APPENDIX 1

1. ENERGY EQUATIONS FOR HOT MOTORING

\[ U = -P\dot{V} + \sum Q_i - \dot{M}_B L_B - \dot{M}_w L_w \]  
\[ U = f(T, M_B, M_w) \]  
\[ \text{Differentiating equation (Al.2), with respect to} \]  
\[ \text{Crank angle} \ \Theta \]  
\[ \dot{U} = \frac{\partial U}{\partial T} \frac{dT}{d\Theta} + \frac{\partial U}{\partial M_B} \frac{dM_B}{d\Theta} + \frac{\partial U}{\partial M_w} \frac{dM_w}{d\Theta} \]  
\[ = \frac{\partial U}{\partial T} \dot{T} + \frac{\partial U}{\partial M_B} \dot{M}_B + \frac{\partial U}{\partial M_w} \dot{M}_w \]  
\[ : \dot{T} = \frac{U - \frac{\partial U}{\partial M_B} \dot{M}_B - \frac{\partial U}{\partial M_w} \dot{M}_w}{\frac{\partial U}{\partial T}} \]  
\[ \dot{T} = \frac{-P\dot{V} + \sum Q_i - \dot{M}_B L_B - \dot{M}_w L_w - \frac{\partial U}{\partial M_B} \dot{M}_B - \frac{\partial U}{\partial M_w} \dot{M}_w \dot{T}}{\partial U} \]  
\[ \text{Let} \ U_A = \Sigma m_j C V_j, \text{where} \ j \text{represents the individual constituents such as} \ O_2, \ N_2, \ C_2H_5OH \ \& \ H_2O \]  
\[ : \dot{U} = U_A \ T \text{ and} \]  
\[ \frac{\partial U}{\partial T} = U_A + T \frac{\partial U_A}{\partial T} \]  
\[ \text{Hence,} \]  
\[ \dot{T} = \frac{-P\dot{V} + \sum Q_i - \dot{M}_B L_B - \dot{M}_w L_w - \frac{\partial U}{\partial M_B} \dot{M}_B - \frac{\partial U}{\partial M_w} \dot{M}_w}{U_A + T \frac{\partial U_A}{\partial T}} \]  
\[ \text{2. ENERGY EQUATION FOR FIRING RUN} \]

Products of complete combustion per kg of fuels are evaluated as below:
**Ethanol**

\[
\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}
\]

1 kg + 2.087 kg ——- 1.913 kg + 1.174 kg
of (ethanol) (Oxygen) of of (CO\(_2\)) (H\(_2\)O)

**Diesel**

\[
\text{C}_{12}\text{H}_{26} + 18.5 \text{O}_2 \rightarrow 12\text{CO}_2 + 13\text{H}_2\text{O}
\]

1 kg + 3.482 kg ——- 3.106 kg + 1.376 kg
of (Diesel) (Oxygen) of of (CO\(_2\)) (H\(_2\)O)

Energy equation can be written as:

\[
\dot{U} = -P\dot{V} - \sum \dot{Q}_j + \dot{Q}_D - \dot{Q}_L
\]

\[
U = f(T, W_B, W_D)
\]

Differentiating equation (Al.8) with respect to crank angle \(\Theta\),

\[
\dot{U} = \frac{\partial U}{\partial \Theta} \dot{\Theta} + \frac{\partial U}{\partial W_B} \dot{W}_B + \frac{\partial U}{\partial W_D} \dot{W}_D
\]

\[
\text{Let } U = U_A . T
\]

Where \(U_A = \sum_j \text{CV}_j\), where \(j\) represents the individual constituents such as \text{C}_2\text{H}_5\text{OH}, \text{C}_{12}\text{H}_{26}, \text{CO}_2, \text{H}_2\text{O}, \text{O}_2\) and \(\text{N}_2\)

\[
\therefore \frac{\partial U}{\partial T} = U_A + T . \frac{\partial U_A}{\partial T}
\]
Let suffix 3 represent CO$_2$
4 represent H$_2$O
5 represent O$_2$
and 6 represent N$_2$

Now $U_A$ can be represented as

$$U_A = (W_B - W_E) CV_E + (M_D - W_D) CV_D + (W_E E_3 + W_D D_3) CV_3 +$$
$$+ (W_B S_4 + W_D D_4) CV_4 + (W_T5 - W_E E_5 - W_D D_5) CV_5 + W_T_6 CV_6 \ldots \text{(A1.11)}$$

From equation (A1.11), the values of $\frac{\delta U_A}{\delta T}$, $\frac{\delta U}{\delta W_E}$ and $\frac{\delta U}{\delta W_D}$ can be computed.

3. DETERMINATION OF CHARACTERISTIC GAS CONSTANT 'R'

$$R = \frac{R_o}{\text{molecular weight}}$$

Mol. wt. = Total weight of the constituents

Number of moles = \frac{\text{Weight of each constituent}}{\text{Molecular weight}}

\begin{align*}
\text{Mol. wt.} &= \frac{(W_T - W_E) + (W_T - W_D) + \ldots}{46} + \frac{W_T - W_D + \ldots}{170} \\
\end{align*}

4. CALCULATION OF $V$

$$V(0) = V_{TDC} + \frac{\pi}{4} B^2 \cdot X(0)$$

where $X(0) = r(1 + 1/r - \cos \theta - \sqrt{1/r^2 - \sin^2 \theta})$

$$\dot{V} = \frac{\pi}{4} B^2 \cdot \frac{dX}{d\theta}$$

where

$$\frac{dX}{d\theta} = r(\sin \theta + \frac{\sin \theta \cdot \cos \theta}{\sqrt{(1/r)^2 - \sin^2 \theta}})$$