Predicting Diesel Particulate Filter Performance

DCL R&D Progress Report

Adhoc/Deep Conference 1997

Introduction

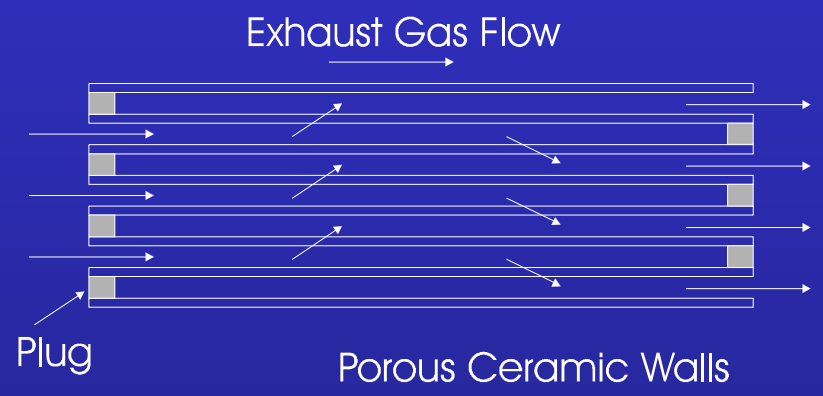
- Diesel Particulate Filter
  - Effective for Reduction of DPM
  - Requires Careful Study of Each Application
- Computer Model
  - Effective Tool for Predicting DPF Performance

Outline

- Physical Description
- Operational Description
- Model Concept
- Results

Description

- Ceramic Matrix
  - SiC or Corderite
- Alternately Blocked Channels
- Wall Flow Device



History

- Excellent Filtration Efficiency
- Application Sensitive
- Inconsistent Field Experiences

History

- Excellent Filtration Efficiency
- Application Sensitivity
- Inconsistent Field Experiences
- Requirement: Accurate Identification of Possible Applications
- Requirement: Accurate Selection of DPF

Filter Operation

- Direct Interception & Brownian Diffusion Filtration Mechanisms
- Conditional Combustion of Soot (Regeneration)

Modes of Operation

- Accumulation
- Regeneration

Regeneration

- Regeneration: Combustion of Soot
- Regeneration Limit: Combustion Decreases Trapped Mass of Soot
- Regeneration Event: Rapid Combustion Significantly Reduces Amount of Soot in Filter
- Problem: Predict Regeneration

Possible Decision Making Tools

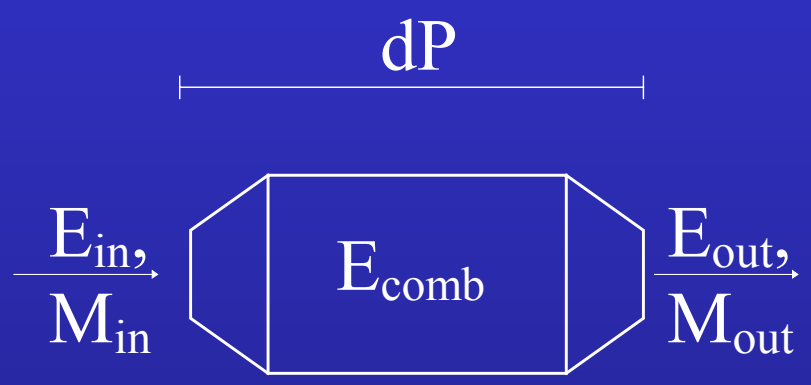
- Arbitrary Sizing Rule
- Threshold Temperature Rule
- Engine-Dynamometer Simulation
- Computer Modeling

Model Goals

- Improved Accuracy
- Extended Range of Applications
- Inexpensive Operation
- Comparison of Different Technologies

