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**COMPUTATIONAL STUDIES OF SOOT PATHS TO CYLINDER
WALL LAYERS OF A DIRECT INJECTION DIESEL ENGINE**

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The investigation reported in this thesis is concerned with the topic of soot formation and soot particle motion in the cylinder of a light duty automotive diesel engine. CFD has been employed to simulate in-cylinder conditions and to investigate the source of particles which are transferred to the oil. The accumulation of soot in the lubricating oil of diesel engines is one of the factors limiting the interval between oil changes and hence service interval. Soot particles can be transferred to oil film on the cylinder wall layers through the complex motion of the fluid flow in the cylinder. The paths of soot particles from specific in-cylinder locations and crank angle instants have been explored using the results for cylinder charge motion predicted by the Kiva-3v CFD code. Using the velocity fields from the simulation data, massless tracking of the in-cylinder soot particles in space and time is carried out employing a particle tracking with trilinear interpolation technique. From this investigation, new computational codes for the prediction of soot particle paths and soot particle size change along a specific path in a diesel engine have been developed. This investigation is the first numerical study into soot particle trajectories within an engine and thus opens up a novel branch of research of soot formation within internal combustion engines.

Computed soot paths from the investigation show that soot particles formed just below the fuel spray axis inside the middle bowl area during early injection period are more likely sources of soot particles on the cylinder wall layers than those formed later. Soot particles that are formed above the fuel axis have less tendency to be transported to the

cylinder wall layers thus are not likely to be the main source of soot at the cylinder walls. Soot particles that are from the bowl rim area are found to be another source of soot transfer to the boundary layer, as they are directly exposed to reverse squish motion during the expansion stroke. Soot particles that are formed near the cylinder jet axis during fuel injection tend to move into the bowl. These soot particles are found to be from the relatively less concentrated area. In contrast, particles from the most concentrated areas tend to be moving into the bowl and pose least risk of contaminating oil films on the liner.

Sensitivity studies of soot particle paths to swirl show that engine operating with low swirl ratios are more vulnerable to soot in oil problem as low swirls cause the bulk fluid flow to be moving closer to the cylinder walls due to fuel jet velocity and reverse squish motions. Decreasing the spray angle lessens the possibilities of soot particles from being transported close the cylinder wall layers while increasing the spray angle increases the possibilities of soot from the bowl region to be transported close to the cylinder wall layers.

The temporal and spatial evolution of soot particle size can be predicted by using the history of temperature, pressure and gas species along the paths. An explorative investigation has been carried out to determine the most suitable method to tackle this soot particle evolution. With proper multipliers, all approaches perform quite satisfactorily in terms of predicting the trend of size change. Soot particles that are likely to be transferred to the cylinder wall layers are predicted to change in size parallel to the average mass profile in the whole cylinder where they quickly peak to maximum at around 18° CA ATDC, and gradually decrease in size through EVO.