DETAILED MODELING OF HOMOGENEOUS CHARGE COMPRESSION IGNITION AND PRE- MIXED CHARGE COMPRESSION IGNITION COMBUSTION AND MULTI-CYLINDER HOMOGENEOUS CHARGE COMPRESSION IGNITION ENGINE CONTROL

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ABSTRACT

This work supports the need to develop a new combustion concept that allows both high efficiency and low emissions for transportation applications. Our work on homogeneous charge compression ignition (HCCI) combustion is a synergistic combination of analysis and experimental work.

On analysis, we have developed advanced methodologies that combine chemical kinetics with fluid mechanics to analyze HCCI engines with accuracy never before achievable for other types of engines. These analysis tools have also been used to guide the experimental effort.

On experimental work we have a multi-cylinder Volkswagen TDI engine that allows us to work on balancing combustion between cylinders. This is a crucial problem with HCCI combustion that has so far precluded commercialization of these engines.

Previously, our analysis capabilities applied only to perfectly homogenized air-fuel mixtures. We have recently extended our methodologies to include mixing between zones. We have used this model to demonstrate that mixing between zones is responsible for most of the production of carbon monoxide in an HCCI engine. In addition to being an important enhancement to our HCCI engine analysis tools, this new model can be used as a framework to analyze engine operating conditions where the charge is not perfectly homogeneous (i.e., PCCI combustion).

We are also developing methodologies for controlling and balancing combustion in a multi-cylinder HCCI engine. We are using an exhaust throttle as a low-cost surrogate for variable valve timing. Our results for using an exhaust throttle in an HCCI engine show some unexpected results. Throttling the exhaust typically advances combustion in a single-cylinder engine, due to the effect of hot combustion gases on HCCI combustion. However, in a multi-cylinder engine, throttling the exhaust of a cylinder *delays* combustion in this cylinder and *advances* combustion in other cylinders. This is due to flow interactions between cylinders, as the exhaust throttle in a cylinder diverts the flow of the fresh charge to the other cylinders. Characterizing these effects is extremely important in obtaining satisfactory combustion in a multi-cylinder HCCI engine.