Model Description

- Zero or One Dimensional
- Heat Transfer
- Reaction Rate
- Pressure Loss



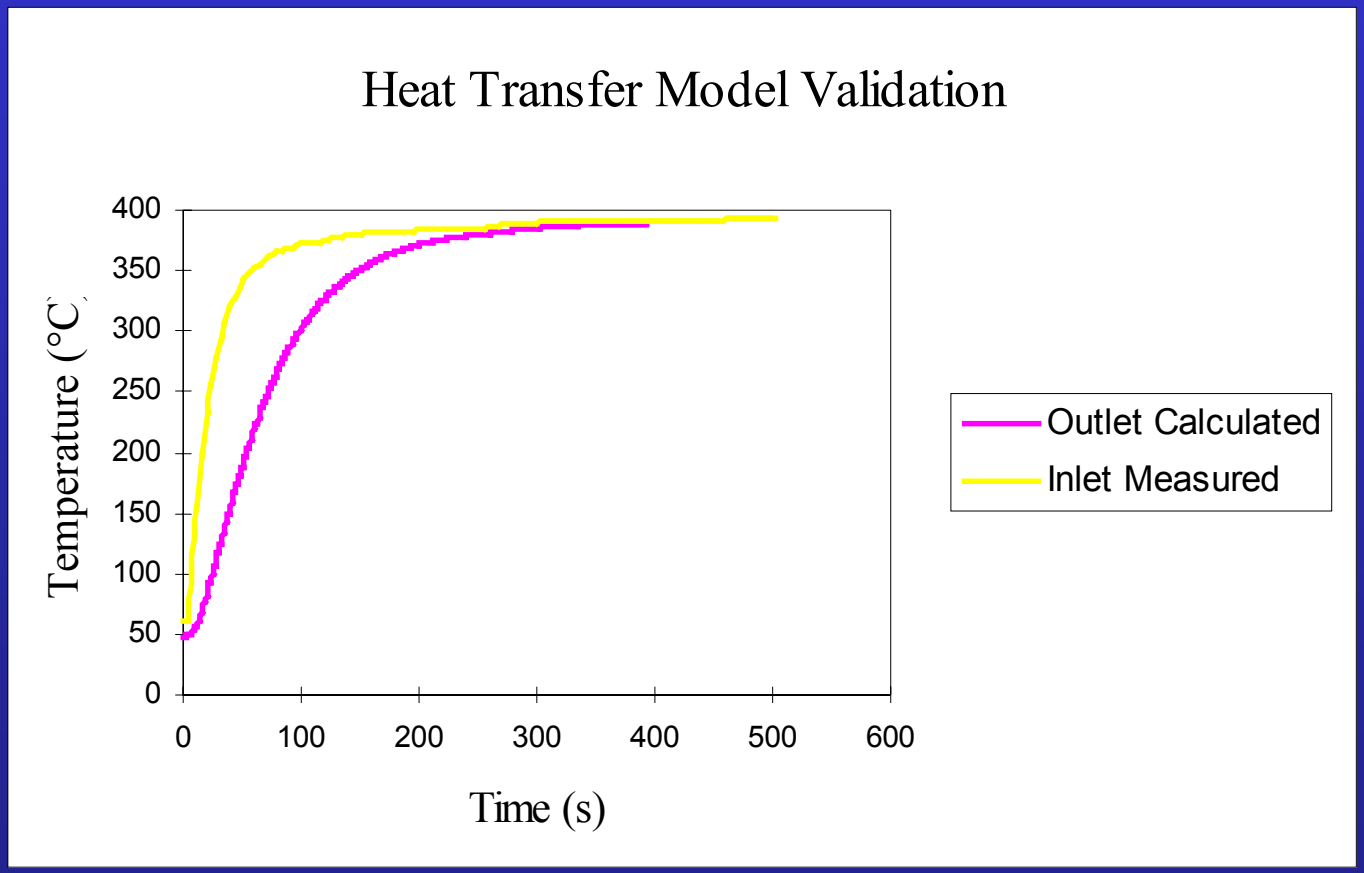
Model Inputs

- Exhaust Flow Rate
- DPM Concentration
- Oxygen Concentration
- Filter Characteristics

