Computer Modeling of Fire-Suppression Agent Behavior for Simulated Engine Nacelle Environments

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Background/Project Info.

- High probability that gases or liquids with high boiling points will be required to provide fire protection in engine nacelles (region between aircraft engine body and the housing)

- Need
  - Eliminate compounds from consideration that will never be suitable
  - Identify favorable properties that successful agents are likely to possess

Purpose & Goals

Overall:

- Develop FORTRAN 90 program to evaluate fire suppression potential for compounds in protecting engine nacelles

- Use program to:
  - Model dispersion of liquid agents into a simulated engine nacelle environment
  - Produce vaporization behavior data to aid search for optimum fire suppression agents

Fundamentals of Heat & Mass Transfer

Flash Vaporization:

- When a liquid is released under pressure into an environment whose ambient temperature is greater than that of its boiling point, a portion of the "super-heated" liquid can change into its vapor state instantaneously, leaving the remaining liquid to evaporate through thermal exchange with the surrounding air

- The amount of liquid which will undergo immediate vaporization upon release, is controlled by the Jakob number (*Ja*):

$$Ja = \frac{\int_{T_b}^{T_{amb}} C_{pL}(T)\, dT}{\Delta H_{vap}}$$

Fundamentals – Cont.

- Classical D-squared Law
- Evaporation Constant

$$D^2(t) = D_o^2 - Kt$$

$$K = \frac{8\lambda_g}{\rho C_{pg}} \cdot \ln(1 + B)$$

Fundamentals – Cont.

- Mass Transfer No.

For environments whose ambient temperature is equal to, or surpasses the boiling point of the agent being released

$$B_H = \frac{C_{pg}(T_{amb} - T_b)}{\Delta H_{vap}}$$

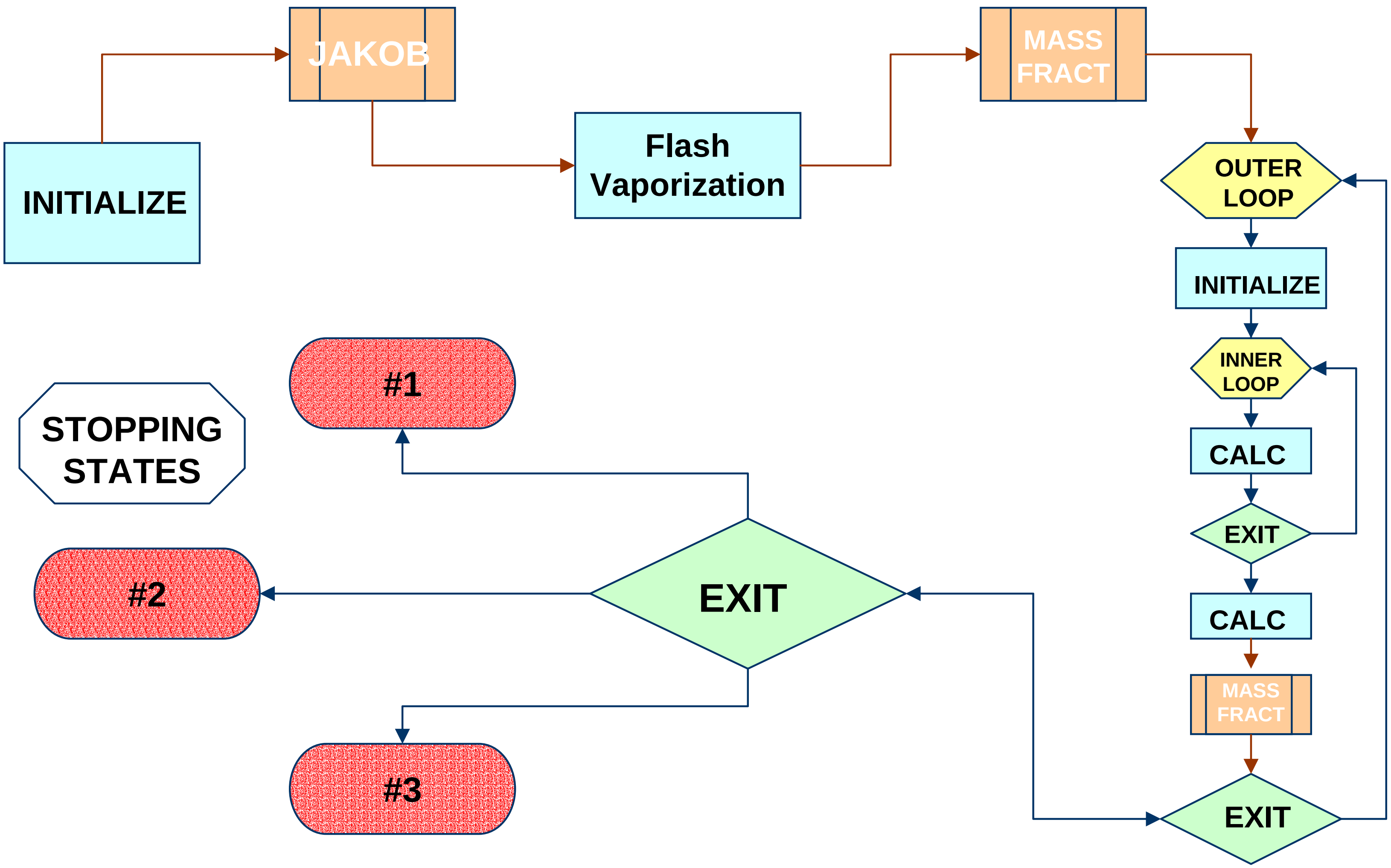
or, for environments where the ambient temperature falls below the agent's boiling point:

$$B_L = \frac{Y_s - Y_a}{1 - Y_s}$$

DIPPR® (801) Chemical Database

- Design Institute for Physical Property Data
- Source for all required agent-specific input, including coefficients for temperature dependent properties

DROP_NACELLE Flowchart



Conclusions/Results

- DROP_NACELLE successfully modeled vaporization behavior for the dispersion of fire suppression agent in a simulated nacelle environment
- Water and Halon 1301 modeled
- Improvements such as a dynamic time-step, along with the inclusion of the affects of the engine airflow on the dispersed agent under evaluation, would help render the program’s data output to be more precise

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