IAF SPACE PROPULSION SYMPOSIUM (C4)
Joint Session on Advanced and Nuclear Power and Propulsion Systems (10-C3.5)

Author: Ms. Sagarika Chikhale
Scuola di Ingegneria Aerospaziale "La Sapienza", Italy

Mr. Pattan Akram
Scuola di Ingegneria Aerospaziale "La Sapienza", Italy
Dr. Antonella Ingenito
Sapienza University of Rome, Italy

OPEN CYCLE GAS-CORE NUCLEAR ROCKET FOR MANNED MARS MISSIONS

Abstract

Open Cycle Gas-Core Nuclear Rocket (GCNR) is an advanced propulsion system which utilizes any radioactive materials as a fuel in gaseous state which delivers heat energy by thermal radiation to propellant to generate high thrust (10^5 lb - 10^6 lb) and high specific impulse (1500 sec - 5000 sec). The present study is carried out for the selection of nuclear fuels for MARS mission by using open cycle GCNR. Nuclear fuels such as uranium(U-235), plutonium(Pu-239), americium(Am-242m), curium(Cm-245), californium(Cf-249) are studied initially on the basis of the nuclear characteristics of fuels for instance half life, fission cross-section, total number of neutrons released per fission, total energy release per fission, later an approach has been done for the calculation of the critical mass for each fuel that contained in an engine to maintain its criticality (keff = 1) and desired power (5900 MW). The critical mass has calculated by using one speed diffusion theory for bare spherical geometry (without moderator/reflector) and for spherical fuel core with moderator/reflector to manifest the importance of moderator/reflector. After,the relation between critical fuel mass and engine parameters such as engine thrust,pressure,specific impulse,propellant to fuel flow rate ratio are examined for different given fuels. By doing the figure of merit analysis on the characteristics of fuels, americium(Am-242m) and californium(Cf-249) are succeeded as considerably best fuels. For the critical mass calculation regarding bare fuel geometry and fuel core with moderator/reflector,Am-242m is resulted as finest fuel with lesser critical mass. Additional analysis has been done on the heat generation from one gram of each fuel,the high heat generation is observed from the Am-242m. It has been observed from the relation between critical mass and engine parameters that the higher critical mass results in the reduction of the thrust for a given specific impulse and high in the pressure and vice versa. With very small mass of fuel,the Am-242m is capable of producing high thrust of 230000 lb at specific impulse of 4400 sec because of its efficiency of delivering high heat to propellant. Thus,it would be wise to nominate Am-242m for Manned MARS Mission. The one way trip to MARS can be done in less than 100 days and with minimum mass of 375 g of Am-242m. The conclusion can be made that the Gas core nuclear rocket is more feasible for MARS mission by utilizing Am-242m as a nuclear fuel.