

Brayton Cycles for Propulsion

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We discussed last time how Brayton Cycles ^{can} breathe air, are light weight, & have an extremely high power to weight ratio. These characteristics make Brayton Cycles ideally suited for propulsion.

~~We've~~ ^{We've} already analyzed the Model 304 & Goblin II turbojet engines.

Figure 9-48 Pg. 521. ^{Slow} A turbojet is a Brayton cycle with a nozzle & a diffuser @ the inlet & exit.

→ The Model 304 & Goblin II turbojets are slightly different from the jet engines you've probably seen on ^{commercial} aircraft. Pg. 525 Figure 9-52 Commercial aircraft are typically driven by turbofan engines. Turbofans have a huge inlet fan that pulls in a large amount of air.

$F_{\text{thrust}} = \dot{m}(\tilde{v}_{\text{out}} - \tilde{v}_{\text{in}})$ they can achieve similar thrust to turbojets simply by processing more air with a smaller Δv . The fan air also helps to significantly reduce engine noise.

→ Increasing the bypass air even more requires removal of the cooling & a turboprop results. Figure 9-54 pg. 526.

→ Finally we have Ramjets & Rockets.

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~~How~~ It's easy enough to imagine how the fuel for these cycles is stored $\Rightarrow$ jet fuel. How would we store energy for longer term, like say for a spacecraft? Voyager 1 was launched in 1977 & has passed Pluto but is still working. How is this possible??

3 words: Radio isotope thermoelectric generators (RTGs)

Show TG. You realize now that whenever you have a gradient, like in temperature for instance, you have an opportunity to produce useful work. Thermoelectric generators operate on

the Seebeck effect. Whenever a temperature gradient is imposed on a dissimilar metal junction, a voltage is created. You should know.

If you have a heat source in space, like Plutonium-238 with a half life of ≈ 87 years, you can power a spacecraft for a long time.

The problem? RTGs have a very low efficiency $\Rightarrow 3 \Rightarrow 7\%$

So we need a light weight, higher efficiency alternative: Brayton cycle.

Show problem.