ENVIRONMENTAL IMPLICATIONS OF CUTTING FLUIDS

Precision Machining Research Consortium

Industrial Advisory Board

Georgia Institute of Technology

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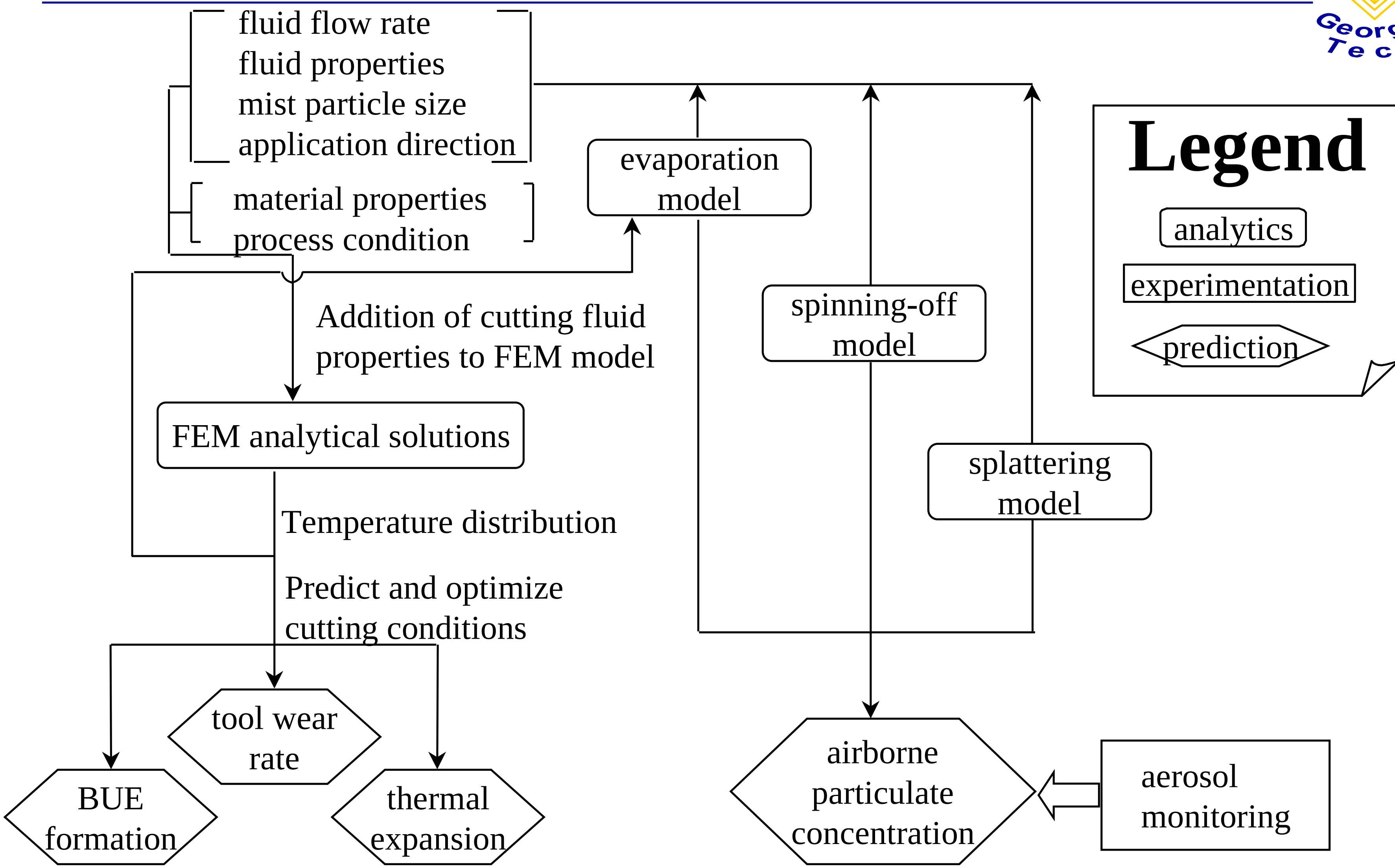
AGENDA

- Introduction
- Agenda
- Objectives
- Analytical Model
- Experimental Work
- Future Work

THE EFFECT OF CUTTING FLUID ON ENVIRONMENT AND PROCESS PERFORMANCE



OBJECTIVES

- ❖ Determine the controlling factors that influence the cutting fluid dosage in the shop floor environment.
- ❖ Determine an analytical model to describe the causality between the controlling factors and the resulting airborne fluid particle concentration.
- ❖ Verify the analytical model by comparing measured cutting fluid concentration in the shop floor environment.

