A mathematical model has been developed to predict the in-cylinder parameters and the apparent mass burning rates of individual fuels of dual fuel combustion system adapting the technique of carburetion. In order to validate the predictions of the model, a well instrumented experimental program involving a 1500 RPM, 3.7 kW, single cylinder, compression ignition engine, modified for dual fuel operation, was executed. Good correlation between the simulated results and the data obtained from several experimental runs validate the combustion model developed. The delay correlation proposed for the first time reasonably estimates the ignition delay periods of igniting diesel under various operating conditions of dual fuel operation.

The experimental investigations, carried out to examine the effects of carbureting ethanol in different types of diesel engines, indicate that it is possible to operate the compression ignition engines on dual fuel system with very little modifications.

Some of the significant conclusions and useful results of the present investigations are:

(i) Compared with air only compression, the magnitude of the compression pressure decreases when the flow of
ethanol is increased or the proof of ethanol is lowered during hot motoring runs.

(ii) Both the values of peak internal energy of the charge and compression work show a decreasing trend with increasing percentage of ethanol or lowering the proof.

(iii) The combustion model developed for the closed period of the dual fuel cycle through reasonable assumptions enabled the prediction of the cylinder pressure development, rate of pressure rise and heat release pattern for various proofs of ethanol. The model also enabled the computation of mass averaged temperature of the mixture and products of combustion for different operating conditions.

(iv) The comparison of predicted and measured data indicates a very satisfactory correlation. A maximum variation between the predicted and measured values was found to be within ±5 percent.

(v) Increase or decrease of peak pressure or rate of pressure rise depend on the delay period and the point of ignition with respect to the TDC position.

(vi) Peak burning rate of diesel decreases with increasing percentages of diesel substitution.

(vii) Induction of ethanol always produced increased ignition delay periods and lowering the proof of ethanol further lengthens the delay period.
(viii) The delay period correlation developed for the dual fuel mode of operation can be represented by the equation, \( \text{DELAY (ms)} = 2.5 \frac{e}{T^{1.02}} /p \).

(ix) Mass flow rate of air remains almost constant during the dual fuel operations.

(x) Improvements in the values of thermal efficiency resulting from increased premixed mode of combustion are possible during full load operations.

(xi) The percentages of water contained in ethanol had no apparent effect on the performance of the engine. However, there are possibilities of combustion quenching occurring earlier for lower proofs of ethanol.

(xii) Knock limited percentage of diesel substitution decreases with increase in speed.

(xiii) The maximum percentages of diesel substitution for different proofs of ethanol are reduced when the injection timing of diesel is retarded.

(xiv) Compared with straight diesel operation, the exhaust gas temperatures are lower during dual fuel operations.

(xv) While the delay period decreases, peak pressure and rate of pressure rise increase when the air-ethanol mixture is heated.
(xvi) The NO/NO\textsubscript{x} emissions are significantly lower during the dual fuel operations, as compared to straight diesel operation and the percentage reduction depend on the quantum of ethanol induction as well as the proof of ethanol.

(xvii) A slight increase in CO levels observed during dual fuel operations may be attributed to the existence of local rich mixture zones.

(xviii) The variation of injection pressure of diesel fuel does not cause any appreciable change in the performance of the dual fuel system.

(xix) Dual fuel operations of multicylinder diesel engine indicate that there is no advantage in inducting ethanol at lower loads. Owing to the maldistribution of air-ethanol mixture between the cylinders, in multicylinder engines, the percentages of diesel substitution are lower compared to the values obtained in single cylinder engines.

(xx) Compared to straight diesel operation, dual fuel operations in turbocharged engine result in higher values of combustion pressure and rate of pressure rise.

(xxi) Addition of ignition accelerator such as cyclo-hexonal indicated an improvement in thermal efficiency due to the reduction in the delay period.
(xxii) At higher percentages of diesel substitution the piston configuration becomes less critical.

(xxiii) No significant wear problem has been identified during long duration of engine operation in the dual fuel mode.

(xxiv) The values of "RATIO" that has been proposed and used in the present model may have to be modified to account for the operating variables such as swirl, air-ethanol ratio, inlet temperature of the mixture and ignition delay of injected diesel.

While the model developed predicts with reasonable accuracy the in-cylinder parameters during the dual fuel combustion the author believes that there is scope for further research efforts to bring in more sophistication by way of introducing multizone concepts, fuel entrainment phenomena and to predict the formation of pollutants during ethanol-diesel dual fuel combustion in C.I. engines.