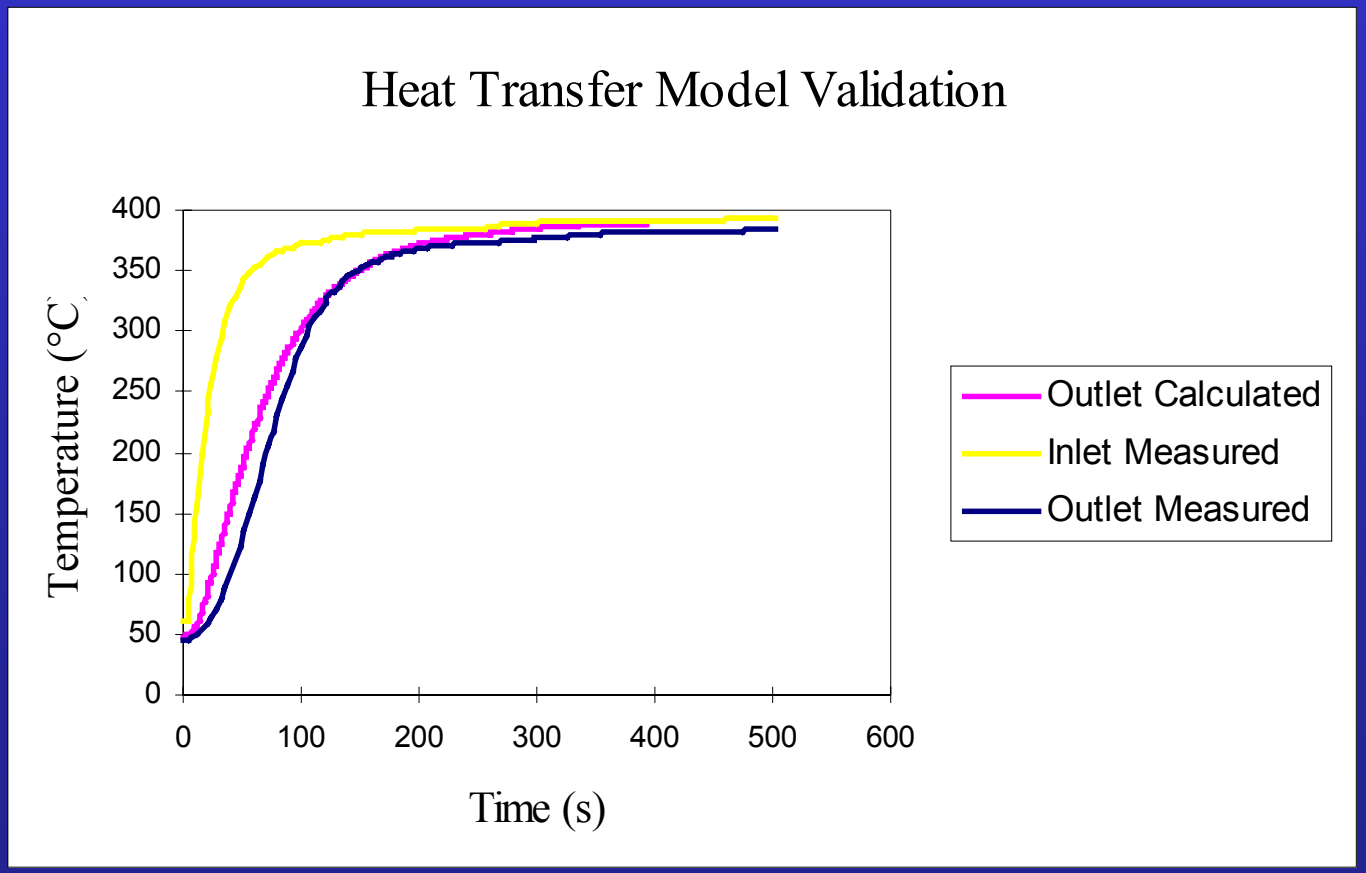
Model Outputs

- Filter Temperature
- Stored Mass of DPM
- Filter Pressure

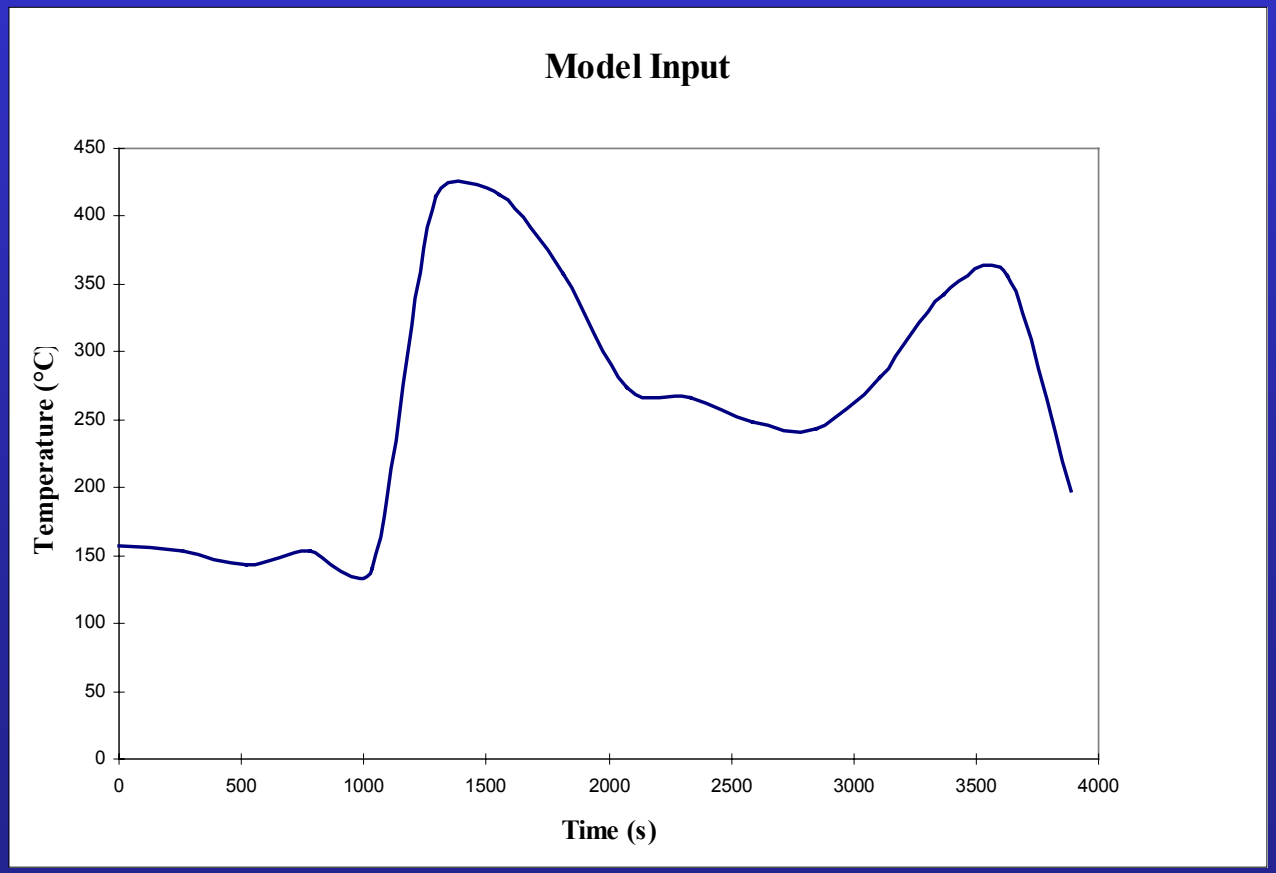
