Proposed Conceptual Model of Process Variables Related to Heat Generation in FSW of Aluminum

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7th International Symposium on Friction Stir Welding

May 22, 2008

Agenda

- *Motivation for work*
- *Conceptual model formulation*
- *Case studies*
  - Changing welding speed
  - Changing spindle speed
  - Changing anvil conditions
- *Conclusions*

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Motivation

- Numerical models and experimental results have shed light on many of the relationships between the process variables in FSW:
  - Reynolds-Khandkar-Seidel, Askari-Silling, Colegrove-Shercliff, Frigaard-Grong, and others – numerical modeling of material flow, stress, temperature, etc.
  - Zettler, Colligan, London, and others – experimental study of material flow
  - Reynolds, Colligan, and others – experimental study of the effects of process variables

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Motivation

- A generalized description needed
  - Numerical models and experimental studies too specific, don’t address variation of parameters outside of the specific study
  - No framework for presenting and testing a fundamental description of the FSW process
- Applications
  - Introduction of the process to new researchers and practitioners
  - Explanation of trends observed in practice
  - Prediction of the effect of process changes

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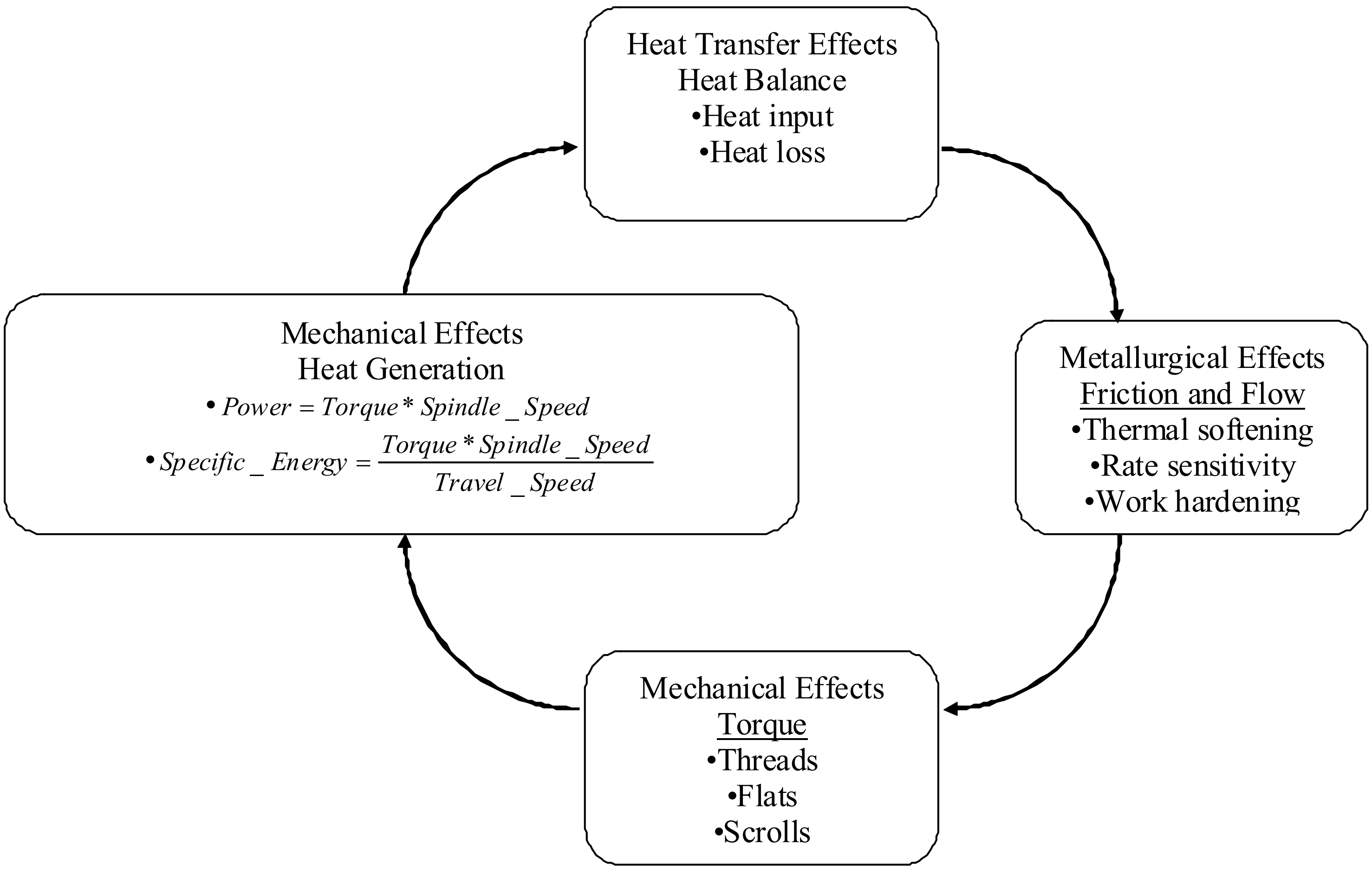
Conceptual Model Formulation

- *At a high level, the conceptual model is based on the interaction of physical effects*
- *The present study examines physical effects related to heat generation, heat transfer and material properties*



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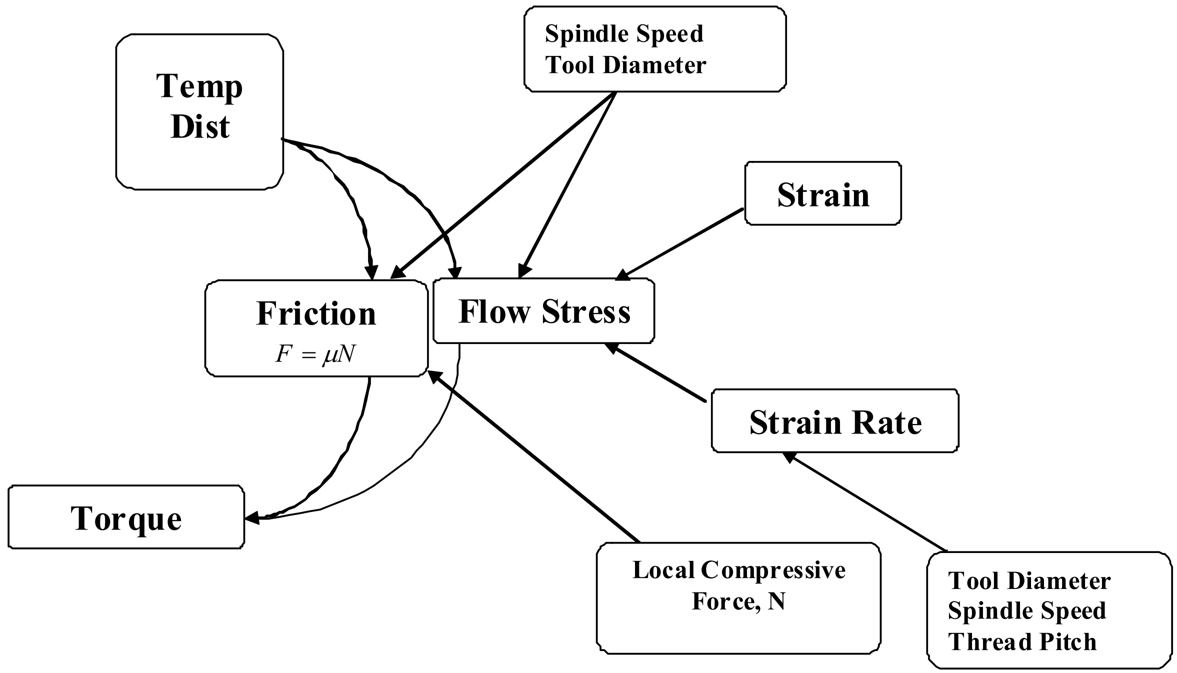
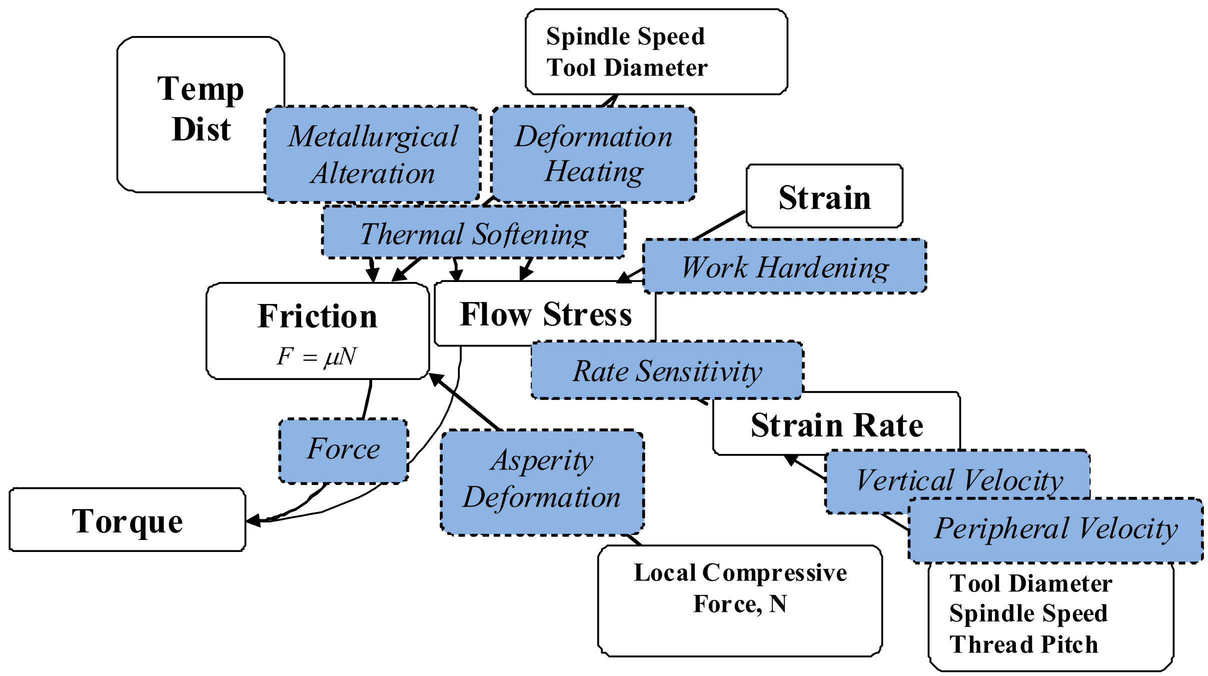
Conceptual Model with Physical Effects



