Can We Build Nuclear-Electric Propulsion Systems from Lunar Resources?

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Introduction

Yes! Why? Construction of nuclear-electric propulsion on the Moon means we can avoid launching *uncrewed* spacecraft from Earth to explore our whole solar system in a cheaper and most efficient way!

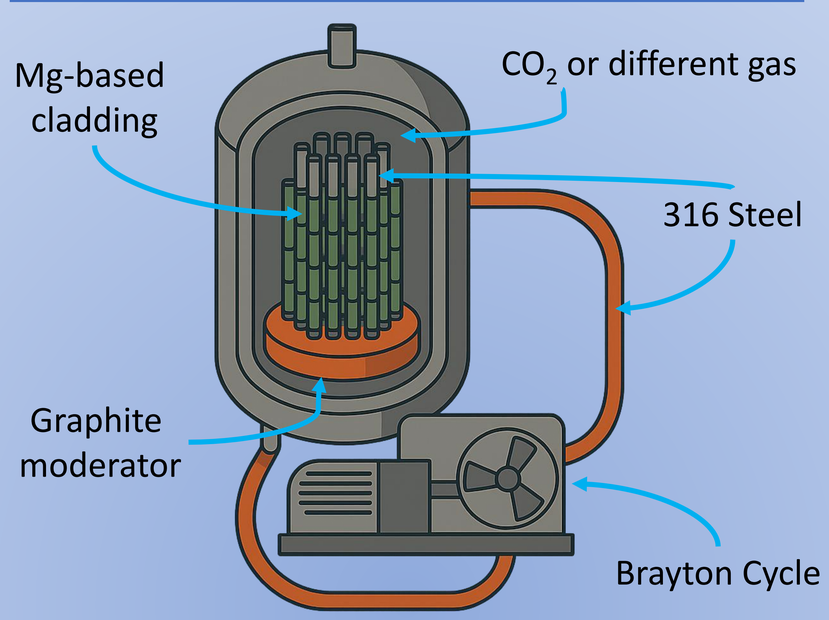
Lunar Nuclear Fuel Supply

- Th is naturally found on the Moon (associated with KREEP)
  - ~7.5 ppm at FMH
  - ~9 ppm at CB region
- Natural Lunar Th - 100% fertile (^{232}Th)
  - $^{232}Th + n \rightarrow {}^{233}Th \rightarrow {}^{233}Pa \rightarrow {}^{233}U$
- HCl and NaOH reagents for extraction

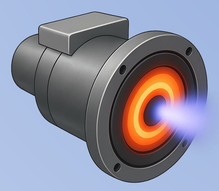
Nuclear reactor type: Magnox

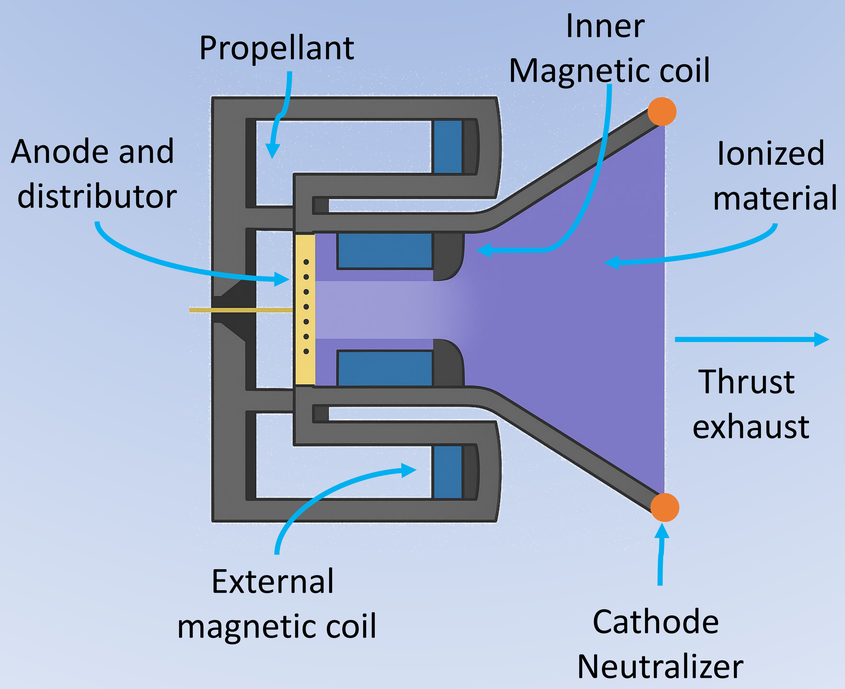
- Gas cooled nuclear reactor (CO_2 gas coolant <450^{o}C/4.3 MPa)
- Minor amounts of CH_4 to compensate no Be cladding
- Mg-0.8Al cladding
  - Forsterite → Mg
  - Anorthite → Al
- Graphite moderator
  C-type material → Graphite
- 316 steel for control rods and piping
  - Ilmenite → Fe
  - M-type material → Ni + Co
  - Chromite → Cr
  - Troilite → S
- Xenotime (YPO_4) for neutron absorption
- 25% eff. using CO_2 Brayton cycle (vs. steam 35%)

Magnox Nuclear Reactor (Built with lunar materials)



Electric Propulsion: Hall Effect Ion Thruster





Hall Effect Ion Thruster

- Molten salt electrolysis → O_2 propellant
  - P=2.2kW
  - I_{sp}=2800s
  - F=27 mN
  - Thruster wall – alumina
- Olivine → Mg propellant
  - I_{sp}=2700-4000s

Conclusions

- A self-sustaining nuclear-electric propulsion system is feasible using entirely lunar resources
- Lunar surface launch – e/m coilgun
- In-space propulsion – ion engine
- Water ice mining is unnecessary for propulsion
- Most significant challenge is the radiator sizing
- Problem does not arise for nuclear power for lunar base/infrastructure
- It is more compact than solar array farm