Model Validation



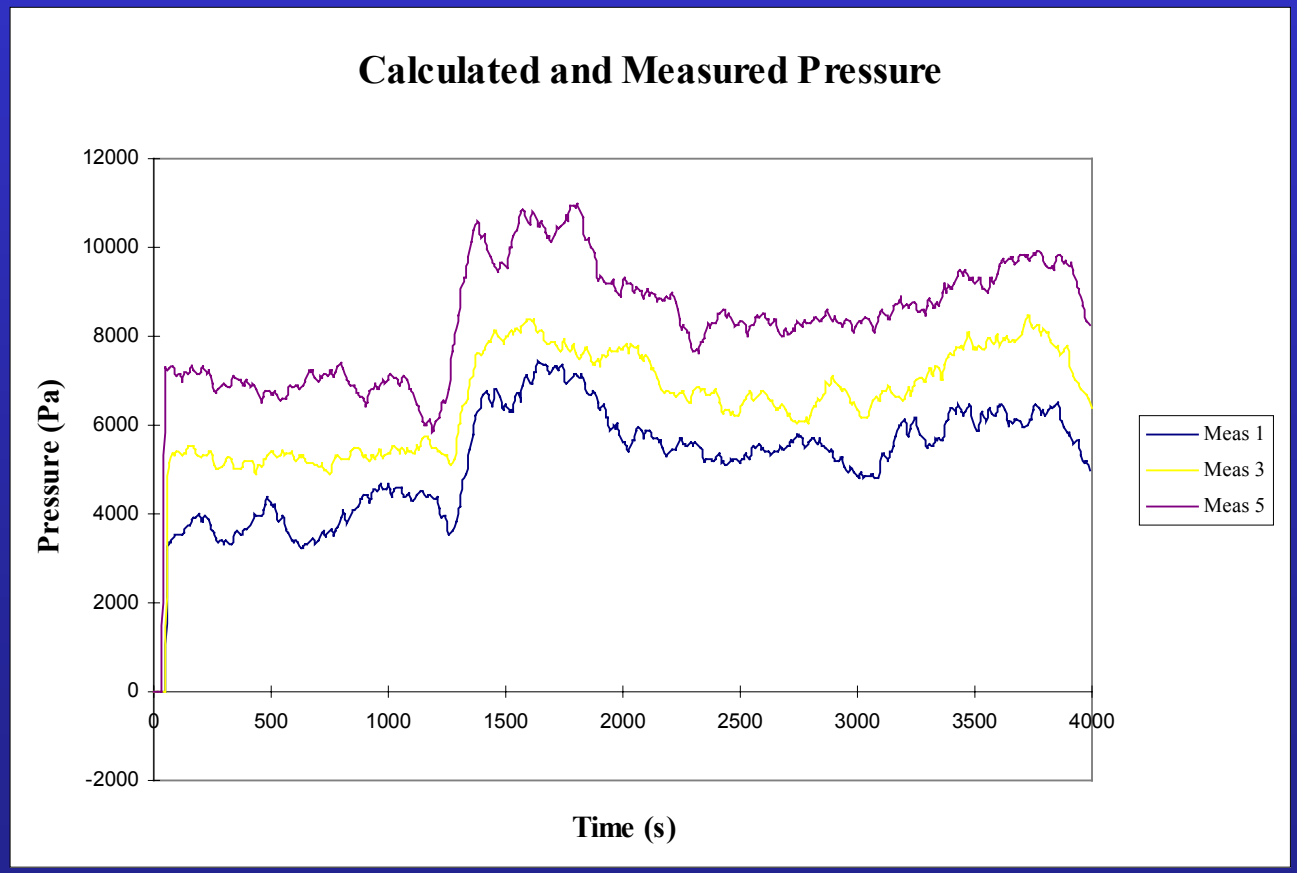
Model Validation



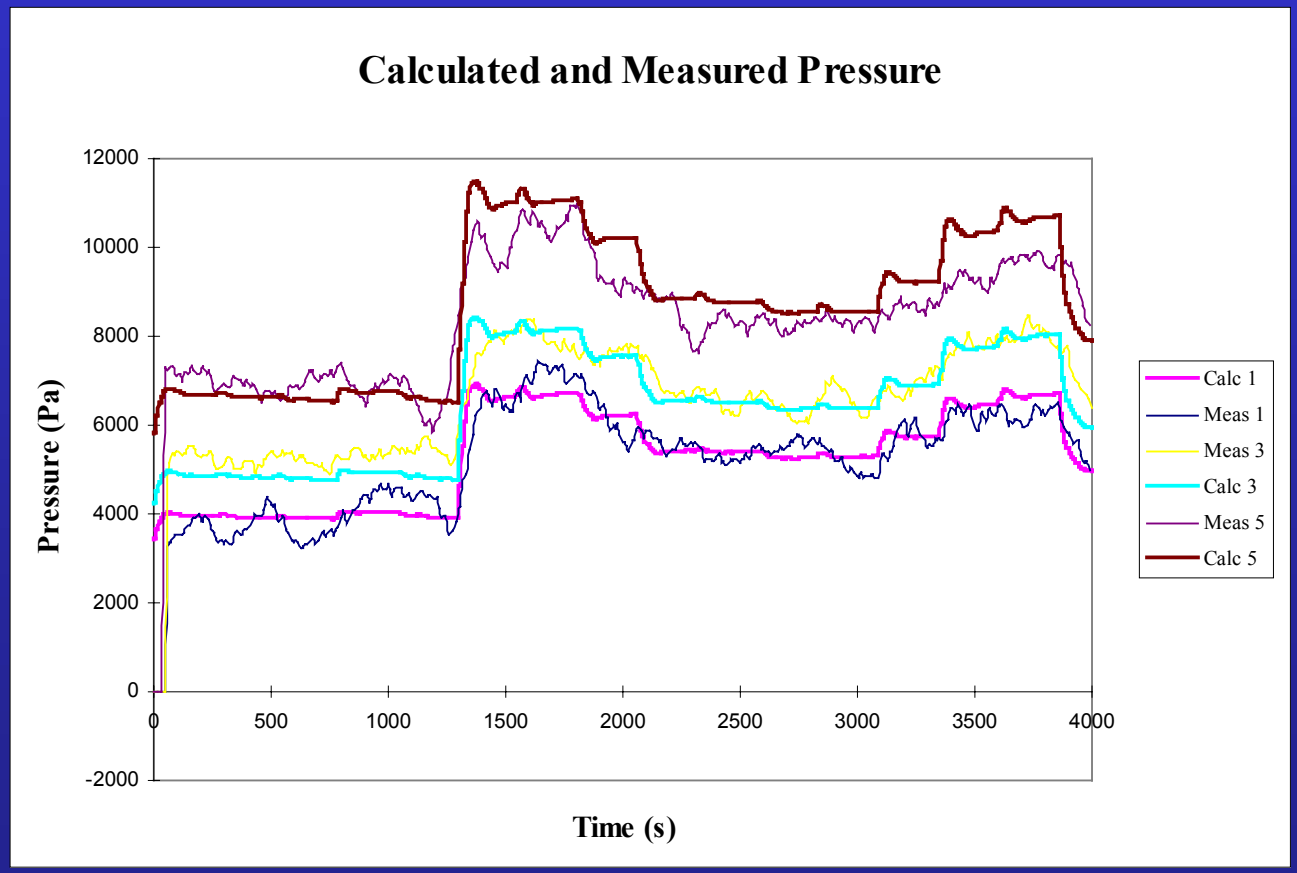
Model Input


Model Input
Temperature (°C)
450
400
350
300
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
3500
4000
Time (s)

Results


Calculated and Measured Pressure
Pressure (Pa)
12000
10000
8000
6000
4000
2000
0
-2000
0
500
1000
1500
2000
2500
3000
3500
4000
Time (s)
Meas 1
Meas 3
Meas 5

