APPENDIX 1

ERROR ANALYSIS

GENERAL FORMS

As mentioned in the chapter 3 and 4, the errors associated with various measurements and the calculations of important parameters are computed in this section. The maximum possible errors in various measured parameters namely temperature, time, voltage and current are estimated from the minimum values of output and accuracy of the instrument. The errors in the estimated parameters such as fuel consumption, brake power, BSFC and BSEC are calculated using the method proposed by Moffat (1985). This method is based on careful specification of the uncertainties in the various experimental measurements.

If an estimated quantity, S depends on independent variables like (x₁, x₂, x₃ ..........xₙ) then the error in the value of “S” is given by

\[
\frac{\partial S}{S} = \left\{ \left( \frac{\partial x_1}{x_1} \right)^2 + \left( \frac{\partial x_2}{x_2} \right)^2 + \ldots + \left( \frac{\partial x_n}{x_n} \right)^2 \right\}^{\frac{1}{2}}
\]  

(A1.1)

where, \( \frac{\partial x_1}{x_1}, \frac{\partial x_2}{x_2} \) etc are the errors in the independent variables.
ERRORS IN MEASURED QUANTITIES

Temperature

Iron constantan thermocouple is used to measure the temperature of the engine exhaust gas. The maximum possible error in the case of temperature measurement is calculated from the minimum values noted and the accuracy of the instrument. The errors in the temperature measurement for the thermocouple are:

\[
\left( \frac{\partial T}{T} \right)_{Exp} = \frac{1K}{353K} = 0.002833
\]

(A1.2)

\[
\left( \frac{\partial T}{T} \right)_{Exp} = \frac{1K}{493K} = 0.00202839
\]

(A1.3)

Brake power

The brake power is given by

\[
B.P = \frac{VI}{1000\eta_s}
\]

(A1.4)

The overall error in the estimation of brake power is given as

\[
\left( \frac{\partial B.P}{B.P} \right) = \left( \frac{\partial V}{V} \right)^2 + \left( \frac{\partial I}{I} \right)^2 \right)^{\frac{1}{2}} = \left(0.0166\right)^2 + \left(0.033\right)^2 \left(\frac{1}{3}\right)
\]

(A1.5)

\[
= 0.0369 \text{ or } \pm 3.69% 
\]

Fuel consumption

\[
F.C = \frac{x.3600.\rho}{t.1000}
\]

(A1.6)
The overall error in the estimation of Specific fuel consumption is given as

$$\left( \frac{\partial F.C}{F.C} \right) = \left\{ \left( \frac{\partial x}{x} \right)^2 + \left( \frac{\partial t}{t} \right)^2 \right\}^{\frac{1}{2}} = \left( (0.005)^2 + (0.016)^2 \right)^{\frac{1}{2}}$$

(A1.7)

$$= 0.0167 \text{ or } \pm 1.67\%$$

**BSFC**

$$\text{BSFC} = \left( \frac{SFC}{B.P} \right)$$

(A1.8)

The overall error in the estimation of BSFC is given as

$$\left( \frac{\partial \text{BSFC}}{\text{BSFC}} \right) = \left( (0.0167)^2 + (0.0369)^2 \right)^{\frac{1}{2}} = 0.0405 \text{ or } \pm 4.05\%$$

**BSEC**

$$\text{BSEC} = \text{BSFC} \times C.V$$

The overall error in the estimation of BSFC is given as

$$\left( \frac{\partial \text{BSEC}}{\text{BSEC}} \right) = \left( (0.0405)^2 + (0)^2 \right)^{\frac{1}{2}} = 0.0405 \text{ or } \pm 4.05\%$$
Table A 1.1 Summary of estimated uncertainties

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Uncertainty (%)</th>
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<tbody>
<tr>
<td>Temperature</td>
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<tr>
<td>Time</td>
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<tr>
<td>Current</td>
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<tr>
<td>Voltage</td>
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</tr>
<tr>
<td>Burette reading</td>
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</tr>
<tr>
<td>Gas collection reading</td>
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<tr>
<td>Brake power</td>
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</tr>
<tr>
<td>Specific fuel consumption</td>
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</tr>
<tr>
<td>BSFC</td>
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</tr>
<tr>
<td>BSEC</td>
<td>4.05</td>
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