Conceptual Model with Physical Effects



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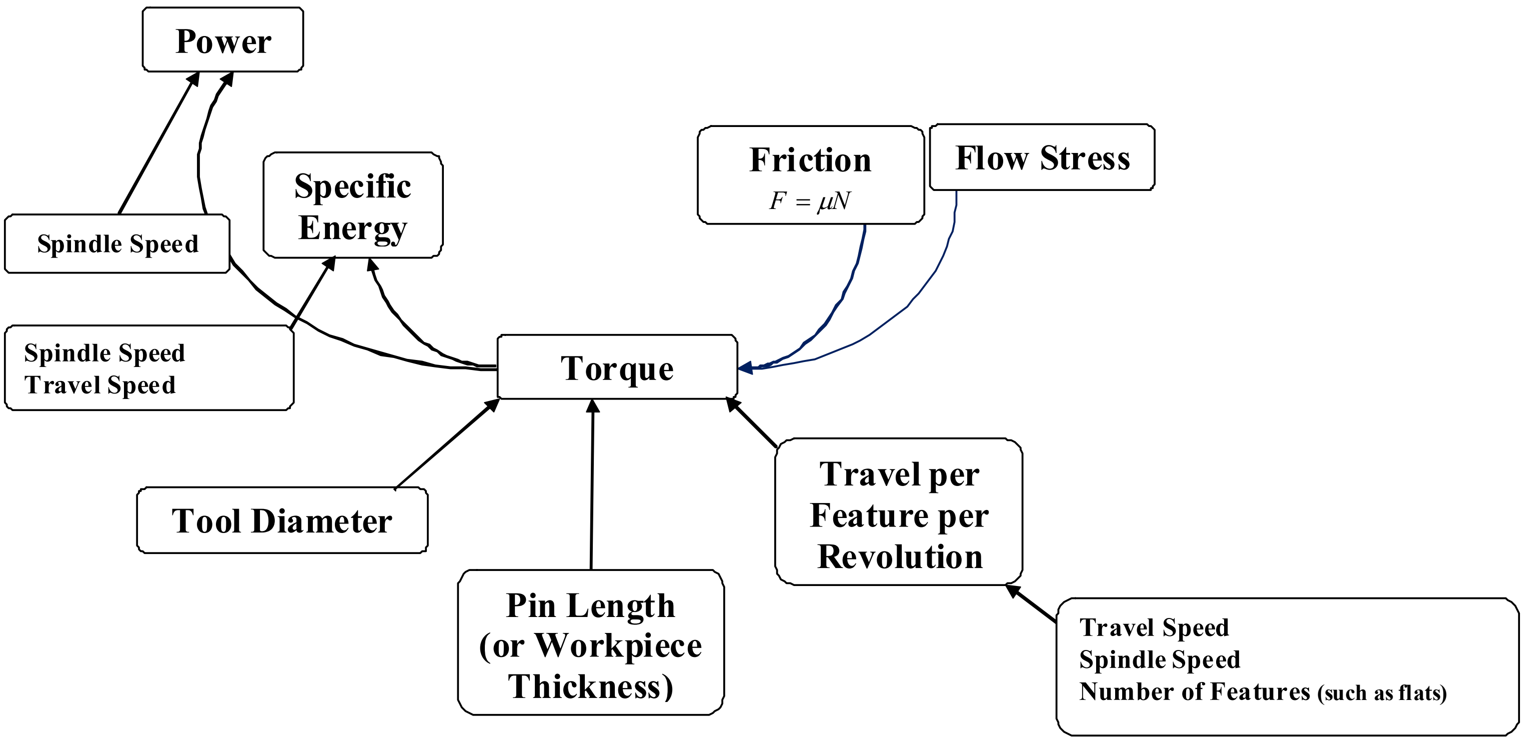