Results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2500
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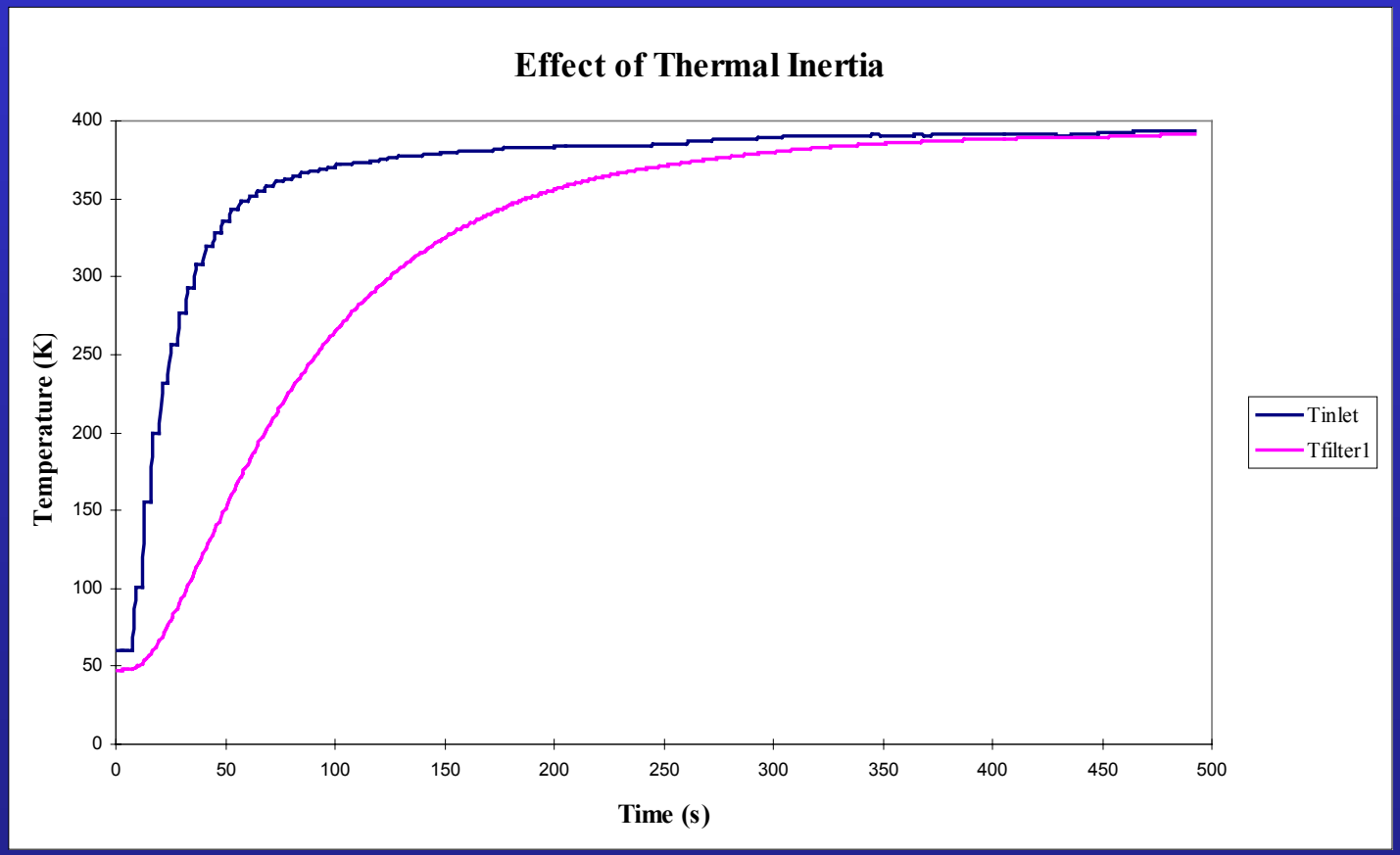
3500
4000
Time (s)
Calc 1
Meas 1
Meas 3
Calc 3
Meas 5
Calc 5

