Solar Collector/Concentrator/Vaporization/Dissociation

System for Spacecraft

or just Solar Vaporization/Dissociation System (SVDS)

Version 2

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Quote :

The highest form of intelligence is to make the most out of the least. (A Jean Gibbs)

Abstract:

This paper is a general discussion and examination of solar energy utilization for a spacecraft for enhancing rocket motor performance and possible life supporting capabilities. This also includes a simple mathematical model, examination and also consequences of that model. This is for a Solar Vaporization/Dissociation System (SVDS). This system described is for a space based craft in Earth orbit or within the orbit or Mars.

References:

A solar thermal rocket is a theoretical spacecraft propulsion system that would make use of solar power to directly heat reaction mass. It is discussed in
https://en.wikipedia.org/wiki/Solar_thermal_rocket
and
https://www.youtube.com/watch?v=xWMrsqs3bFc.

Introduction:

From a cursory examination of current online information about Solar Collectors/Concentrators, temperatures at the focal points of a mirror and/or lens can reach over 1000+ degrees Celsius (°C) or 1832+ degrees Fahrenheit (°F). At such temperatures fuels and oxidants can undergo vaporization/ chemical dissociation. This could be used as a means to improve rocket motor performance, also to provide life support services for a space craft by breaking down human waste products like CO_2 as well as solid and liquid waste (removal of water for reuse).

Definition/Description:

Solar Collector/Concentrator a means of collecting and concentrating solar energy by using mirrors and/or lenses and in so doing create localized high temperature regions. These regions can transfer this heat via a working fluid for other uses. In the case of SVDS this fluid would be to a fuel that would be passed to a rocket firing chamber, to be burnt and thrust generated. By doing this, efficiency of the motor rocket could be increased.

Mathematical treatment:

Constants and Laws needed (Note: the treatment here is non standard and is more of a ball park set of figures, to get a feel of how the SVDS would behave).

Solar constant

The amount of solar radiation just outside the Earth's atmosphere 1.361 kilowatts per square meter (kW/m^2) solar minimum, 0.1% greater (roughly 1.362 kW/m^2) at solar maximum.

Gray body version for the Stefan-Boltzmann Law

Power absorbed $P = \varepsilon \sigma A T^4$

ε = emissivity of the object (one for a black body)

σ = 5.6703 10-8 (W/m^2K^4) - The Stefan-Boltzmann Constant

T = absolute temperature Kelvin (K)

A = area of the emitting/absorbing body (m^2)

Simple input output power relation for system (SDVS)

Power out (Po) = Power in (Pi) - Power Losses (Pl), it will be assumed that Power Losses (Pl) are proportion to Power In (Pi) this gives:-

Po = Pi × (1 – k), k $\leq$ one and is the fraction of power lost either within the system or due to geometric considerations - alignment with the sun.

Power = intensity × area, P=IA

from the above we get:-

$t = ([I_i A_i(1 - k)/\varepsilon \sigma A_o]^{1/4}) - 273$ degrees Celsius (°C)

where

I_i = intensity of radiation the solar constant

A_i = input or collection area

A_o = output area (Concentrated to an area)

273 figure to shift from Kelvin (°K) to Celsius (°C)

t = the temperature Celsius (°C) of the absorbing grey body under equilibrium/stable conditions

Example: Applying the above assuming absorbing body is black ε = emissivity one for a black body and assuming minimal losses good alignment to the sun and ratio $A_i/A_o = 100$ gives t ~ 900 Celsius (°C). This is 7.9 times the boiling point of hydrazine (114 °C; 237 °F).

Note: Hydrazine was used as a fuel on the Apollo spacecraft.

The meaning of this is, that if enough solar energy could be collected and concentrated and used to heat enough fuel (to a percentage 900 °C) then passed to a rocket chamber we should see an increase in performance.