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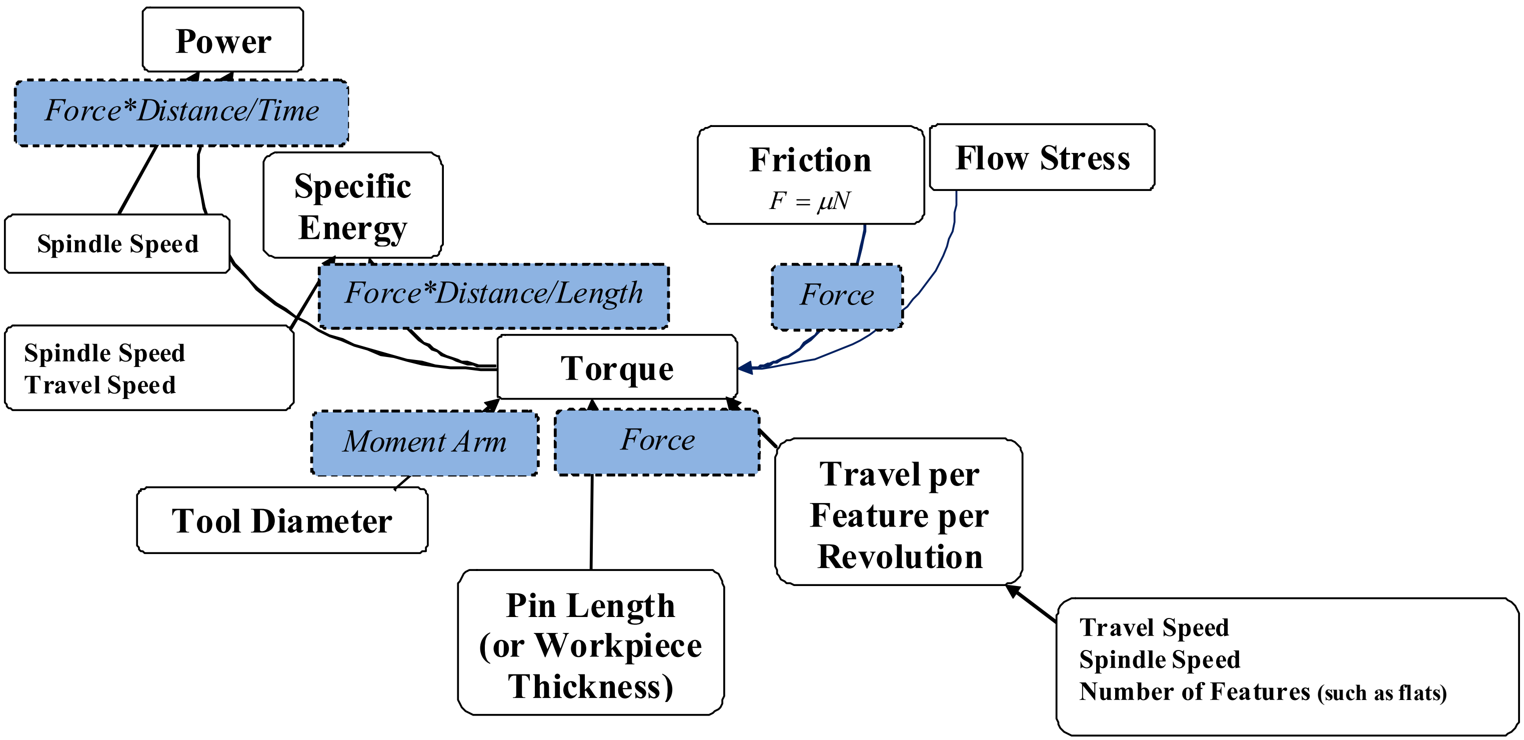
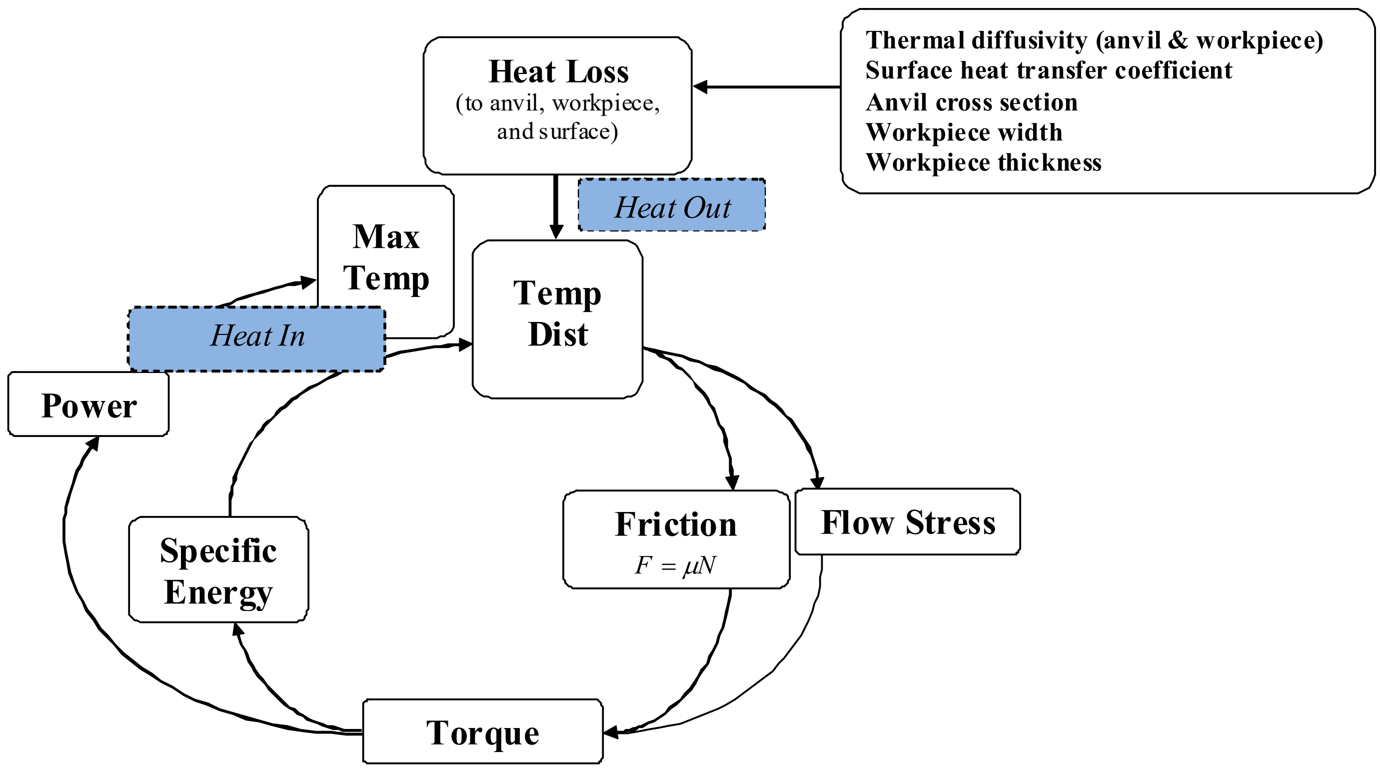
Conceptual Model with Physical Effects



Conceptual Model with Physical Effects



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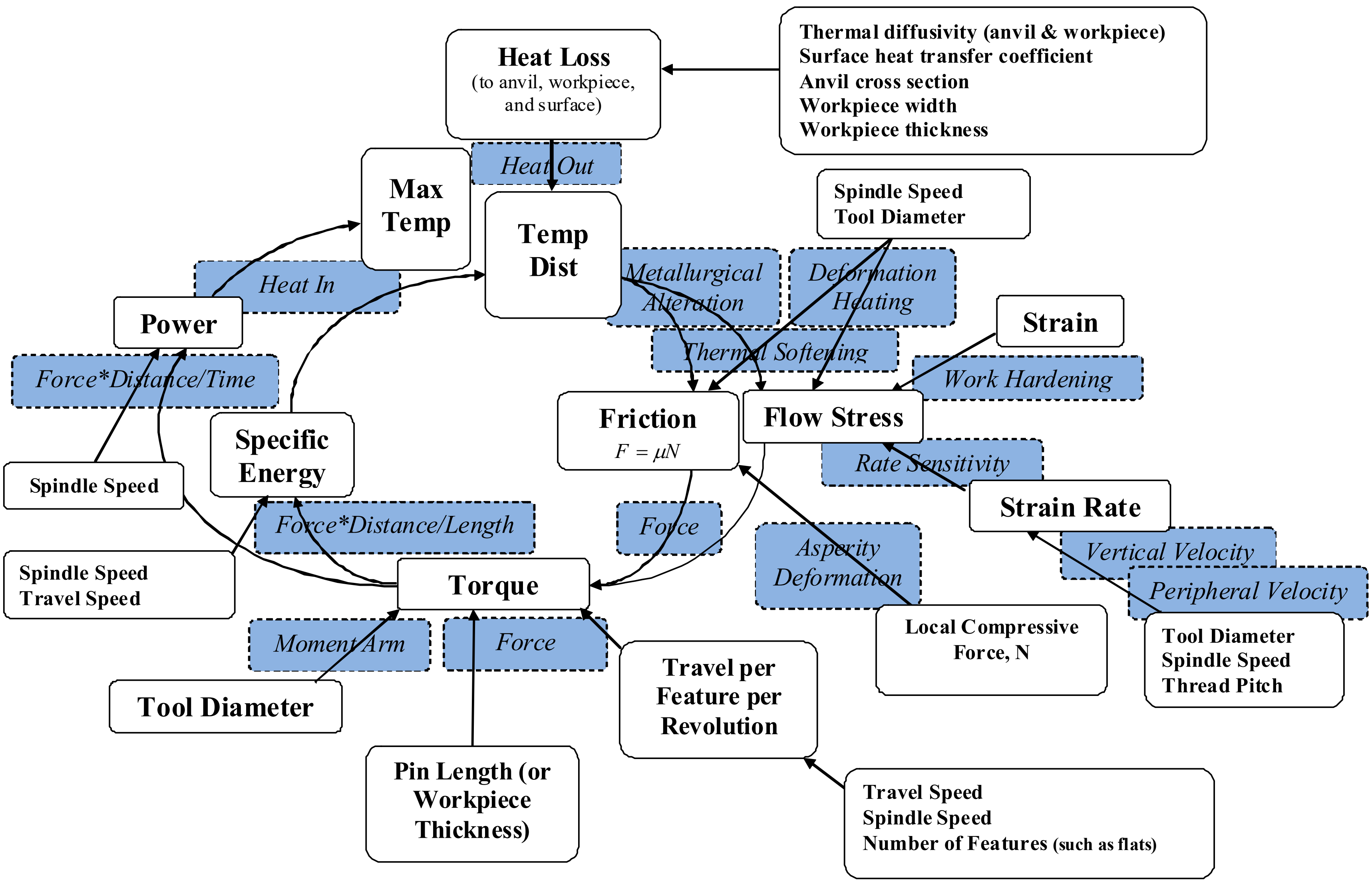

