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## **Predicting Combustion Process in Dual Fuel Engines by Incorporating Quasi-dimensional Multi-Zone and Detailed Chemical Kinetics Models**

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### **Abstract**

In the present work for prediction of combustion process in dual-fuel engines, a multi-zone combustion model for predicting combustion of pilot fuel and a chemical kinetic model for predicting gaseous fuel combustion are incorporated. Chemical kinetic model is consisting of 105 reactions with 31 species. Average pressure and mass average temperature, which are derived from two models, are considered as pressure and temperature of dual fuel engine. Predicted values of pressure and heat release rate from this modeling for dual fuel operation show good agreement with corresponding experimental data than the previous models.

**Key words:** dual fuel, combustion modeling, chemical kinetics, pilot fuel, multi-zone model.

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$$\frac{d(M_{bi}U_{bi})}{d\theta} = -P \frac{dV_{bi}}{d\theta} + \frac{dQ_{bi}}{d\theta} + \frac{dM_{ebi}}{d\theta} H_a \quad ( )$$

$i = 1, 2, 3, \dots, (j - 1)$

$$\frac{d(M_{bj}U_{bj})}{d\theta} = -P \frac{dV_{bj}}{d\theta} + \frac{dQ_{bj}}{d\theta} + \frac{dM_{mp}}{d\theta} H_{mp} + \frac{dM_{ebj}}{d\theta} H_a \quad ( )$$

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$Q, V, M, U$  .

$ebj, bj, bi, mp, ec, f, c$

$i$

[ ]

$$T_m = \frac{\sum M_{bi} T_{bi} + M_a T_a + M_c T_c}{\sum M_{bi} + M_a + M_c} \quad ( )$$

$m$

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$$\frac{dQ_{bi}}{d\theta} = \left[ \frac{M_{bi} T_{bi}}{\sum M_{bi} T_{bi} + M_a T_a + M_c T_c} \right] \frac{dQ_m}{d\theta} \quad ( )$$

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$$P_i V_i = m R_i T_i \quad ( )$$

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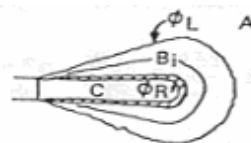
$$\sum V_{bi} + V_a + V_c = V_{ch}(\theta) \quad ( )$$

$B_i$

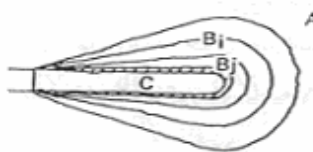
$$\frac{d(M_c U_c)}{d\theta} = -P \frac{dV_c}{d\theta} + \frac{dQ_c}{d\theta} + \frac{dM_f}{d\theta} H_f + \frac{dM_{ec}}{d\theta} H_a - \frac{dM_{mp}}{d\theta} H_m \quad ( )$$

$$\frac{d(M_a U_a)}{d\theta} = -P \frac{dV_a}{d\theta} + \frac{dQ_a}{d\theta} - \frac{dM_a}{d\theta} H_a \quad ( )$$

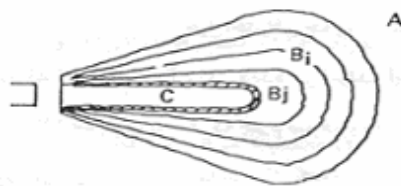
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ورود مداوم هوا و آماده شدن مخلوط



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$$k_{jb} = A_{jb} T^\beta \exp\left(\frac{-E_{jb}}{TR}\right) \quad ( ) \quad \Sigma \frac{dM_{ebi}}{d\theta} + \frac{dM_{ec}}{d\theta} = \frac{dM_a}{d\theta} \quad ( )$$

