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BASELOAD FISSION REACTOR FOR LUNAR OPERATIONS

Abstract

Breakout performance for human operations will be realized once there are MW-class continuous-operation fission reactors on the Moon. This is likely to be realized only when there is a means for producing fissile fuel from ISRU resources, such as lunar thorium, because of the concerns associated with earth-launch of radioactive materials. Space is pervaded by gamma rays which produce neutrons upon interaction with beryllium. When moderated by graphite said neutrons can be captured by the thorium nucleus, which transmutes into protactinium, which further decays into the U-233 isotope of uranium. U-233 is an excellent source because the radioactive byproducts of spent fuel are short-lived, becoming safe after about 80 years. Thorium dioxide (ThO2 or thoria) is much more dense than the regolith average, and is found in concentrations exceeding those on earth in certain craters of the north Near Side, possibly because of the excavation of rich subsurface deposits due to meteorite impacts. Using jaw crushers and trommels made of durable lightweight metals a lunar mining operation can extract hundreds of kilograms of thoria by using a polymeric adaptation of a Wilfley sorting table laid along the sloped wall of a crater. An acid leach process can be used to remove intermediate protactinium from further neutron irradiation, which will decay to U-233. After processing the transmutated urania (UO2) is packed into fuel rods for a first-generation lunar fission reactor. The same gamma rays and beryllium will initiate a controlled chain reaction to provide baseload power. A Brayton cycle generator can produce power in a manner similar to the small modular reactor concept in development for terrestrial loads. With power outputs in the range of 10 to 60 MW, a single reactor can provide heat and power for a sizeable human base plus mining operations, as well as electromagnetic launchers to deliver payloads into orbit. Water harvested from polar craters can be shipped to any orbit. Greenhouses on the Moon can become the breadbasket to the Solar System. Electric power can be delivered over transmission lines, or via wireless power transfer to a variety of loads such as rovers, orbiting spacecraft, and even multiple habitats. With no nuclear materials needing to be launched from the earth's surface, and with relatively short-lived hot waste, this is a pathway to the long duration settlement of the Moon.