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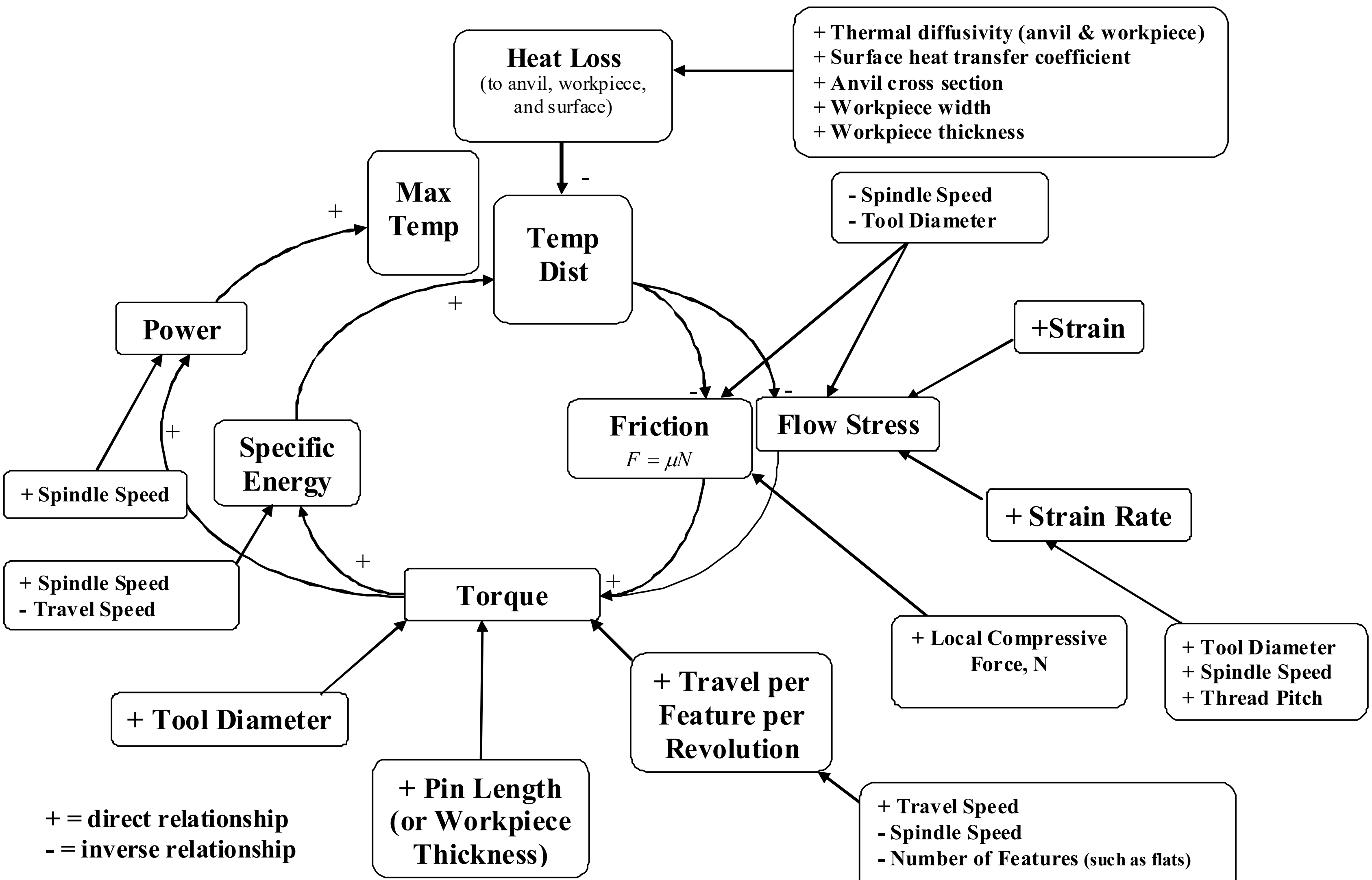
Conceptual Model with Physical Effects



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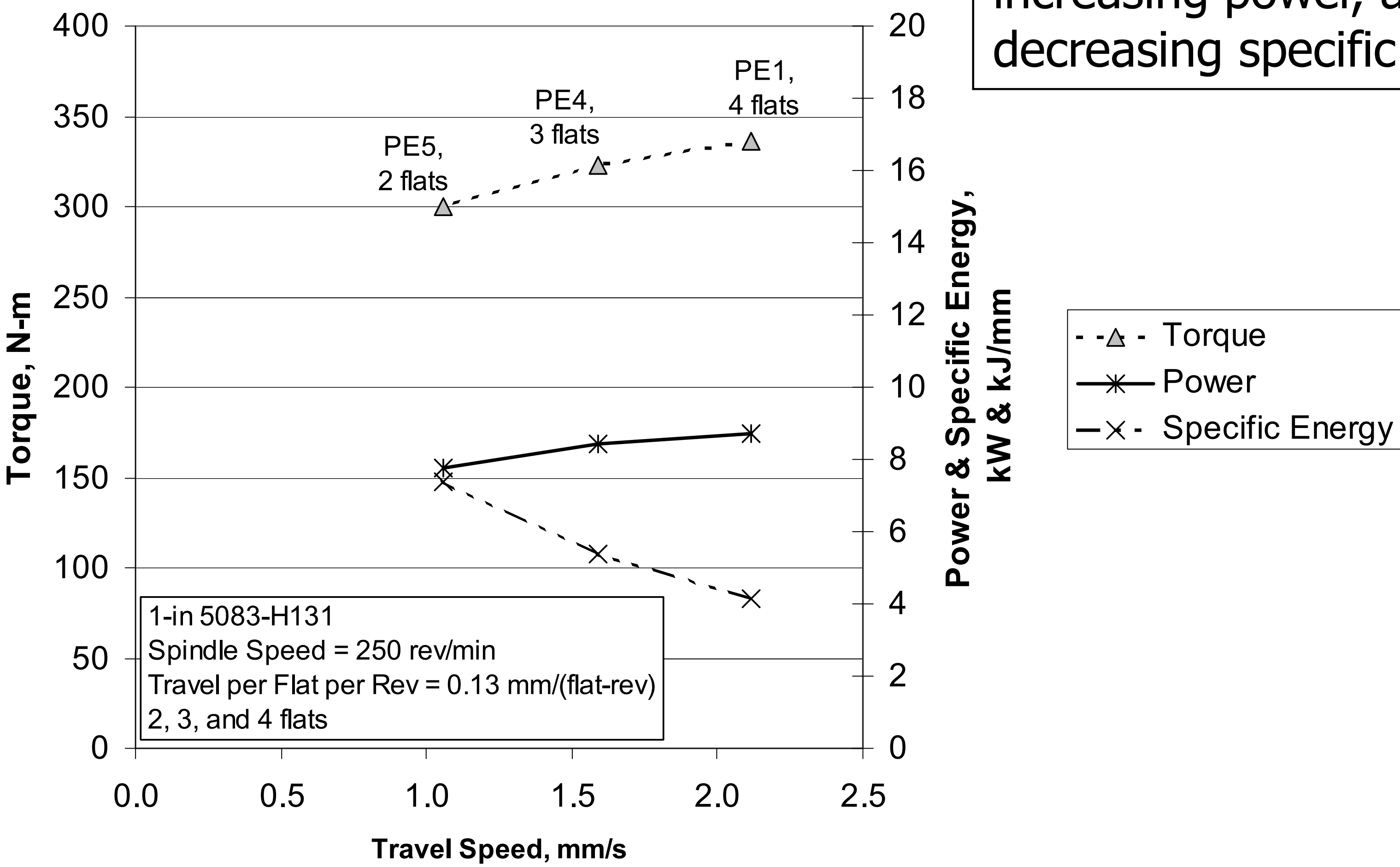
Case Studies

- Three sets of data used to demonstrate the model
  - Colligan, et. al. – TMS 2003
  - Xu et. al. – ASM 2003
  - Unpublished work
- Three effects examined
  - Effect of changing travel speed
  - Effect of changing spindle speed
  - Effect of changing anvil conditions

Case Study 1 – Effect of Increasing Travel Speed

- From Colligan, TMS 2003

Increasing travel speed led to increasing torque, increasing power, and decreasing specific energy.