[ ]

$$R_{jf} = k_{jf} \prod_{i=1}^{31} (\rho x_i)^{\alpha_{if}} \quad ( ) \quad \frac{d(M_{ch} U_{ch})}{d\theta} = -P \frac{dV_{ch}}{d\theta} + \frac{dQ_m}{d\theta} + \frac{dM_f}{d\theta} H_f \quad ( )$$

$$R_{jb} = k_{jb} \prod_{i=1}^{31} (\rho x_i)^{\alpha_{ib}} \quad ( ) \quad \frac{dM_f}{d\theta} H_f$$

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$$\rho = \frac{M}{V(\theta)} \quad ( ) \quad - -$$

$$-\rho \frac{dx_i}{dt} = \sum_{j=1}^{105} (\alpha_{ijf} - \alpha_{ijb})(R_{jf} - R_{jb}) \quad ( )$$

C2H, C2H2, C2H3, C2H4, C2H5, C2H6, C3H8, NC3H7, iC3H7, C3H6, CH4, CH3, CH2, CH2CO, CH2O, CH3O, CHO, CH3CHO, CH3CO, CO, H2, H, CO2, C, HO2, H2O2, H2O, O, OH, N2, O2.

$$PV = MRT \quad ( )$$

R T P M

$$\sum_{i=1}^{31} \alpha_{ijf} A_i \Leftrightarrow \sum_{i=1}^{31} \alpha_{ijb} A_i \quad j = \dots \quad ( )$$

$\alpha_{ijb} \alpha_{ijf}$

$k_{jf}$

j

[ ]

$$\sum_{i=1}^{31} x_i RT \times \frac{f'(t)}{f(t)} + \sum_{i=1}^{31} \left\{ \left( \int_{T_0}^T C_{vi} dT + \Delta U_{fi} \right) \frac{dx_i}{dt} + x_i C_{vi} \frac{dT}{dt} \right\} = \dot{Q}_p \quad ( )$$

$$k_{jf} = A_{jf} T^\beta \exp\left(\frac{-E_{jf}}{TR}\right) \quad ( )$$

$$k_{jb} \quad ( )$$

$$\frac{dp}{d\theta} \dot{q}$$

$$\dot{Q}_p$$

MZCM

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/ kg/h

/ kg/h

rpm

$$\dot{q} = \frac{\gamma_{av}}{\gamma_{av} - 1} p \frac{dV}{d\theta} + \frac{1}{\gamma_{av} - 1} V \frac{dp}{d\theta} + \dot{q}_{wall} \quad ( )$$

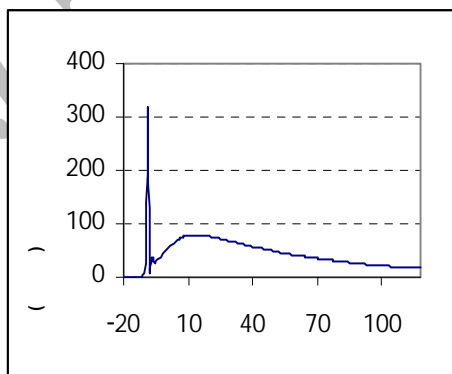
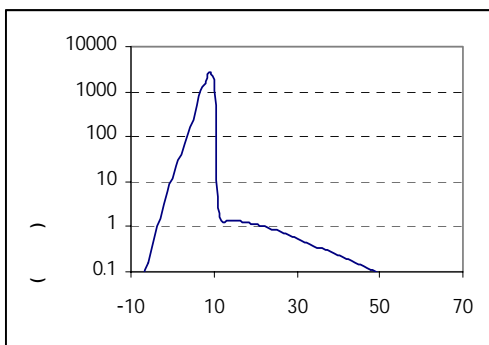
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Methane /	Ethane /	Propane /	i-Butane /	n-Butane /
neo-pentane /	i-pentane /	n-pentane /	Hexanes /	Carbon Dioxide /
Nitrogen /	Heptanes /	octane /		

