AM-04.42

O/F mixture ratio: how much oxidizer for how much fuel?

Version PDF de travail - contenu du cours HTML canonique

Course compass

Guiding question: How do we turn an O/F ratio into two real flow rates?

Essential answer

O/F mixture ratio: how much oxidizer for how much fuel?. The question to solve is: How do we turn an O/F ratio into two real flow rates? We start from the concrete problem before notation. The goal is to understand what we seek, then why mathematics becomes useful. The rest of the course turns that idea into an auditable line of reasoning: explicit units, stated assumptions, reproducible calculations, order-of-magnitude checks and interpretation limits. A result is useful only when the reader can explain what it measures, where every input came from and which engineering decision it can support.

Starting synthesis: derivations, examples, limitations and sources are developed in the course body.

Key terms before you start

thrust · unit · order of magnitude · assumption · variable

1 — The physical question

How do we turn an O/F ratio into two real flow rates?

We start from the concrete problem before notation. The goal is to understand what we seek, then why mathematics becomes useful.

2 — How to read the symbols and units

$O/F = \dot{m}_O / \dot{m}_F$. Read: "O over F equals m dot O divided by m dot F".

O/F — oxidizer-to-fuel mass ratio ; $\dot{m}_O$ — oxidizer mass flow ; $\dot{m}_F$ — fuel mass flow

3 — Where does the relation come from?

Mixture ratio compares oxidizer and fuel mass flow. If total flow is known, solve two equations: $\dot{m}_{total}=\dot{m}_O+\dot{m}_F$ and $O/F=\dot{m}_O/\dot{m}_F$.

Every number used below is explicitly treated as data, convention, learning assumption, or calculated result.

4 — A — Ratio 3

Where do the numbers come from? O/F=3 and total flow=40 kg/s.

Step-by-step calculation: $\dot{m}_F=40\div(3+1)=10$; $\dot{m}_O=30$ kg/s.

The four total parts are 3 parts O + 1 part F.

5 — B — Ratio 3.6

Where do the numbers come from? O/F=3.6; total=460 kg/s.

Step-by-step calculation: $\dot{m}_F=460\div4.6=100$; $\dot{m}_O=360$ kg/s.

The calculation directly gives the two flows.

6 — C — Constant total, ratio 2

Where do the numbers come from? Total=60 kg/s, O/F=2.

Step-by-step calculation: $\dot{m}_F=60\div3=20$; $\dot{m}_O=40$ kg/s.

Changing ratio redistributes total flow between two circuits.

7 — Sensitivity, inverse calculation, and sanity check

Change one input, predict the direction of the result, calculate, then check units, sign, order of magnitude, and limits.

Essential limit for O/F mixture ratio: how much oxidizer for how much fuel?: the displayed relation is a learning model. A real system adds detailed geometry, variable properties, sensors, uncertainty, transients, and testing.

8 — Why this matters in a mission

In a space mission, how do we turn an O/F ratio into two real flow rates? The useful skill is not reciting the formula but knowing which data are needed, which are measured, and when the model becomes insufficient.

10 — Go deeper: from calculation to physical understanding

O/F is a mass ratio, not an intuitive percentage

If O/F=3.6, it means 3.6 kg of oxidiser for 1 kg of fuel under that convention. The corresponding total flow contains 4.6 parts. To recover individual flows from total flow, first divide by 4.6 to obtain the fuel part, then multiply by 3.6 for the oxidiser part. This decomposition explains the algebra instead of asking the learner to memorise a recipe.

Why the ratio influences combustion

Changing O/F changes mixture chemistry and therefore combustion products, temperature, gas properties, and potentially performance and thermal margins. The chemically stoichiometric ratio is not necessarily the operating point selected for a real engine; cooling, materials, cycle, and performance objectives can influence the choice.

Measuring two flows to control one ratio

An engine controller does not know mixture ratio by magic. It receives measurements or estimates of flow, pressure, temperature, and valve positions, then compares observed state with command. A measurement error on one side can make the ratio appear correct when it is not, so sensor quality becomes part of the problem.

Total flow and mixture ratio are different constraints

Two engines can have the same O/F but very different total flows and therefore different thrust. Conversely, holding total flow constant while changing O/F redistributes mass between oxidiser and fuel. This conceptual separation is essential before studying throttling.

9 — Exercises and answers

Challenge 1

O/F=3 and total flow=40 kg/s.

Challenge 2

O/F=3.6; total=460 kg/s.

Challenge 3

Total=60 kg/s, O/F=2.

Primary and technical sources

• NASA Glenn — Liquid Rocket Engine

- NASA Glenn — Rocket Thrust Equation