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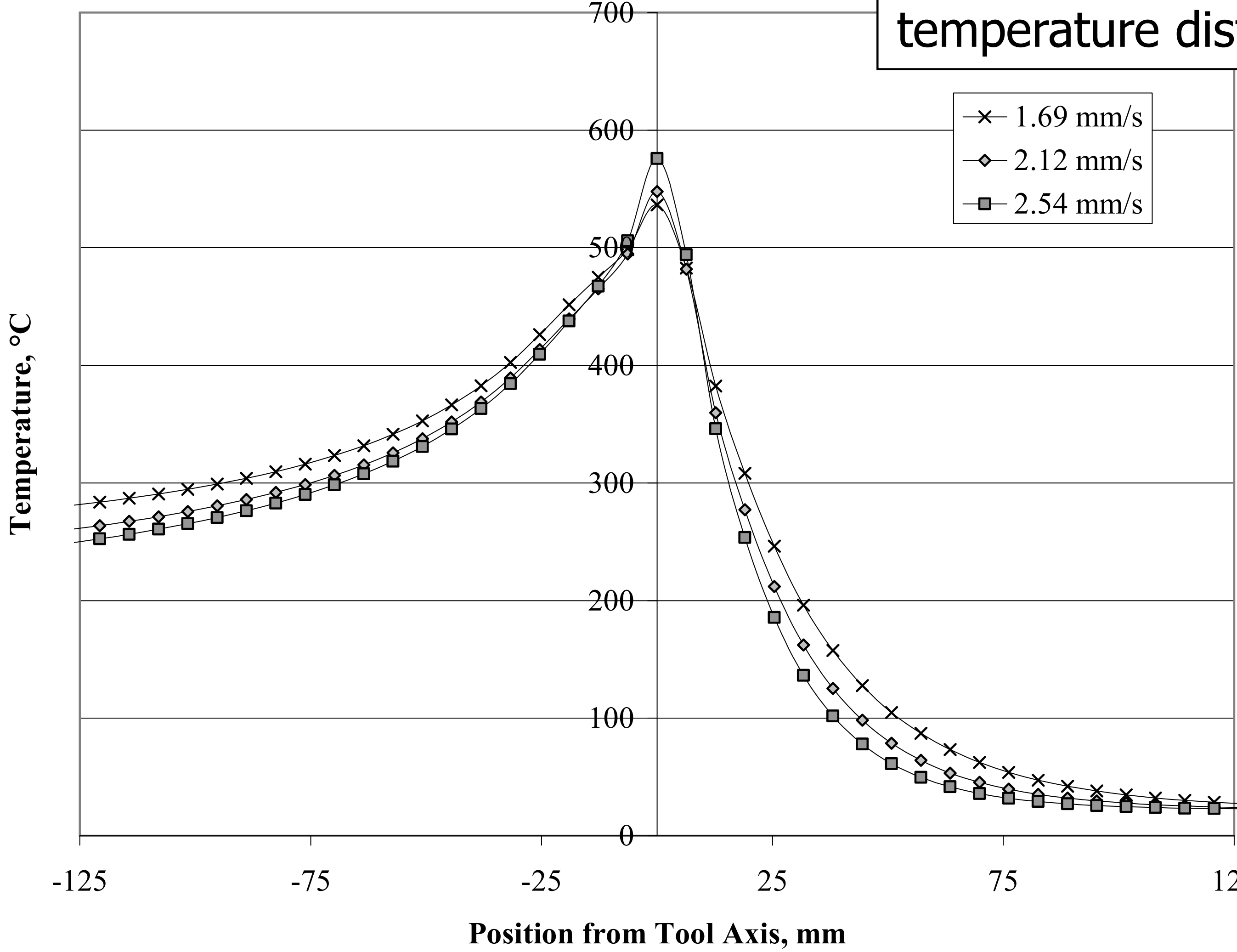
Case Study 1 – Effect of Increasing Travel Speed

- From Xu, ASM 2003

Increasing travel speed led to increasing maximum temperature, and decreasing temperature distribution.



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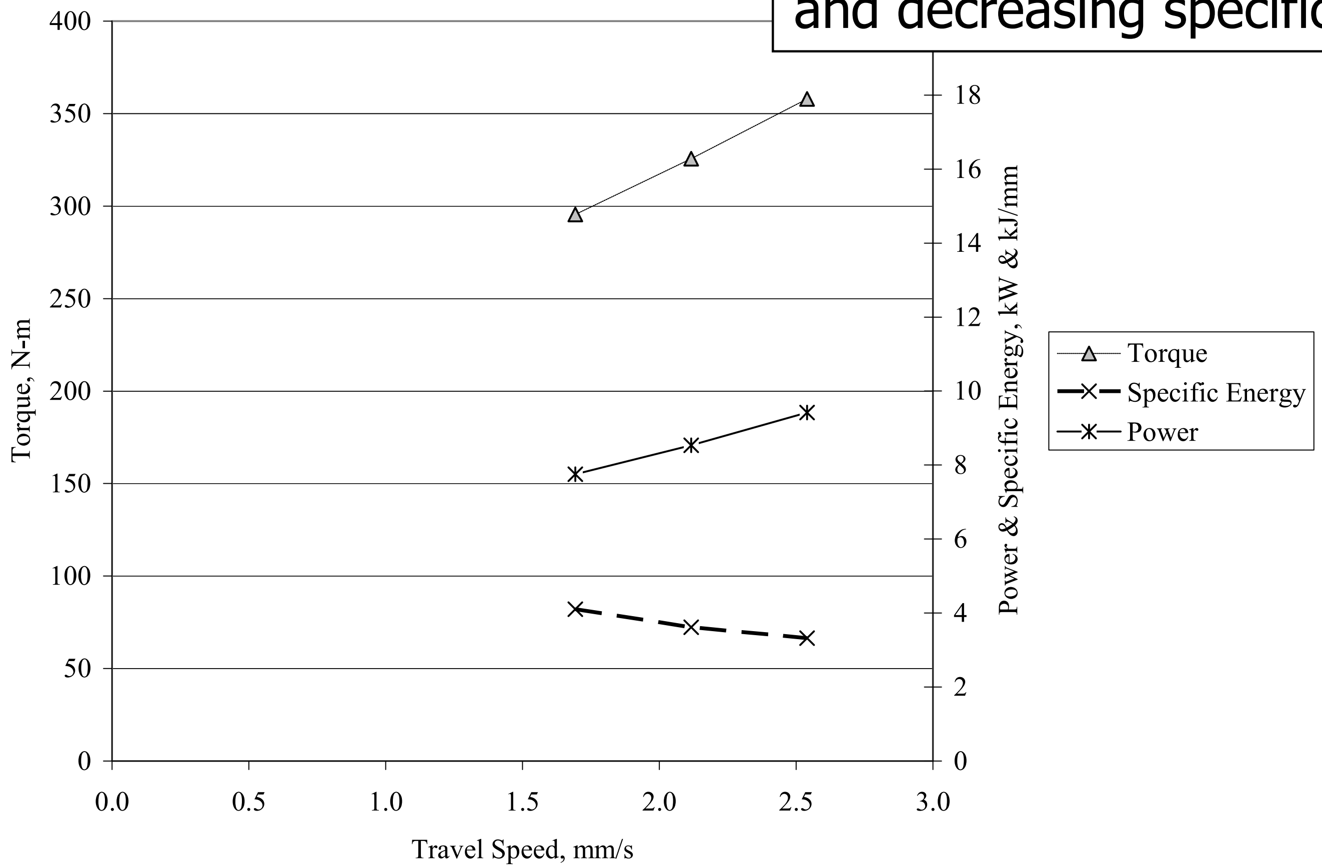
Case Study 1 – Effect of Increasing Travel Speed

- From Xu, ASM 2003

Increasing travel speed led to increasing torque and power, and decreasing specific energy.



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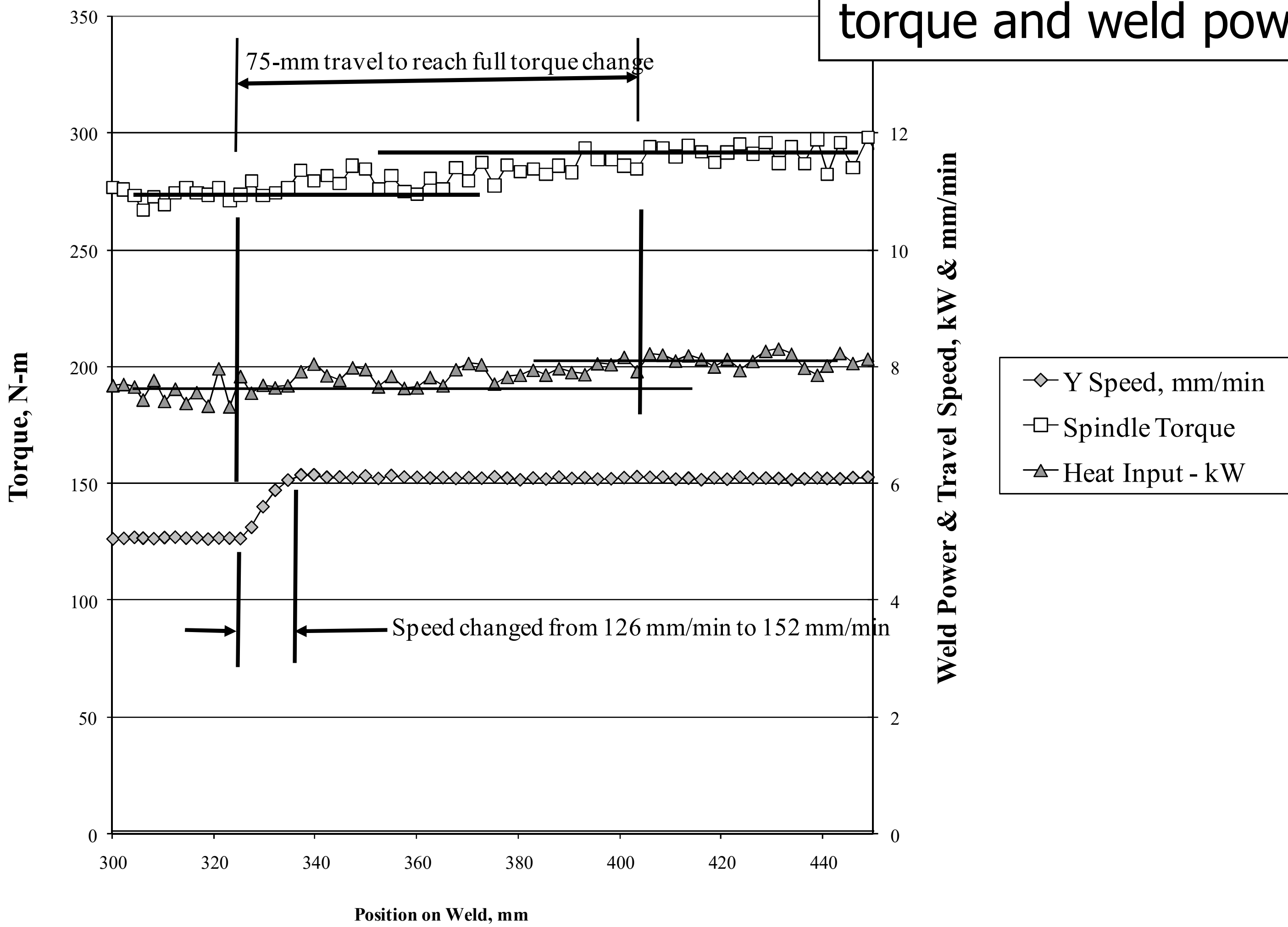
Case Study 1 – Effect of Increasing Travel Speed

