

Figure 3 Cylinder Pressure (top curve), Apparent Heat Release Rate (middle curve), and Injection Rate (bottom curve) for single and double injections at 75% load

Fig 4 shows the effect on particulate and NO_x emissions when the fuel quantity in the first injection was varied. Within simulation repeatability, the quantity is seen to have little effect on the overall particulate vs. NO_x tradeoff. From these results, it appears that a double injection with zero dwell between injections behaves very similarly to a single injection, regardless of the fuel amounts in the first and second pulses. However, when the dwell time between injections, was increased, particulate levels were found to be lowered significantly.

Figure 5 illustrates the considerable reduction in particulate levels that resulted when a longer dwell.

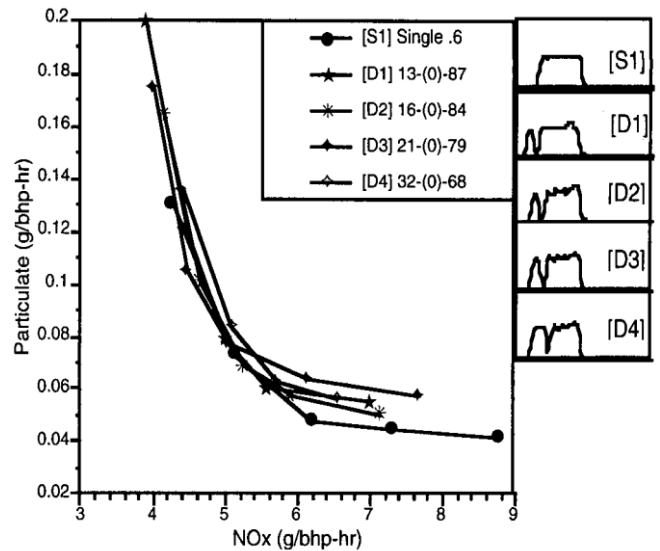


Figure 4 Particulate vs. NO_x tradeoff curves for double injections at 75% load. Start-of-injection timings varied from -14° to -2° ATDC

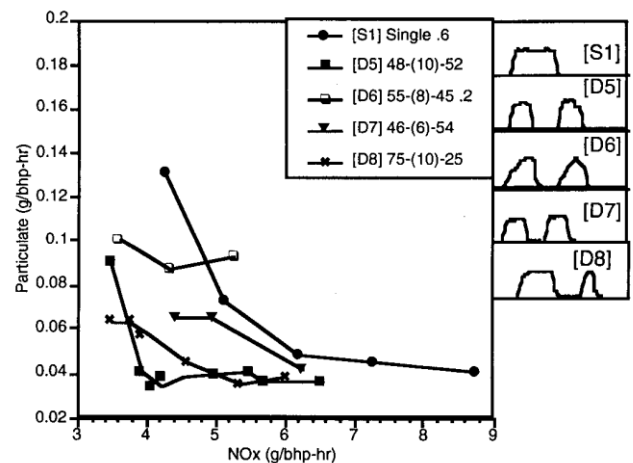


Figure 5 Particulate vs. NO_x tradeoff curves for double injections at 75% load

Start-of-injection timings varied from -12° to 1° ATDC between injection periods was used. A ratio of approximately 50/50 fuel mass in the first to second injection was used in cases D5, D6, and D7 whose dwells were 10, 8, and 6 crank angle degrees, respectively. The difference in particulate level between D5 and D7 shows the effectiveness of a relatively long (10° CA) dwell which produces a combustion process in which the particulate emissions do not increase significantly with timing retard.

9. Summary and Conclusions

The results of this study show the following specific conclusions:

- Particulate reductions by a factor of three with no increase in NO_x and only 2.5% increase in BSFC compared to single a injection were found at 75%, load using a double injection with a relatively long dwell between injections (case D5)

- Reduction in NO_x and peak pressure at 25% and 75% load were found with small first quantity double injection (D1). Ramped injection (case S2) was not as effective

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