OM355

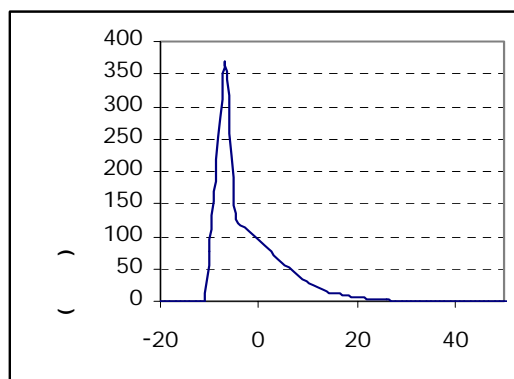
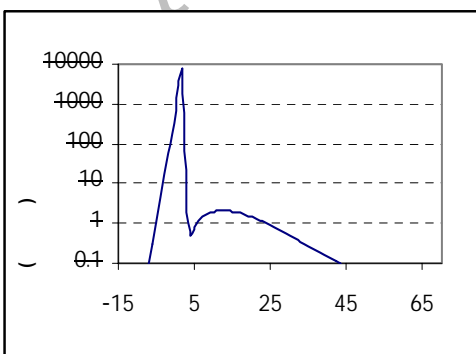
rpm	
n.m	
rpm	
*	*
( liter)	

[ ]



MZCM 1400 rpm

MZCM 1400 rpm



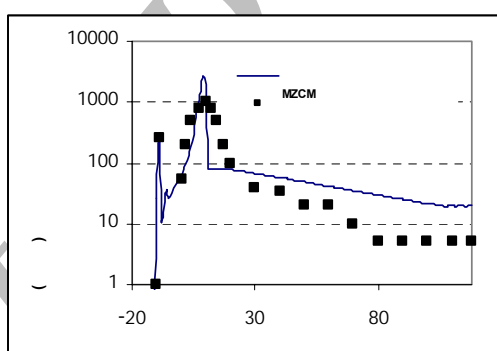
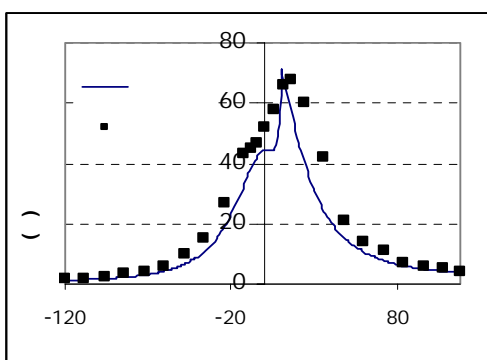
[ ] 1400 rpm

[ ] 1400 rpm

+ )  
 ( OM-

( P- $\theta$ )

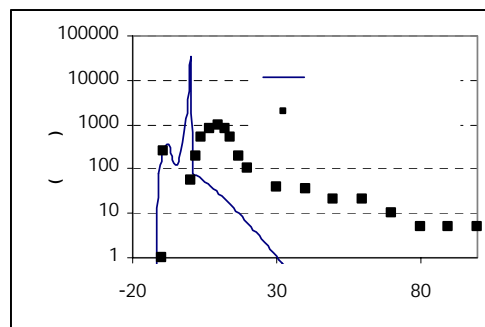
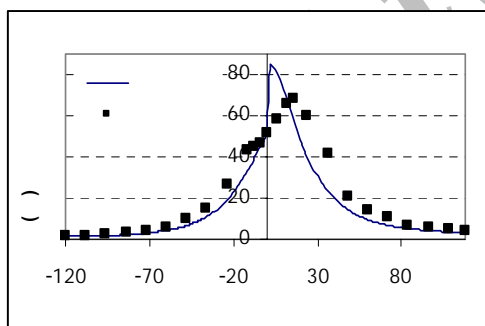
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MZCM