- Unpublished, Colligan

Increasing travel speed led to a gradual increase in spindle torque and weld power.



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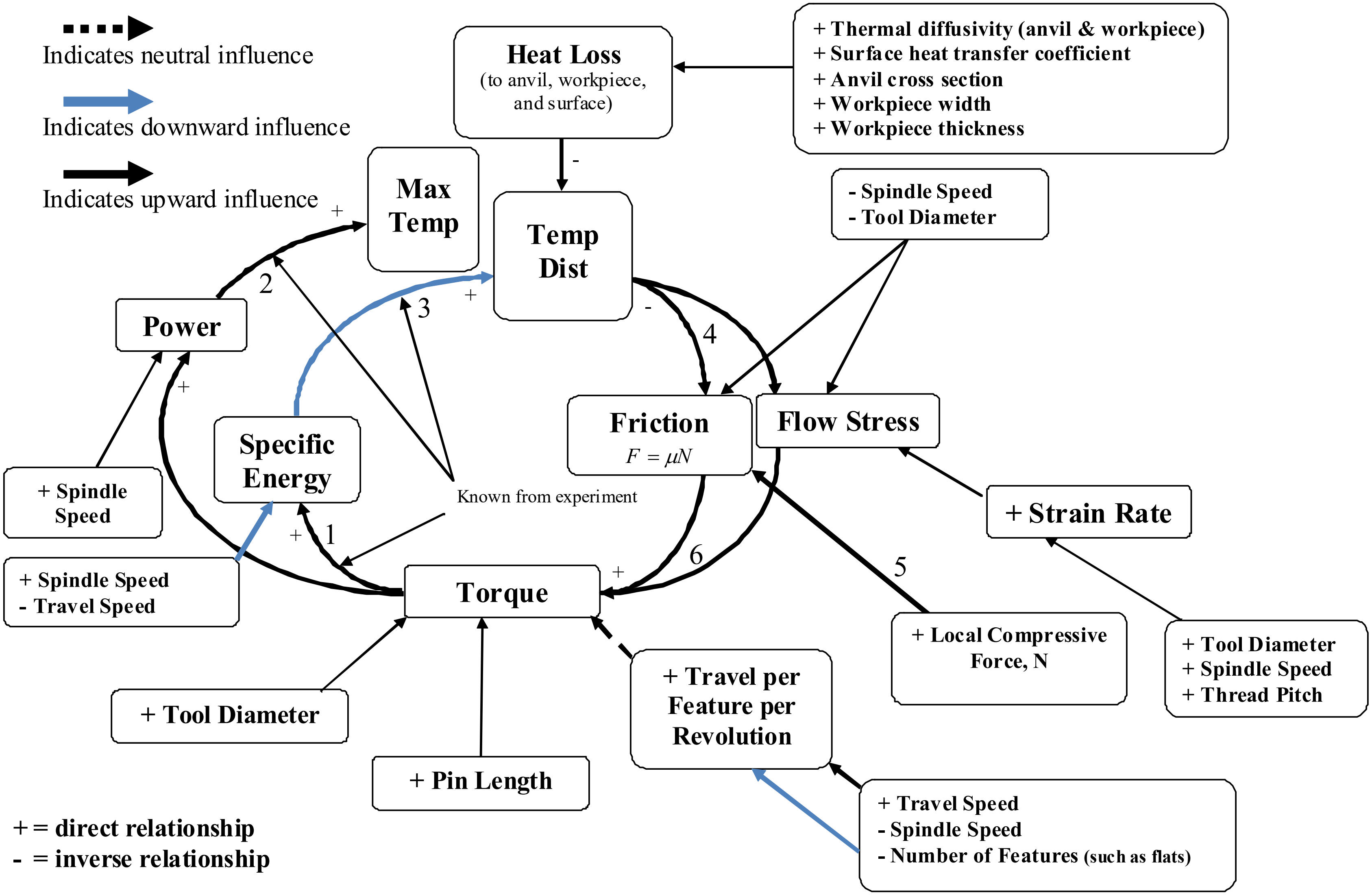
Case Study 1 – Effect of Increasing Travel Speed



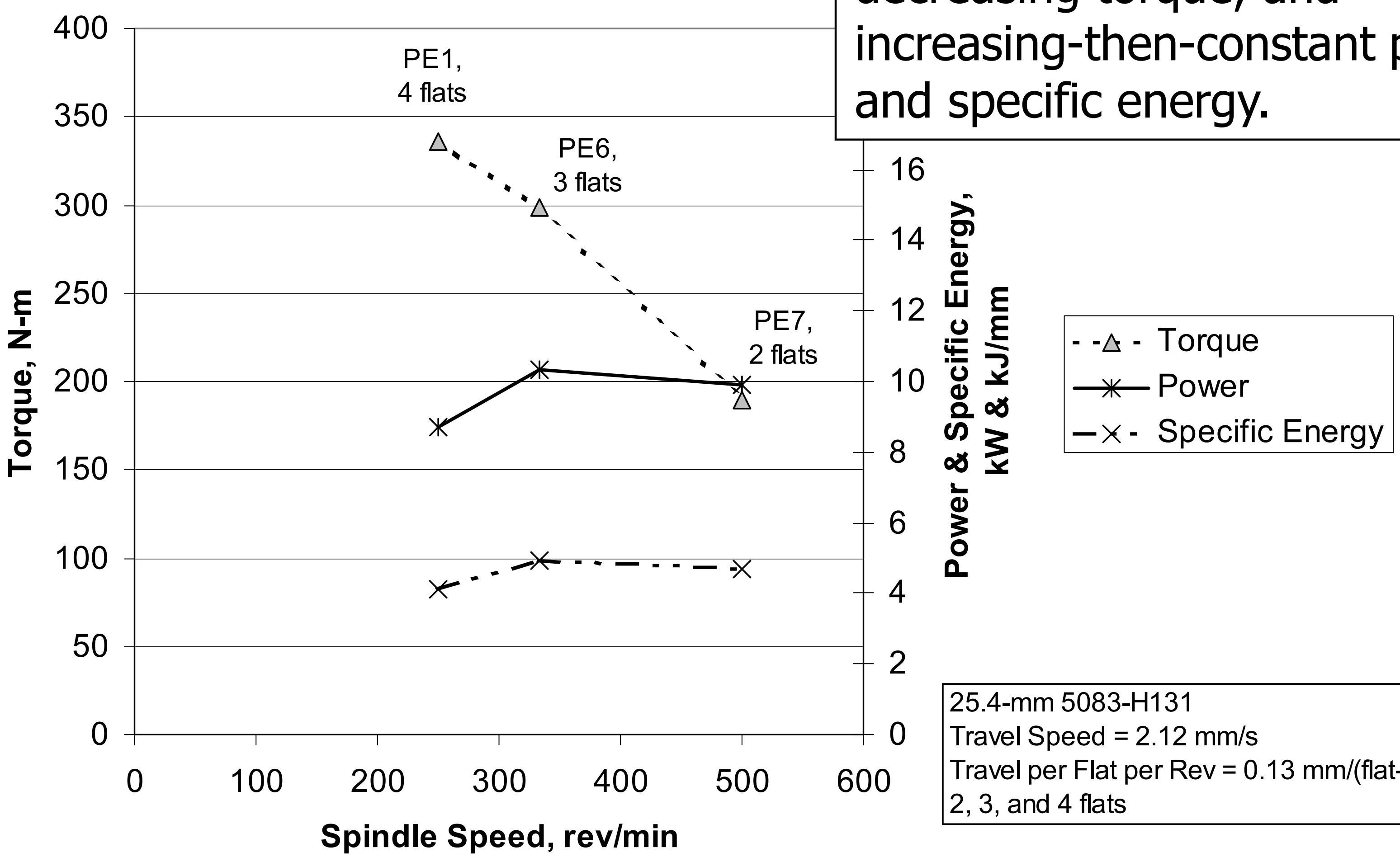
\+ = direct relationship

\- = inverse relationship

Case Study 2 – Effect of Increasing Spindle Speed

- From Colligan, TMS 2003

Increasing spindle speed led to decreasing torque, and increasing-then-constant power and specific energy.

