Advanced Thermal Control Consortium
March 2014

Technology trends

- Smart systems will be where the value is delivered
  - Modern mechatronics systems increasingly complex
  - Correct system architectures critical to performance and manufacturability
    - Hierarchical system decomposition (system x where x is increasing)
    - Ability to identify critical feedback parameters (or metrics) flowing to and from different sub-systems
  - Increasing complexity of systems paired with increasing reliability requirements - well structured, verifiable or automatically generated software

ATC Project Overview

- Industrial research on the field of advanced thermal control of high precision systems
  - Advance the theoretical and applied approaches to design, simulation, measurement and compensation techniques

Research Programme

- Thermal Design & Optimisation
  - Transients more important for precision systems than steady-state effects
  - Metrology calibration at relatively high frequencies
  - Reduced sensitivity to slow temperature variations
  - Relatively high sensitivity for high-frequency variations

Research Programme

- Structural dynamics design rules: maximal stiffness and high first eigenfrequency
  - Useful guidelines
  - More advanced and automated design & analysis tools developed

Research Programme

- Mechanical modeling tools
  - Thermo-mechanical modeling tools
Thermal Design & Optimisation

Design Freedom
- New modeling & simulation approaches
- Metrology for manufacturing

Equipment Optimisation
- Resolution & speed
- Process control
- Dynamics
- Structural integrity
- Surfaces
- Multi-material
- Nanomaterials

Materials

AM Challenges & Opportunities

Thermal Design & Optimisation
- Next generation topology optimisation tools
- Starting point developments on so-called ‘augmented adjoint sensitivities’
  - thermal modal basis used to speed up thermal transient optimization
- Improvements:
  - Mode selection
  - Integration of feedback-control

Additive manufacturing allows increased design freedom in geometric design – new ways for improved thermal design.

Research Program
- Advanced Identification & Control for Thermal Systems
  - “Overlay” error in photolith of order one nanometer
  - Thermal control next generation printheads increasingly difficult problem.
  - Advanced servo (or position) control of high-accuracy electro-mechanical devices long-standing and well developed competence

- Overlay/relative alignment not only determined by structural dynamics of mechanical physics and its position control, but dynamics of thermal physics and its control

Research Program
- Focus on advanced methods for:
  - experimental modelling (i.e. identification)
  - feedback control for thermal problems

- Advanced servo position control can be reused and tailor-made to advanced thermal modelling and control
  - differences in time scales and spectral contents of the disturbances
  - Experimental modelling of the plant P
  - Feedback and feedforward control design

- Advanced inferential control

Research Program
- Next Generation Model Reduction
  - Create compact models that allow for fast and accurate simulations (time & frequency domains)
  - Suitable for controller design
  - Strategies for model reduction of complex systems
  - Coupling approaches
  - Address non-linear effects & parametric reduction

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Overview

- Design rules & optimisation tools for module designer
  - Optimisation for systems under feedback control.
- Advanced methods for experimental modelling (i.e. identification) and feedback control for thermal problems.
- Model reduction including next generation techniques for complex systems.
  - Multivariable feedback control for thermal applications. Controller design methods.
  - Systematic and effective tools for observer design.
  - Thermal management of optical systems.

Industrial Partners

- Core Work Programme
  - (Academic Partners, Research Area Leaders + PM)
- Tier 1 Partners
- Tier 2 Partners
- Satellite Network

Advanced Thermal Control Consortium

- Steering Committee
  - (2 off Tier 1 partner reps, 1 off Tier 2 partner reps. Chair – Tier 1)
- Project Manager
- Executive Board (Chaired by PM)

Satellite Network

- Body of international expertise and interest in the field
  - Insight on developments within the generic research of the consortium.
  - Annual workshop attendance (incl. invitation to present).
  - Copy of annual report and cleared publications.
  - Preferred supplier status in regard to the project research activities.
  - Inclusion and access re any roadmapping activities.

Forum for sharing industry perspectives and academic developments.

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