Optimal Design Methodology

Optimal Design Problem Definition

In **multi-stage** rocket design, basic **design** variables are **masses** within each stage.

Payload mass and ideal burnout **velocity** can either be **objective** function or **constraint**.

Optimal Design Problem Definition

In most cases, **objective** is to maximize, either $\mathbf{m}_*$ for a given $\mathbf{V}_*$, or vice versa.

In all these **cases**, No**.** of stages is used as a **parameter**.

Optimal Design Method

Among the **many** techniques, **gradient** based methods are **useful** for problems that allow **differentiation.**

Typically, there is an **objective** function that is optimized, with respect to the **design** variables.

Optimal Design Description

Further, there are **constraints** that the solution needs to **satisfy.**

In the **present** case, either $\mathbf{V}_*$ can be taken as **objective** function & $\boldsymbol{\pi}_*$ **as constraint** or vice versa.

Optimal Solutions Concept

In **gradient** based methods, **partial** derivatives of objective **function**, with respect to design **variables,** are driven to **zero**, while satisfying the **constraint** exactly.

Thus, for an **'N'** stage vehicle having '**N**' design variables, we have **'N+1'** equations, for 'N' **unknowns.**

Optimal Solutions Concept

It is **well** known that for **such** a system of **equations**, we can extract **'N'** solutions based on **least** squares method.

However, if an **exact** solution is **desired**, then we need to **add** one more **unknown**, to make the system **square.**

Summary

To **summarize**, optimal methods are **capable** of providing good solutions for the **stage-wise** payload ratios.

Further, we **note** that we can make use of **gradient-based** techniques to set up the applicable **solution** methodology.