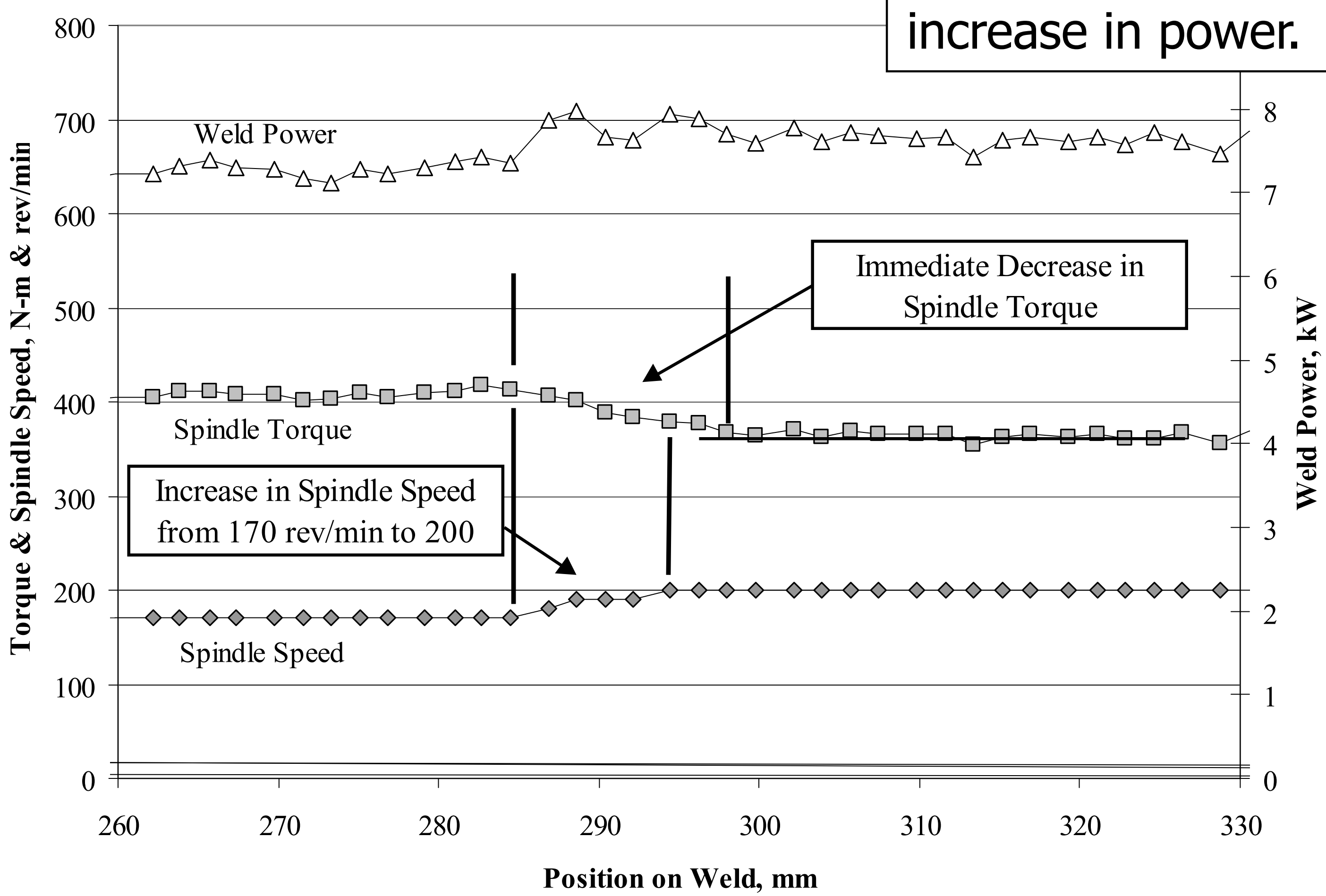


25.4-mm 5083-H131
Travel Speed = 2.12 mm/s
Travel per Flat per Rev = 0.13 mm/(flat-rev)
2, 3, and 4 flats

Case Study 2 – Effect of Increasing Spindle Speed

- Unpublished, Colligan

Increasing spindle speed led to immediate decrease in torque, and limited increase in power.



