Trade-off Ratio Problems

Problem No. 01

Consider a rocket with the following **mass** configuration.

$$m_{p1} = 21087kg; \quad m_{s1} = 1296kg; \quad I_{sp1} = 261s$$
$$m_{p2} = 3854kg; \quad m_{s2} = 360kg; \quad I_{sp2} = 324s$$
$$m_{*} = 668kg$$

Obtain the **trade-off** ratios.

Solution No. 01

The **trade-off** ratios are as follows.

$$m_{01} = 27265 \qquad m_{f1} = 6178$$
$$m_{02} = 4882 \qquad m_{f2} = 1028$$
$$\frac{\delta m_*}{\delta m_{s1}} = -0.116 \qquad \frac{\delta m_*}{\delta m_{s2}} = -1$$
$$\frac{\delta m_*}{\delta m_{p1}} = 0.34 \qquad \frac{\delta m_*}{\delta m_{p2}} = 0.118$$

Parallel Staging Problems

Problem No. 02

Consider the booster and first **stage** of PSLV, as defined **below**.

$$m_0 = 295T; \quad m_{p0} = 9T; \quad m_{s0} = 2T; \quad I_{sp1} = 262s; \quad t_{b0} = 44s$$

$$m_{p1} = 138T; \quad m_{s1} = 30T; \quad I_{sp2} = 269s; \quad t_{b1} = 105s$$

Assuming that there are 6 **boosters** and that all 6 boosters and the **first** stage fire together, **determine** the ideal burnout velocity at the **end** of the first stage burnout.

Solution No. 02

The **solution** at the end of 44s is as follows.

$$\dot{m}_0 = \sum_{i=1}^{n} \dot{m}_{0-i} = 6 \times 0.2045 + 1.3143 = 2.5415 T/s$$

$$I_{sp-0} = \frac{\sum_{i=1}^{n} \dot{m}_{0-i} I_{sp0-i}}{\sum_{i=1}^{n} \dot{m}_{0-i}} = \frac{1.2272 \times 262 + 1.3143 \times 269}{2.5415} = 265.6s$$

$$V_{b-0} = g_0 I_{sp-0} \ln \frac{m_0}{m_{0-1} - \dot{m}_0 t_{b0}} = 9.81 \times 265.6 \times \ln \frac{295}{295 - 2.5415 \times 44}$$

$$= 1241.7 m/s$$

Solution No. 02

The **solution** at the end of 105s is as follows.

$$V_{b-1} = V_{b-0} + g_0 I_{sp-0} \ln \frac{m_{0-1}}{m_{0-1} - \dot{m}_{0-2}\left(t_{b1} - t_{b0}\right)}$$

$$= 1241.7 + 9.81 \times 269 \times \ln \frac{183.2}{183.2 - 1.3143 \times (105 - 44)}$$

$$= 1241.7 + 1518.9 = 2760.6 m / s$$