Project proposal template
Graduate School studentships
March 2015

Project title	Predicting and preventing pre ignition in multi-cylinder spark engines
First Supervisor	Dr — Olga Duran
Second Supervisor	Dr Yahya Zweiri
School	Mechanical and Automotive Engineering
Other member of supervisory team (no more than three KU supervisors in total)	
Specific requirements beyond 2:1 degree	

Project summary

(max 4,000 characters)

i) Problem Statement

Pre-ignition is an anomaly in the combustion process where ignition takes place during the compression stroke, before peak pressure is obtained and prior to the plug generating a spark. Occurrence follows intermittent sequences consisting of multiple cycles with pre-ignition, alternated with regular burning cycles. Major causes of pre-ignition are delays in ignition timing, over-heated spark plug tips, lean fuel mixtures, insufficient cooling, residual gas, low octane, high wall temperature and carbon deposits on cylinder and piston surfaces. Pre-ignition represents a significant problem in current engine technology and has significant effects on engine knocking, power output and piston mechanical stress.

Current approaches to pre-ignition control are limited to detection by means of pressure transducer and knock sensors. Image processing and analysis have also been implemented on a few test engines. However, as the occurrence of pre-ignition is random and with no prior sign, selective detection of the event relative to normal combustion remains a challenge. To the best of our knowledge, there is currently no validated solution addressing prediction and prevention of pre-ignition events.

ii) PhD deliverables

The proposed study shall address the problem of prediction of pre-ignition through the development of an adaptive estimation predictor algorithm and fuel/ignition control systems without requiring hardware modifications. On the basis of this prediction, the system would be able to prevent pre-ignition occurrence by controlling fuel/ignition delivery in real time while lowering emissions, improving engine reliability and output.

Key PhD stages:

- Understand pre-ignition
    - Study pre-ignition in the context of on-board engine sensor measurements and combustion thermodynamics.
    - Statistical analysis of physical data and creation of pre ignition correlation nomographs.
- Expand pre-ignition understanding using computer simulation
- Develop an adaptive estimation algorithm for pre-ignition prediction utilizing physical and simulation data
- Develop fuel and ignition control strategies with pre-ignition preventive ability
- Test, validate and quantify solution and overall prevention efficacy

iii) Solution technical overview

The proposed PhD would aim to establish a pre-ignition knowledge database correlating the phenomenon to a wide range of engine and sensor parameters. Anomaly detection would be based on on-board sensor data in parametric variations, including pressure transducers, temperature sensors, knock sensors and coolant oil temperature sensors. In this context, angular speed of crank shaft, inter-cylinder pressure/temperature and exhaust gas emissions would be examined extensively.

Novel, statistically substantiated knowledge of parameters preceding and affecting pre-ignition will be used to develop an adaptive prediction algorithm using **Fourier-based signal processing techniques combined with pattern recognition, artificial intelligence and Kalman filters**. The predictor would be integrated with current engine design through the development of a variable structure control system. The proposed solution would actively prevent pre-ignition by real-time regulation of fuel supply and ignition. The research study would include extensive development, training and validation of the algorithm and control system under a range of engine and environmental conditions to be agreed with the manufacturer.