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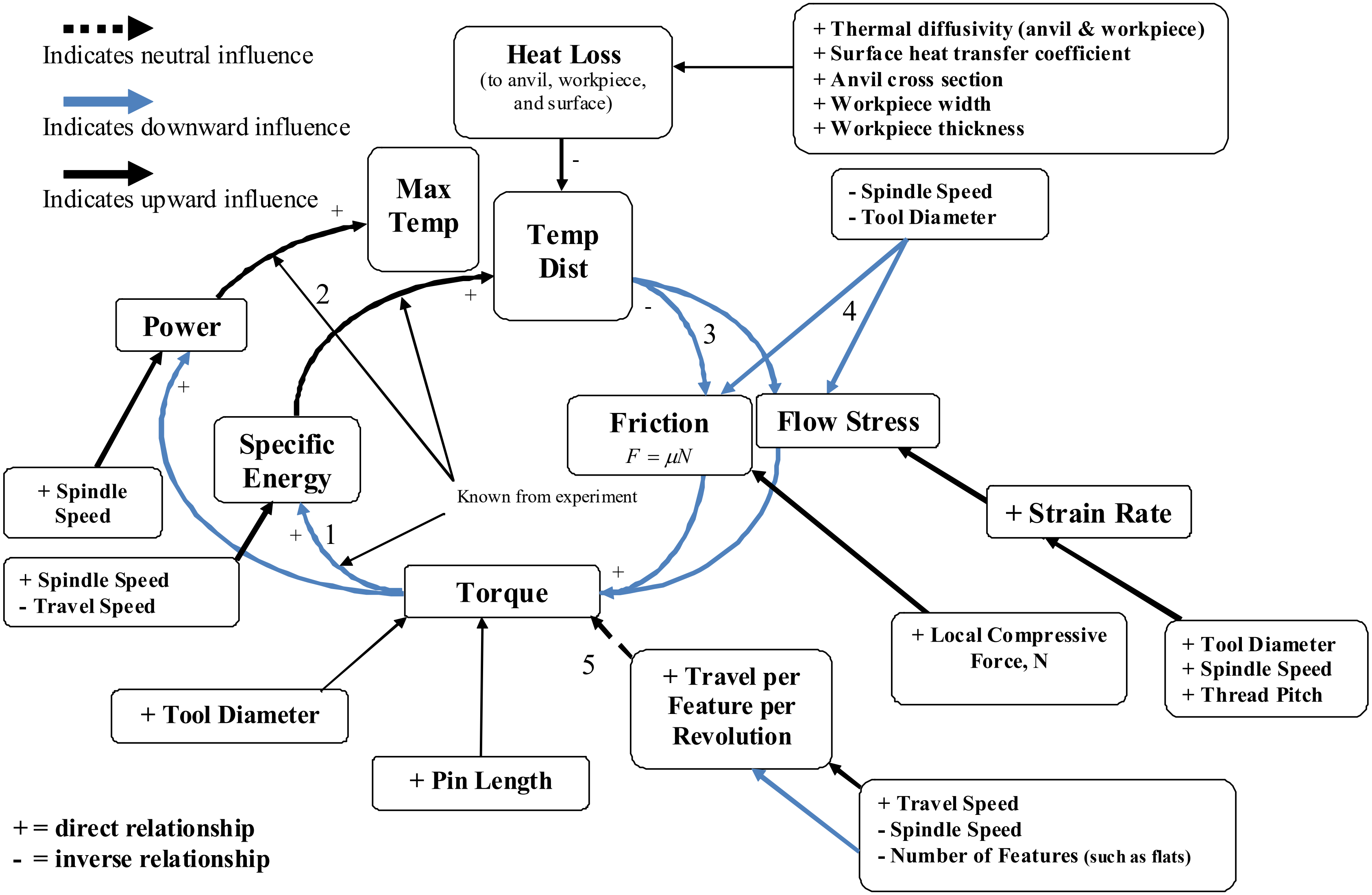
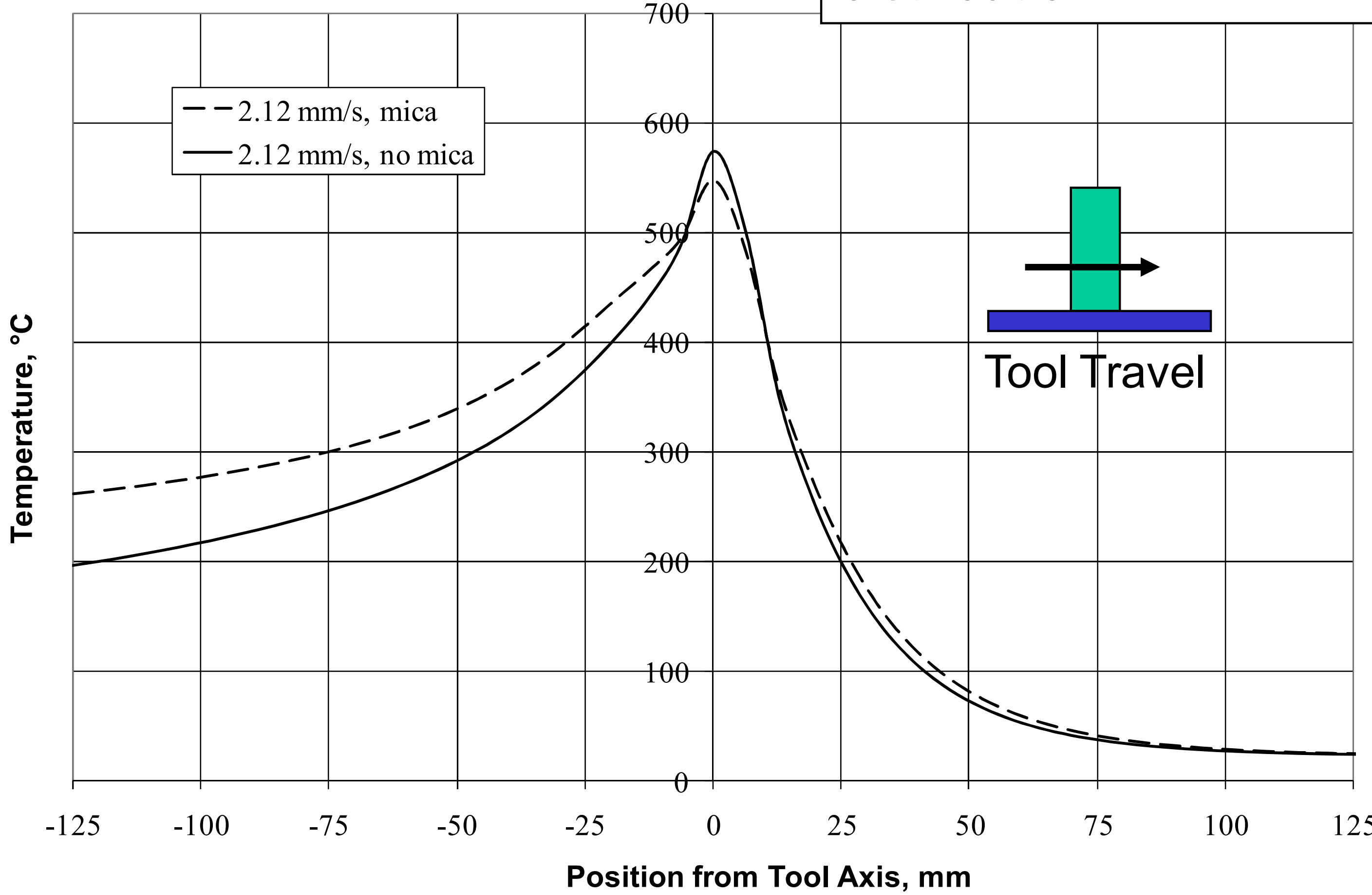
Case Study 2 – Effect of Increasing Spindle Speed



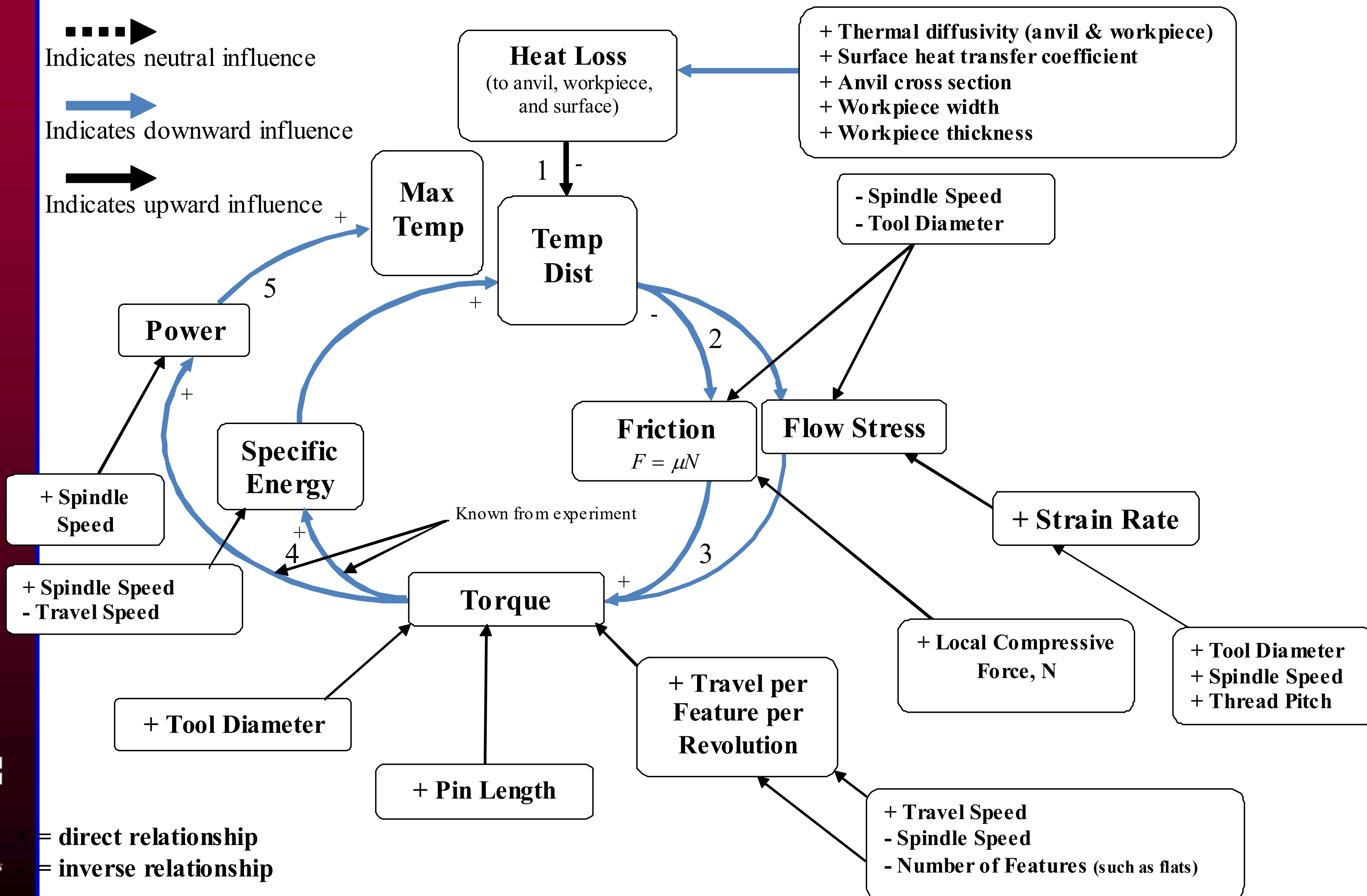
Case Study 3 – Effect of Anvil Conditions

- From Xu, ASM 2003

Adding an insulating layer of mica to the anvil decreased the peak temperature but increased the temperature distribution.



Case Study 3 – Effect of Adding Anvil Insulation



Conclusions

- Conceptual model proposed relates key process and material variables through the interaction of physical effects
- The model was confirmed using data from three case studies
- Potential future work –
  - examination of other case studies (other materials?),
  - assignment of weights to interactions,
  - development of similar model addressing forces.