Additional information

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PAGES (including Cover Sheet): 3

REF: "Pulsing-Thrust" Technique and the Second Law of Thermodynamics

We have received several inquiries about the "pulsing-thrust" technique. The enclosed description answers the important question of compatibility with the second law of thermodynamics.

In conventional steady-state combustion, there is continuous free-expansion within the same system, and hence no useful work (or thrust) is done. This is similar to the Joule's free expansion experiment where the compressed gas in one vessel does work on the gas flowing into the connected vessel; but there is absolutely no useful work because "the work is done by one part of the system on another part; and is not by the system as a whole on its surroundings." This is to say, that the part of the combustion gas which expands the combustion chamber does no useful work. Alternatively, the internal high pressure in the chamber increases the kinetic energy of the gas molecules within the chamber (in addition to the useful thrust, F_1).

In "pulsing-thrust," the same situation as described above occurs during the upsurge of pressure. However, on termination of the pulse, the internal pressure is allowed to flow into the surroundings (i.e., out of the nozzle) and, hence, useful work, F_2, is done.

In both cases, the entropy is positive, and the second law of thermodynamics is not violated. The second law is violated only if the entropy is negative. At the ideal limit of "pulsing-thrust" operation, the entropy will be zero. In practice, there will be energy losses, and the entropy will be a positive value, but much less than in steady-state combustion.

It is true that the efficiency of rocket engines has reached 99% of steady-state combustion. But, this is only 99% out of 200%; or more accurately, 50% of 100%. "Pulsing-thrust" utilizes that part of the combustion energy that is usually dissipated into strain energy, heat and other forms of unusable energy.

The same 2:1 (or 100%) advantage has been derived and confirmed in our other write-ups from other engineering areas, including, transient dynamic response, mechanical work, physics, electronic engineering, etc.; and with supporting data from tests or operational measurements.

We look forward to hear from you, and to work with your teams.

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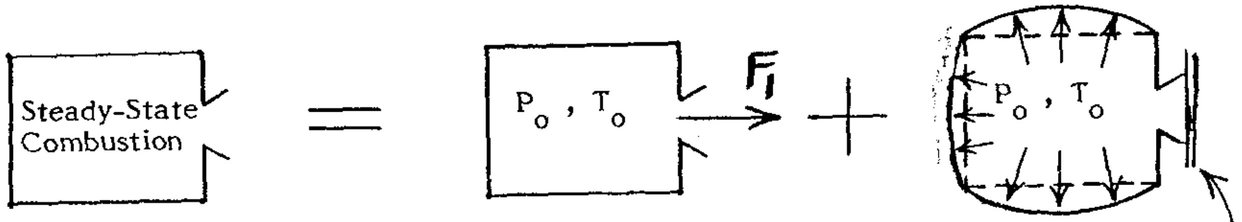
Conventional steady-state combustion produces
USEFUL THRUST, F_1, plus (EQUALLY) WASTED HEAT, Q_1

The total ENTROPY of the COMBUSTION SYSTEM increases: $S \geq \frac{Q_1}{T} \geq 0$
Therefore, the second-law-of-thermodynamics is not violated.

For example: Strain energy maintained (or wasted) throughout flight (or combustion)



Free expansion occurs within the system, and no useful work is done.

System closed to the surroundings

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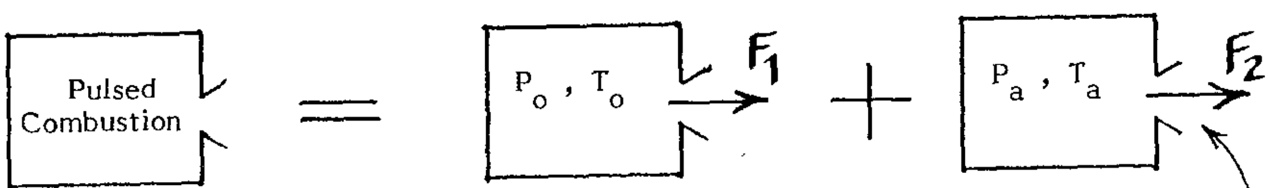
Pulsing-thrust combustion produces
USEFUL THRUST, F_1, plus (EQUALLY) USEFUL THRUST, F_2

The total ENTROPY of the COMBUSTION SYSTEM is small: $S \geq 0$
Therefore, the second-law-of-thermodynamics is not violated.

For example: Strain energy is recovered during flight (or combustion)



Free expansion into surrounding, and useful work (or thrust) can be done.

System open to the surroundings

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Pulsing-thrust utilizes combustion energy that is wasted in other methods.

P_o is Operating pressure (high)

T_o is operating temperature (high)

P_a is ambient (or sink) pressure

T_a is ambient (or sink) temperature

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