



## Air Breathing Technology

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#### Ramjet

One of the concepts for air breathing technology being studied worldwide is a ramjet. A ramjet is a form of air breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion without an axial compressor.

- Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites. Ramjets cannot produce thrust at zero airspeed; they cannot move an aircraft from a standstill.
- A ramjet-powered vehicle, therefore, requires an assisted take-off, like a rocket assist, to accelerate it to a speed where it begins to produce thrust.
- The ramjet works best at supersonic speeds and as the speed enters the hypersonic range, its efficiency starts to drop.

#### Scramjet

Another concept is the scramjet. A scramjet engine is an improvement over the ramjet engine as it operates at hypersonic speeds and allows supersonic combustion, which gives it its name – supersonic combustion ramjet, or scramjet.

- The exhaust gases are then accelerated to hypersonic speeds using a divergent nozzle.
- The scramjet is composed of three basic components – a converging inlet where incoming air is compressed, a combustor where gaseous fuel is burned with atmospheric oxygen to produce heat, and a diverging nozzle where the heated air is accelerated to produce thrust.
- Unlike a typical jet engine, a scramjet does not use rotating, fan-like components to compress the air. Instead, the speed at which the vehicle moves through the atmosphere causes the air to compress within the inlet. As such, no moving parts are needed in a scramjet, which reduces the weight and the number of failure points in the engine.

#### Dual Mode Ramjet (DMRJ)

The third concept is a mix of ramjet and scramjet, which is called DMRJ. There is a need for an engine which can operate at both supersonic and hypersonic speeds. A DMRJ is an engine design where a ramjet transforms into a scramjet over Mach 4-8 range, which means, it can operate in both the subsonic and supersonic combustor mode.



