Minimum Weight for Pulsed Gas Reactors Rocket Motors

R. H. Fox

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ADN # 9

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FROM: R. H. Fox

Subject: MINIMUM WEIGHT FOR PULSED GAS REACTOR ROCKET MOTORS

ABSTRACT

A scheme for efficient use of fissionable material in a pulsed gas reactor rocket motor is considered. It is shown that high efficiency leads to an impracticable size of device.

ADVANCED DEVELOPMENT NOTE NUMBER NINE

In ADN-2 the throughput requirements for a gas reactor rocket motor were discussed. The minimum number of throughputs required for satellite missions is so large that efficiency of or alloy burnup becomes quite apparent. Now the only means known at present for achieving high burnup in times characteristic of rocket acceleration periods ($\tau \sim \frac{\Delta V}{g}$) or less is by means of bombs of proper design. One might consider, for example, exploding a moderate sized bomb inside a thick sphere of liquid H_2 , allowing the hot sphere to expand until it filled a pressure vessel and then allowing the gas to flow out through a nozzle. This process would be repeated many times (see ADN-2). The allowable pressures and the specific impulse one might expect are discussed in ADN-6, ADN-1 respectively.

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We now want to calculate the weight of pressure shell required per kiloton yield of bomb, assuming all the energy to be distributed uniformly in the hydrogen. If the shell radius is r , the total energy contained in the hydrogen is

$$E = \frac{4}{3} \pi r^3 \frac{\rho}{\gamma - 1} \quad (1)$$

The shell volume is

$$V_{sh} = 4 \pi r^2 T \quad T = \text{thickness} \quad (2)$$

If the pressure is equal to the static failure pressure then

$$T = \frac{\rho r}{2S} \quad S = \text{tensile strength} \quad (3)$$

The shell weight is therefore

$$W = 4 \pi \rho r^2 T = \frac{3(\gamma - 1)}{2} \frac{\rho E}{S} \quad \rho = \text{shell density} \quad (4)$$

Using $\rho = 8 \text{ gm/cm}^3$, $E = (0.41) 10^{20} \text{ erg/kt}$, $S = 30,000 \text{ psi}$,

$\gamma = 1.40$ we obtain from (4),

$$W \approx 10^5 \text{ tons/kiloton} \quad (5)$$

Since several kiloton yields are required for high efficiency such a device seems quite impractical.

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