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Technical Comments

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Comment on "Numerical Studies on Specific Impulse of Partially Filled Pulse Detonation Rocket Engines"

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THE authors of [1] are to be commended for their physically appealing and transparent development of the "empirical formula" given by Eq. (7) that simultaneously illuminates and correlates their discrete numerical results. The derivation is an excellent application of energetics to the pulse detonation rocket engine problem. The general results and the reasoning that led to them should be useful to the entire pulse detonation propulsion community.

Nevertheless, the rocket must also carry the "inert" mass aloft, and therefore system designers must be concerned with propulsion performance based upon the total mass flow rate rather than just the "detonable" mass flow rate. With this in mind, it can be easily shown that the "overall specific impulse" based on the total mass flow rate (i.e., detonable mass flow rate plus inert mass flow rate) becomes

$$I_{\text{sp,overall}}/I_{\text{sp,full}} = \sqrt{Z}, \quad \text{where } Z = \frac{m_{\text{detonable}}}{m_{\text{detonable}} + m_{\text{inert}}} \leq 1$$

This version of Eq. (7) of [1] reveals that the total mass flow rate must increase in proportion to $1/\sqrt{Z}$ to maintain constant thrust. Put simply, this means that to obtain the detonable mass based specific impulse benefits associated with partial filling, the rocket engine and the propellant tanks must be made larger to accomplish a fixed mission.

This result has similar implications for airbreathing pulse detonation engines, even though their inert mass is obtained from the atmosphere, because these devices must process more total mass flow to obtain the detonable mass based specific impulse benefits associated with partial filling. A useful and relevant mental image for this situation is presented by the modern high bypass turbofan engine, which operates on the same physical principle of spreading the available kinetic energy over more mass flow to increase the total thrust. In this manifestation of the concept, it is evident to the naked eye that the required fan and bypass duct dwarf the original core engine.

References

[1] Sato, S., Matsuo, A., Endo, T., and Kasahara, J., "Numerical Studies on Specific Impulse of Partially Filled Pulse Detonation Rocket Engines," *Journal of Propulsion and Power*, Vol. 22, No. 1, 2006, pp. 64–69.

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