ANALYTICAL MODEL

❖ The analytical model is determined for turning a circular cylinder on an open-lathe.

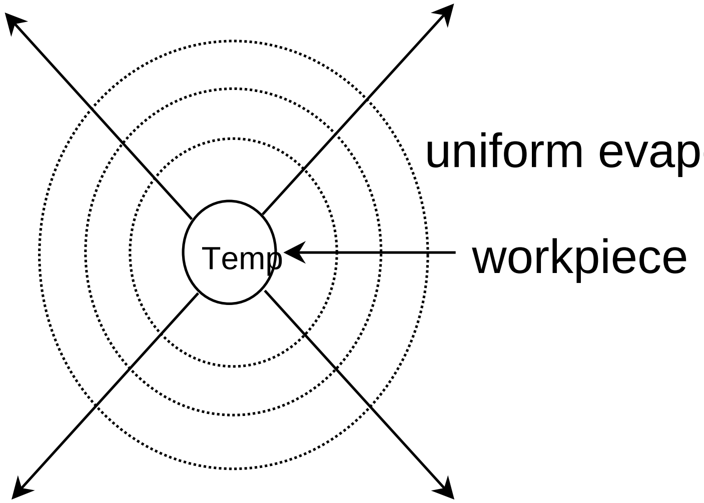
ANALYTICAL MODEL (cont.)

- There are 3 mechanisms for the cutting fluid to leave the cutting zone. These methods include:
  - Evaporation
  - "Spin-off"
  - "Splatter"

- Each mechanism has different controlling factors that influence how the cutting fluid will permeate into the shop floor environment.

ANALYTICAL MODEL (cont.)

EVAPORATION



$$\text{Evap\_rate} = \left(\frac{\text{Measured\_evap\_rate}}{\text{Calculated\_evap\_rate}}\right)\cdot\sqrt{\left(\frac{MW}{2\cdot\pi}\right)}\cdot\left(\frac{p_{tr}}{\sqrt{Ttr}} - \frac{p_{min}}{\sqrt{Tv}}\right)$$

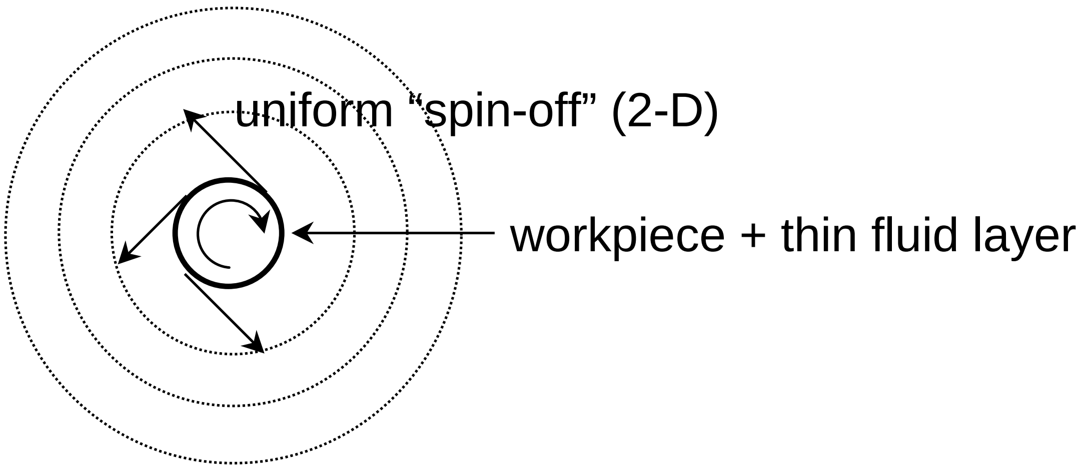
Hertz-Knudsen Eqn.

$$\text{Concentration}_{\text{fluid\_evap}} = \int_{t_1}^{t_2} f_0\cdot\text{Evap\_rate}\cdot\left(\frac{1}{\text{distance}^2}\right)dt$$

(f_0 will be calculated experimentally)

ANALYTICAL MODEL (cont.)

