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Optimization of Heat Source Assisted Combustion on Solid Rocket Motors

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Abstract : Solid Propellant ignition consists of rapid and complex events comprising of heat generation and transfer of heat with spreading of flames over the entire burning surface area. Proper combustion and thus propulsion depends heavily on the modes of heat transfer characteristics and cavity volume. Fire safety is an integral component of a successful rocket flight failing to which may lead to overall failure of the rocket. This leads to enormous forfeiture in resources viz., money, time, and labor involved. When the propellant is ignited, thrust is generated and the casing gets heated up. This heat adds on to the propellant heat and the casing, if not at proper orientation starts burning as well, leading to the whole rocket being completely destroyed. This has necessitated active research efforts emphasizing a comprehensive study on the inter-energy relations involved for effective utilization of the solid rocket motors for better space missions. Present work is focused on one of the major influential aspects of this detrimental burning which is the presence of an external heat source, in addition to a potential heat source which is already ignited. The study is motivated by the need to ensure better combustion and fire safety presented experimentally as a simplified small-scale mode of a rocket carrying a solid propellant inside a cavity. The experimental setup comprises of a paraffin wax candle as the pilot fuel and incense stick as the external heat source. The candle is fixed and the incense stick position and location is varied to investigate the find the influence of the pilot heat source. Different configurations of the external heat source presence with separation distance are tested upon. Regression rates of the pilot thin solid fuel are noted to fundamentally understand the non-linear heat and mass transfer which is the governing phenomenon. An attempt is made to understand the phenomenon fundamentally and the mechanism governing it. Results till now indicate non-linear heat transfer assisted with the occurrence of flaming transition at selected critical distances. With an increase in separation distance, the effect is noted to drop in a non-monotonic trend. The parametric study results are likely to provide useful physical insight about the governing physics and utilization in proper testing, validation, material selection, and designing of solid rocket motors with enhanced safety.

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