Effect of Thermal Inertia



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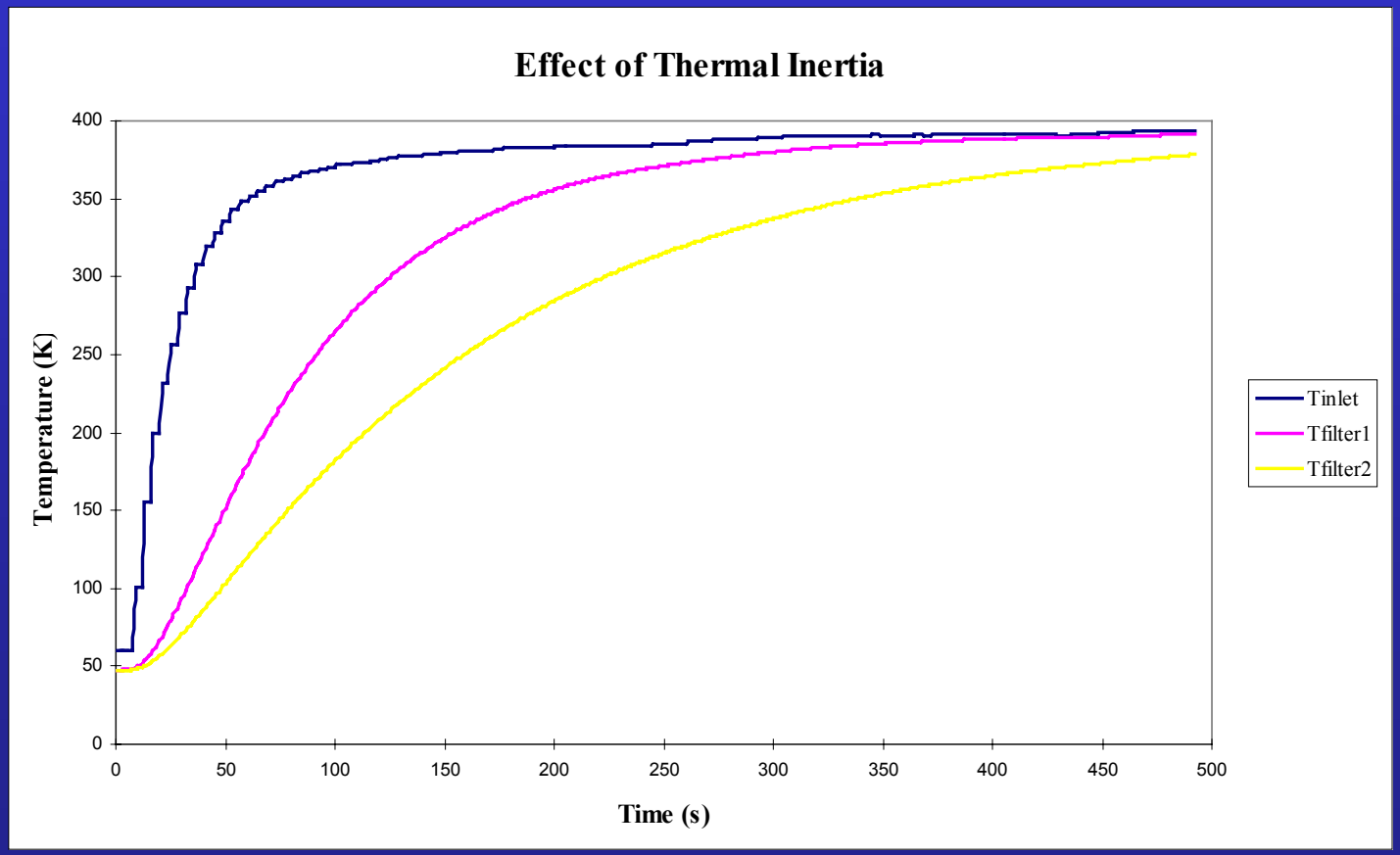

Summary

- Identification of Suitable Applications
- Prediction of Filter Performance
- Comparison of Different Technologies
- Improved Understanding of Filter Operation

Conclusions

- Improved Reliability of Products
- Increased Range of Applications for Products
- Accurate Selection of Appropriate Technology