"SPIN-OFF"



$$\text{distance} = f_1 \cdot \text{rpm}$$

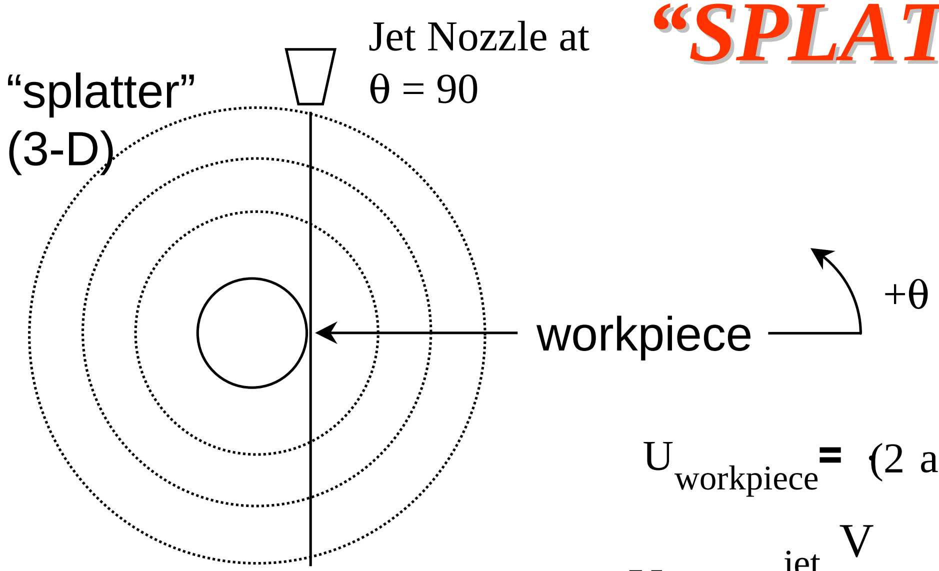
(f_1 will be calculated experimentally)

$$\text{Concentration}_{\text{fluid\_evap}} = \int_{t_1}^{t_2} \left[f_2 \cdot \left(\frac{1}{\text{distance}} \right) \cdot \left(\frac{1}{\mu_{\text{fluid}}} \right) \cdot \rho \right] dt$$

(f_2 will be calculated experimentally)

ANALYTICAL MODEL (cont.)

"SPLATTER"



$$U_{workpiece} = (2\ accel \cdot y)^{1/2}$$ (y will be found experimentally)

$$U_{jet} = \frac{V_{jet}}{A_{jet} \cdot t}$$ (U_{jet} will be found experimentally)

$$f_3 = \frac{U_{workpiece}}{U_{jet}}$$

$$V_{splatter} = f_3 \cdot V_{jet}$$; $$Concentration = \int_{t_1}^{t_2} \frac{V_{splatter} \cdot \rho}{V_{DataRAM}}\, dt$$ ($V_{splatter}$ will be verified experimentally)

EXPERIMENTAL WORK

- Using a real-time particle measurement device (DataRAM from MIE, Inc.), the experimental work seeks to accomplish the following goals:
  - Provide real-time data of shop floor environment particle concentration.
  - Determine amount of particles that are due to cutting fluid.
  - Verify the analytical model by comparing measured cutting fluid concentration in the shop floor environment.

EXPERIMENTAL WORK (cont.)

DataRAM

HotMeter

10/2.5 μm Selector

Omni-directional Inlet

FUTURE WORK

- The proposed formulation is valid for:
  - Turning a circular cylinder on an open-lathe

- Several more levels of complexity must be added to the system in the form of:
  - Optimizing cutting operation to minimize toxic airborne particles
  - A closed environment formulation for the Hardinge machine
  - Different operations
    - (e.g. milling, grinding, drilling)
  - More complex part geometry.