
# David Stewart

Physics-Grounded Machine Learning DPhil Candidate

Rolls-Royce/ESPRC Funded Student

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## Research Portfolio: https://davidstewart.uk

I build physics-grounded **machine learning** models that turn expensive, high-fidelity CFD simulations into fast, deployable surrogates. I'm a final-year **DPhil** student at the Oxford Thermofluids Institute, **University of Oxford**, sponsored by **Rolls-Royce**. I own a full **surrogate-based optimisation pipeline** built on experimentally validated CFD: generating proprietary experimental ground-truth data, validating RANS CFD models (ANSYS Fluent) against it, then training **Gaussian Process surrogates** from a design-of-experiments campaign and running **Bayesian Optimisation and NSGA-II** searches over them. This pipeline identified a **novel heat exchanger geometry** predicted to **outperform** current **commercial** designs by over **200%** (**patent** application **planned**). Published at AIAA AVIATION (Journal under review) and preparing papers for ASME Turbo Expo and Journal of Turbomachinery.

## Technical and Core Skills

- ***Machine Learning & Optimisation* - Bayesian Optimisation** (Expected Improvement acquisition) and **NSGA-II** multi-objective search over **Gaussian Process surrogate models**, built from an adaptively-sampled design of experiments (**DoE**) campaign.
- ***CFD & Simulation* -** Extensive experience running **ANSYS Fluent** for multi-physics CFD, including **turbulence** modelling and **conjugate heat transfer** studies; RANS models validated against experimental ground-truth data. **ANSYS Workbench** for automated DoE campaigns.
- ***Data Pipeline & Programming* - MATLAB** (**Statistics & Machine Learning Toolbox**, Global Optimization Toolbox) for the full **surrogate**/**optimisation pipeline** - Gaussian Process regression, Latin Hypercube DoE sampling, NSGA-II Pareto search, and a custom **Sobol sensitivity**/**bootstrap uncertainty quantification** implementation; built staged data pipelines converting raw rig and CFD outputs into analysis-ready datasets. Currently porting the MATLAB optimisation pipeline to the Python ecosystem (**GPyTorch**, **BoTorch**).
- ***Experimental Ground-Truth Generation* -** Designed, commissioned, and operated a bespoke wind tunnel and instrumentation suite to **generate** the proprietary **high-fidelity datasets** - **real experimental ground truth** most ML candidates never get to generate themselves.

## Education & Qualifications

**DPhil (PhD) in Aerothermal Engineering –** *Worcester College, University of Oxford [2022-2027]*

- ***Thesis*** - Investigation of Surface Heat Exchangers for Jet Engines *[Feb 2027]*
- ***Industry Collaboration* –** My DPhil is sponsored by Rolls-Royce with the aim to create industrially applied thermal solutions for the next generation of jet engines (LH2 & UltraFan).
- ***Research Overview*** - Defined the thermal architecture for a liquid-hydrogen jet engine from developed thermodynamic cycle models. A novel heat exchanger was innovated and optimised using the surrogate-based pipeline for potential industrial application.
- ***Key Contributions*** – Identified a novel heat exchanger geometry (patent application planned) predicted to outperform the commercial state-of-the-art by over 200%.

- ***Publications*** - D. A. Stewart, J. D. Coull, P. Ireland, "The Effect of Turbofan-Representative Distortion on Surface Heat Exchanger Performance," AIAA 2026-4433, AIAA AVIATION Forum 2026; under review for *AIAA* ***Journal*** *of* ***Thermophysics*** *and* ***Heat Transfer***. Further papers in preparation for ASME Turbo Expo 2027 and **Journal** of **Turbomachinery**. I am presently a **reviewer for** *AIAA* ***Journal*** *of* ***Thermophysics*** *and* ***Heat Transfer***.

## Research Studies during DPhil

**Surrogate Model Based Heat Exchanger Optimisation (via Rig-Validated CFD)**

- **Requirement:** optimise novel heat exchanger geometry across a large design space to maximise its aerothermal performance through experimentally validated RANS CFD.
- **Method:** built Gaussian Process (machine learning) surrogate models via Bayesian Optimisation (Expected Improvement) in an adaptively sampled design of experiments campaign (ANSYS Workbench); ran NSGA-II multi-objective and Pareto front searches.
- **Outcome: cut** evaluation time **hours** to **milliseconds**; identified a **novel geometry** (patent in planning) predicted to **outperform commercial designs** by **over 200%;** results in preparation for ASME Turbo Expo 2027 and **Journal of Turbomachinery.**

**Heat Exchanger Experimental Testing & CFD Validation**

- **Requirement:** quantify the effect of inlet distortion on surface heat exchanger performance and validate a predictive RANS CFD model for design exploration.
- **Method:** ran an aerothermal experimental campaign and validated RANS CFD models.
- **Outcome:** generated a proprietary high-fidelity experimental dataset allowing identification of aerothermal mechanisms - results presented at *AIAA* AVIATION 2026, paper **under review** for ***AIAA*** **Journal of Thermophysics and Heat Transfer.**

**Thermal Management for Liquid Hydrogen Jet Engine**

- **Requirement:** define a thermal management architecture for a liquid hydrogen jet engine, sizing heat exchangers against a full-flight-envelope cycle model.
- **Method:** built low-order sizing models from established correlations; selected an intermediate-nitrogen-loop architecture over direct hydrogen recuperation.
- **Outcome:** delivered the **architecture** and **conceptual novel HX geometry** underpinning every later stage of the programme.

**Wind Tunnel Development**

- **Project Overview:** Led major modifications to an existing annular wind tunnel, delivering the proprietary **data-generation pipeline** underpinning all downstream **CFD validation** and **surrogate optimisation** work.

**Thermal Management for Steam-Injected Turbofan Concept**

- **Project Overview:** Consulted for Rolls-Royce and Cambridge University, designing three novel heat exchangers from thermodynamic cycle models. The resulting high-efficiency geometries were a **contributing factor** behind **Cambridge's successful £100k research grant**.

## Personal and Social

Member of University of Oxford's Cricket, Hockey, and Snowsports societies. Keen golfer, mountain biker, and runner. Independently designs and delivers engineering workshops for STEM students.