Split Cycle Combustion Engines

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Research Overview

- Traditional internal combustion engines generate high levels of CO_2 and NOx emissions, exacerbating climate change and failing to meet stringent global regulations like Euro 7 standards.
- With the automotive sector under pressure to transition to sustainable propulsion, innovative designs are essential to reduce environmental impact while preserving performance and economic viability for manufacturers.
- Through my Engineering Doctorate research, we developed and simulated a combustion-lead split-cycle engine topology that achieves up to 90% emission reductions and 15-20% efficiency gains, paving the way for zero-emission viable engines.

Industry Relevance

- Advanced engine designs for passenger vehicles, commercial trucks, and hybrid systems; integration into electric vehicle auxiliaries for thermal management.
- Significant cost savings through reduced fuel consumption (up to 20% efficiency boost); enhanced sustainability by minimizing emissions and enabling compliance with net-zero targets; improved manufacturing scalability via simulation-driven prototyping.
- Addresses key automotive priorities like decarbonization (aligned with UK Industrial Strategy and EU Green Deal); tackles supply chain disruptions in battery tech by offering internal combustion alternatives

Methods & Technologies

- Ansys CFD and Ricardo 1-D WAVE® Simulations for modelling engine performance comparisons including combustion phasing, heat transfer evaluation and emissions predictions
- Experimental validation through testing, focusing on propulsion system parameters like fuel injection and exhaust gas recirculation using UWE Bristol's Automotive Rolling Road and research Engines testbed facilities
- Support from UWE's Research Governance and Ethics framework, plus high-performance computing (HPC) for more advanced combustion modelling.

Innovations

- Novel combustion-lead design in split-cycle topology decouples engine strokes to prioritize efficient burning, reducing unburnt hydrocarbons by 85-90% – a breakthrough over traditional Otto/Diesel cycles.

Parameter	Conventional Engine	Split-Cycle Design	Improvement
CO_2 Emissions (g/kWh)	200-250	20-50	85-90%
Thermal Efficiency (%)	35-40	50-55	+15%
NOx Emissions (ppm)	500-1000	<100	>80%

Opportunities

- Co-development of prototypes for hybrid/zero-emission engines with automotive/aerospace firms in the region
- Internships and placements for Mechanical/Aerospace Engineering students to support simulation/modelling projects
- Testing collaborations using UWE facilities for validation and scaling
- Contribute to societal impact (e.g., emissions reduction) while accessing talent pipeline from part-time Mechanical Engineering programmes; potential for joint funding via UWE's Business Innovation and Degree Apprenticeships.

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