Understand the Power of CoTherm: How to Solve Complex Transients by Coupling Thermal & CFD Codes

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Background

• Last month’s webinar introduced the benefits of using TAITherm and CFD and demonstrated steady-state coupling
  • [https://support.thermoanalytics.com](https://support.thermoanalytics.com)
    • Webinars > “Shorter Run Times, Better Simulations: Leveraging the Strengths of TAITherm and CFD”

• These tools can also be leveraged to simulate complex transient scenarios
  • CoTherm automation software will be the basis for coupled simulation
  • Automotive underhood hot shutdown scenario will be demonstrated
Problem Statement

• Hot shutdowns / key-offs are a challenging condition for underhood/underbody thermal management
  • Typical scenario: high engine load driving phase followed by a brief idle and vehicle shut-down
  • Less air movement available to dissipate thermal mass and internal residual heat
  • Can result in temperatures higher than steady-state

• Example hot-shutdown (high-performance sedan):
  • Initial condition: Steady-state uphill driving at 50 kph
  • Idle phase: 90s with vehicle stopped and cooling fan active
  • Soak phase: 18.5 minutes with engine and cooling fan off
Model Setup: Driving Phase

- CFD Model Setup
  - Ambient velocity 50 kph
  - Fan modeled with MRF (multiple reference frame) model at 2500 RPM
  - Heat exchangers modeled with dual-stream method

- Thermal Model Setup
  - Exhaust heat source modeled with exhaust stream method
    - Mass flow 0.18 kg/s
    - Inlet temp 750° C
    - 2 turbo and 2 catalyst components with calculated heat rates
Model Setup: Idle Phase

• CFD Model Setup
  • Ambient velocity 3 kph (low-speed wind)
  • Fan modeled with MRF (multiple reference frame) model at 1000 RPM
  • Heat exchangers modeled with dual-stream method

• Thermal Model Setup
  • Exhaust heat source modeled with exhaust stream method
    • Mass flow 0.06 kg/s
    • Inlet temp 600° C @ 10s / 350° C @ 90s
    • 2 turbo and 2 catalyst components with calculated heat rates
Model Setup: Soak Phase

- CFD Model Setup
  - Ambient velocity 3 kph (low-speed wind)
  - Fan turned off
  - Heat exchangers turned off

- Thermal Model Setup
  - Exhaust stream effectively turned off
Pseudo-transient coupling method

- Pseudo-transient coupling is a method for coupling between:
  - Fully transient TAITherm model
  - Multiple steady-state CFD models ("Snapshots" at different points in time)
- Number of CFD points coupled is arbitrary
- Fully supported in CoTherm
CoTherm Process Setup

• Pseudo-transient thermal-CFD coupling document
  • Supported with standard examples for Fluent and STAR-CCM+ CFD models
• Process iterates over standard thermal-CFD coupling sub-process
• Key input is table of steady CFD models and corresponding times during transient scenario
Driving Phase Results: CFD Temperatures
Driving Phase Results: CFD Velocities
Soak Results: Exterior Boundary Conditions

Heat Transfer Coefficients (W/m²-K)

Fluid Temperatures (°C)
Soak Results: Underbody Boundary Conditions

Heat Transfer Coefficients (W/m²-K)  Fluid Temperatures (°C)
Soak Results: Surface Temperatures
Soak Results: Surface Temperatures
Soak Results: Surface Temperatures
Soak Results: Surface Temperatures
Component-Level Temperature Predictions
Additional Post Processing Possibilities

• Design temperatures
  • Part status: exceeding, near limit, or within limit

• Relations mode
  • Determine contributing heat sources

• Results export
Conclusions

• CoTherm can be used to help simulate complex transient scenarios
• Peak component temperatures can be predicted under soak conditions
• The pseudo-transient coupling method is a good tradeoff between accuracy and run time for many automotive scenarios, such as idles and soaks
Where do we go from here?

• More complex transient scenarios may require more advanced methods
• Complex scenarios may be too computationally expensive to run with a standard pseudo-transient coupling process
• Join us next time for our webinar on modeling Drive Cycles
ThermoAnalytics

USER GROUP MEETING

April 30 – May 1, 2019 | Novi, Michigan

Join us & learn from some of the top leaders in thermal management!

www.thermoanalytics.com/ugm2019
Questions?

Thanks for your attention!