1400 rpm

MZCM



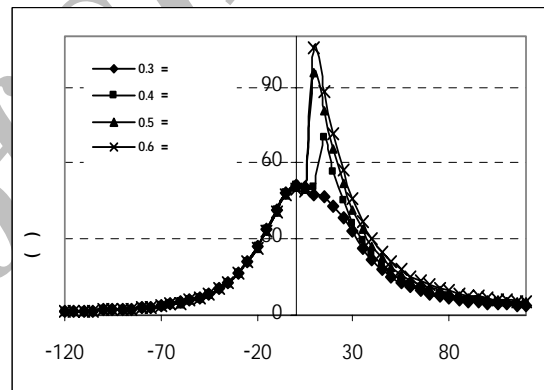
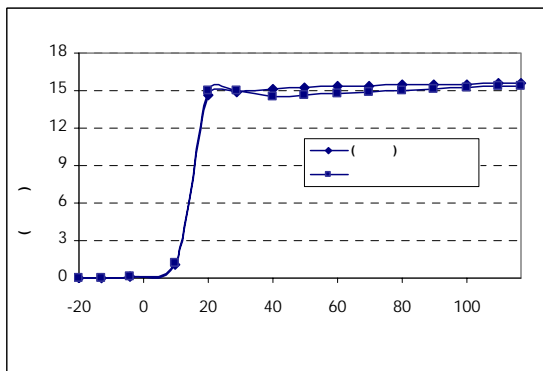
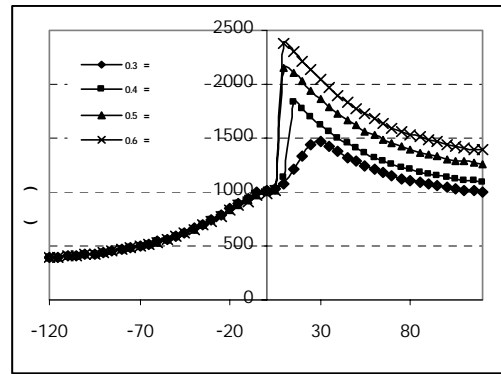
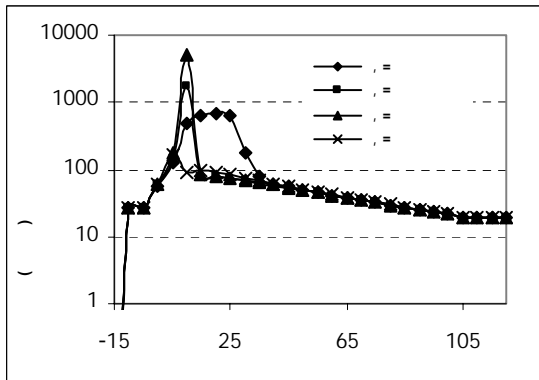
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1400 rpm

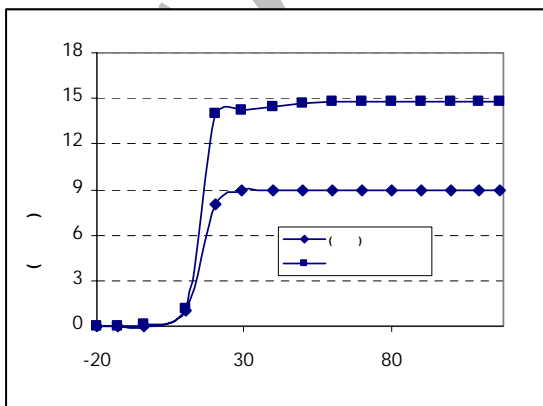
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1400rpm / Kg/h





1400 rpm



$\phi=0.3$

( )

1400 rpm

[ ]

1- Accumulative Heat Release

<i>A</i>	-
$\alpha$	
<i>k</i>	
<i>R</i>	
$\rho$	:
<i>M</i>	-
$T_c$	
$T_{bi}$	
<i>p</i>	( )
<i>T</i>	
$C_v$	.
$\Delta U$	-
<i>H</i>	
a	
bi	i
bj	
bj	
ebi	MZCM
ec	( )
i	
j	
f	-
b	
d	
p	
s	
c	
ch	)
mp	(
av	

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$\theta$   
 $\dot{Q}_p$   
*x*

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