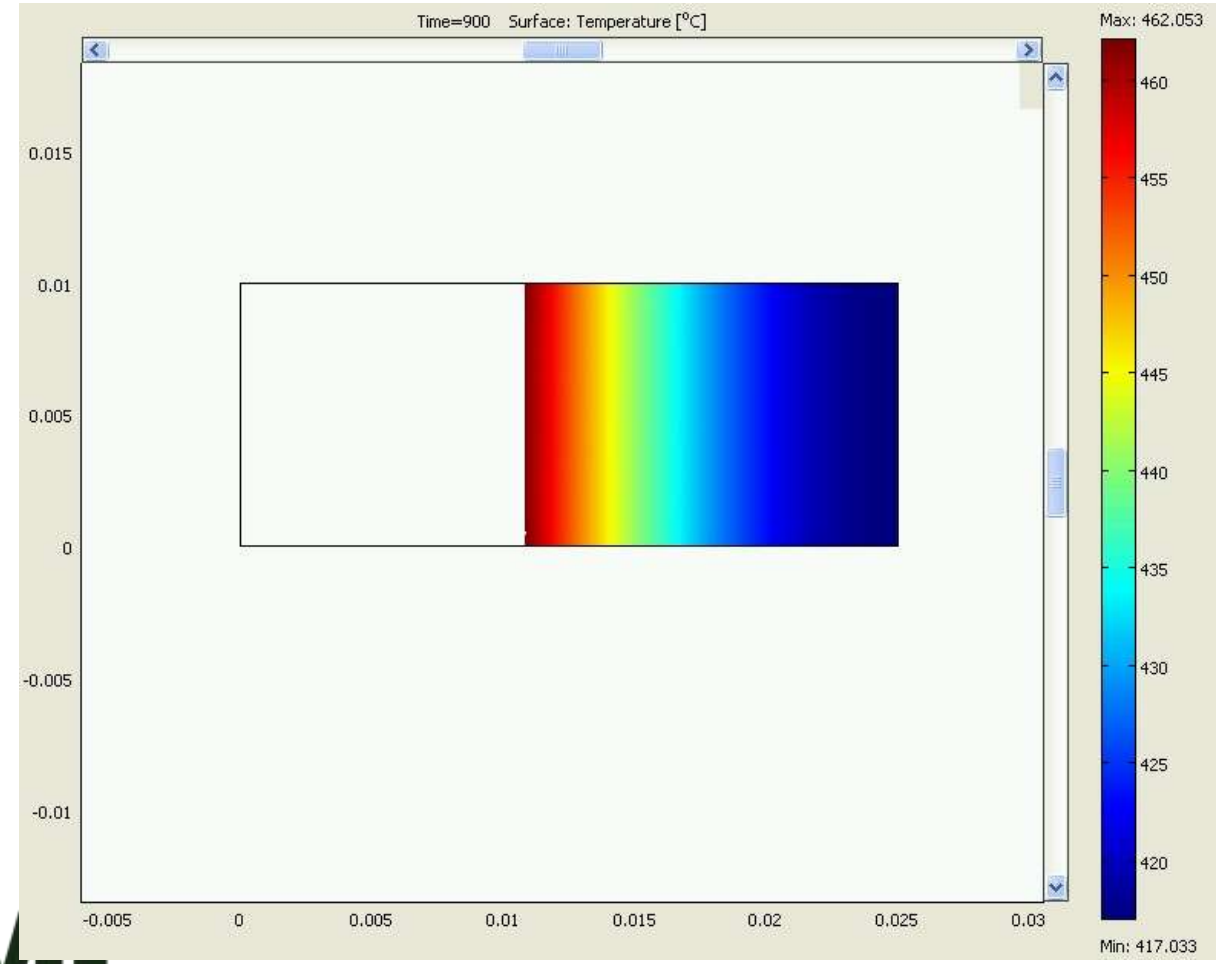
This model demonstrates the use of the Moving Mesh (ALE) application mode. The thermo-physical and thermo-chemical Properties of composite used in calculations.

