Module-7

Lecture-30

Flight Experiment: Cruise and Climb performance

Experiment # 2

Estimation of profile Drag coefficient (C_{D_o}) and Oswalds efficiency (e) of an aircraft from experimental data obtained during steady and level flight.

The following steps will elaborate the procedure to estimate the performance characteristics such as profile drag coefficient (C_{D_o}) and oswalds efficiency factor (e) of a propeller driven aircraft using flight data obtained during its cruise.

- Record the velocity of flight, engine manifold pressure, outside air temperature, rpm of the engine, during the cruise.

- Use the conversion equations and calibration plots to obtain break horse power of the engine from the above recorded data.

- Now, the power required during the steady and level flight is given as:

$$P_{req} = \frac{1}{2}\rho V^3 S C_{D_o} + \frac{\frac{W^2}{\frac{1}{2}\rho V S}}{\pi A R e}$$

- The above equation can be further modified as:

$$\Rightarrow PV = \left(\frac{1}{2}\rho S C_{D_o}\right) V^4 + \frac{2W^2}{\pi A R e \rho S} \tag{1}$$

- For the sake of convenience we can rewrite the Equation 1 as follows:

$$Y = m \times X + c \tag{2}$$

- By comparing Equation 1 & 2

$$Y = PV$$
$$m = \frac{1}{2}\rho S C_{D_o}$$
$$c = \frac{2}{\pi A R e \rho S}$$

Since we have measured velocity and calculated power required, if we plot PV vs V^4 we will get a straight line whose y intercept is c and slope will be m. Now after calculating slope and y intercept of experimental data, using the Equation 1 & 2 we can estimate the profile drag coefficient (C_{D_o}) and oswalds efficiency factor (e).

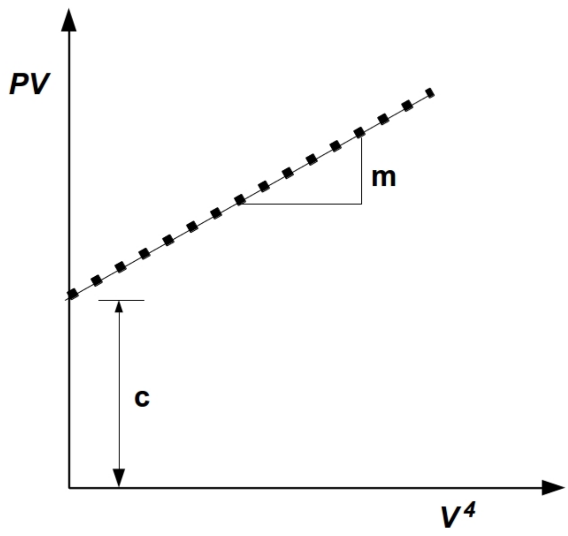

Figure 1: Graphical representation of variation of PV vs V^4

Record Chart: Cruise

Altitude =...........

OAT = ...

V	MP	RPM	Weight: Initial Weight: Final	Time: Start Time: End
-	-	-	– –	– –
-	-	-	– –	– –
-	-	-	– –	– –
-	-	-	– –	– –
V_5	-	-	– –	– –

OAT: Outside Air Temperature

MP: Manifold Pressure

RPM: angular speed of propeller blade

Note: The value of these two along with altitude and OAT will be used to calculate power delivered by engine at that altitude.

Experiment # 3

Flight test for steady climb experiment

- **Step 1:** Record the take-off weight (W_T).

- **Step 2:** Note the initial altitude h_1 and time t_1 and the final altitude h_2 and the corresponding time t_2 during the steady climb experiment.

- **Step 3:** Simultaneously record the velocity (V), rpm of propeller, propeller pitch setting, manifold pressure of the engine and outside air temperature from the cockpit.

- **Step 4:** Repeat the experiment for different climb velocities.

- **Step 5:** Record the weight after landing (W_L). The weight that has to be considered for calculations is average of takeoff and landing weights.

$$W = \frac{(W_1 + W_2)}{2}$$

- **Step 6:** Find out the rate of climb for each velocity and the corresponding angle of climb γ using the following equations.

$$RC \approx \frac{(h_2 - h_1)}{(t_2 - t_1)} \text{ , } RC_{true} = RC_{observed} \times \frac{T_o}{T_s}$$

$$\sin\gamma = \frac{RC}{V}$$

- **Step 7:** Plot Rate of climb vs velocity.

- **Step 8:** Plot Angle of climb vs velocity.

- **Step 9:** Plot Rate of climb vs. altitude (h).

Rate of climb (TRUE)

If the time required to traverse the altitude band is also recorded, we can easily calculate true rate of climb at each speed at choosen altitude. The observed rate of change of pressure altitude is corrected to true rate by using the following relation:
Let the observed temperature be T_o and standard temperature at altitude be T_s.
Then, since the pressure change recorded is always the true pressure difference for altitude change shown by the altimeter.

$$\Delta p = -\rho_s g \left(\Delta H\right)_p$$

s: standard altitude

p: pressure altitude

$\left(\Delta H\right)_T$, is the true change in altitude, will have the same pressure difference.

$$\therefore \Delta p = -\rho_T g \left(\Delta H\right)_T$$

$$\frac{\left(\Delta H\right)_T}{\left(\Delta H\right)_p} = \frac{\rho_s}{\rho_T} = \frac{T_o}{T_s} \text{ (using } p = \rho RT\text{)}$$

Therefore,

$$RC_{true} = RC_{observed} \times \frac{T_o}{T_s}$$

Record Chart: Climb

Altitude =..........

OAT = ...

V	H_1	H_2	t_1	t_2	$\Delta H = H_2 - H_1$	$\Delta t = t_2 - t_1$
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
V_5	-	-	-	-	-	-

H_1: Altitude at which climb begins

H_2: Altitude at which climb ends

t_1: Start time of climb

t_2: End time of climb