Parameter	Value	Unit
ρ_s	1,140	kg/m^3
$c_{p,s}$	760	J/kg K
λ_s	0.43	$w/(m \cdot K)$
E_{A0}	2.13E+05	kJ/kmol
A_0	5.59E+13	1/s

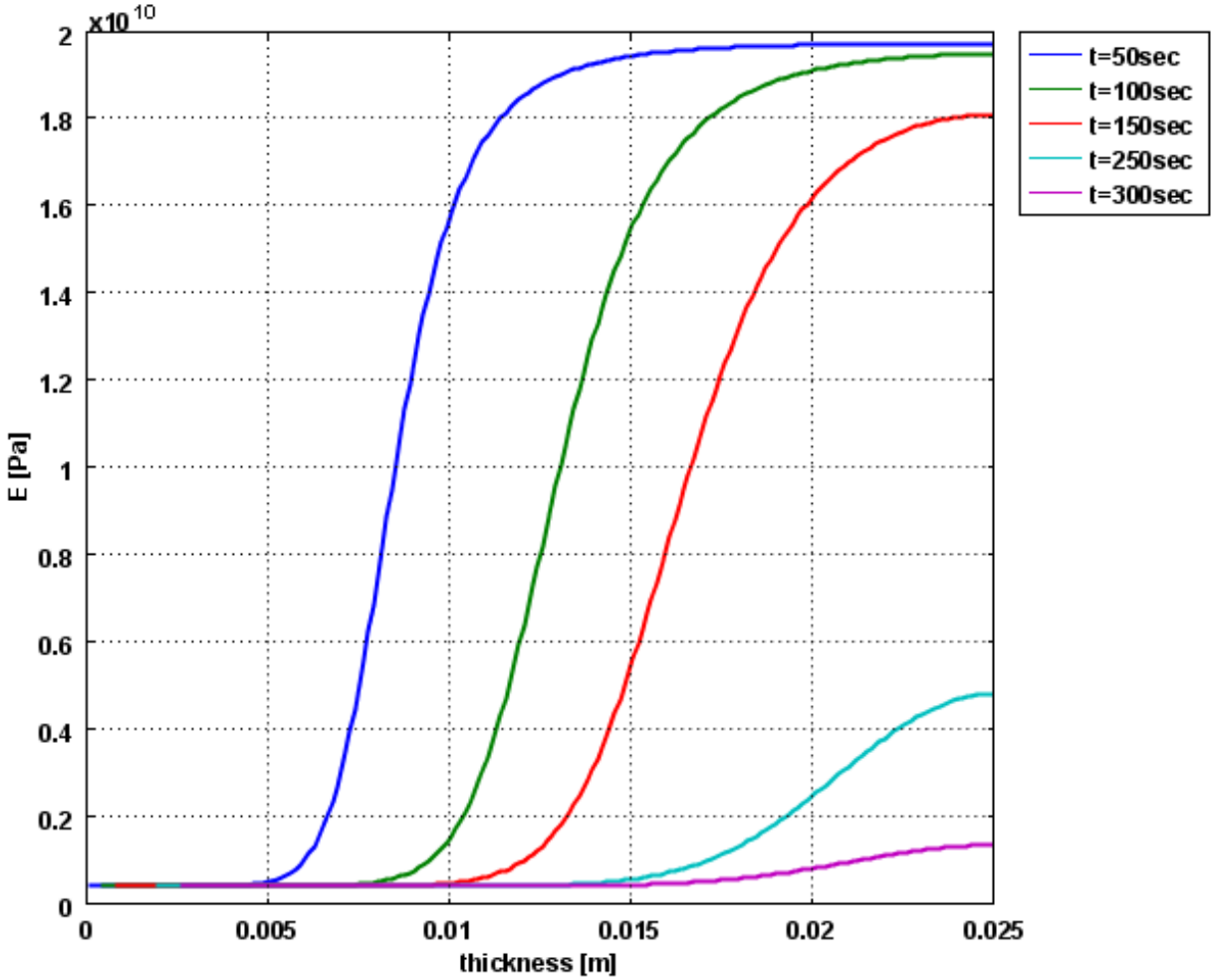
Predicted thickness of the composite as a function of time



Temperature field and erosion of the composite after 900 sec.



Young's modulus of the composite at several temperatures



Concluding Remarks

- **A preliminary transient model was developed to describe the spatial temperature distribution inside composite material.**
- **The simulation of the burning composite is composed of three phases.**
- **It has been shown that the Young's modulus decreases at higher temperatures.**