A computer-based tool for preliminary design and performance assessment of Continuous Detonation Wave Engines

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The Continuous Detonation Wave Engine (CDWE) is a concept of rocket engine based on local pressure increase in the combustion chamber through the use of detonation. Detonation is a rapid and violent form of combustion in which all important energy transfer is by mass flow in strong compression waves. It is characterized by a faster burn rate and higher energy release rate as compared to deflagration. In theory, rocket engines based on detonations are expected to have a better performance than conventional engines in terms of engine cycle efficiency and specific impulse due to the more efficient thermodynamic processes [1, 2]. As the current technology of classical liquid rocket engines (LRE) is approaching its physical limits, and further performance improvements are very difficult to achieve, the use of detonation for propulsion applications becomes increasingly interesting due to the significant improvements it can theoretically achieve. However, although the technology seems very promising in theory, many practical difficulties still need to be overcome and are therefore currently being investigated, numerically as well as experimentally, to bring this concept to reality.

To allow an easy parametric analysis and performance assessment of a CDWE, a computer-based tool is being developed to simulate the engine operational process. The goal is to develop a fast and simple tool to study the influence of different design parameters on the performance of a CDWE and for preliminary design of launch vehicles equipped with this propulsion technology. The CDWE geometry under consideration consists of an annular combustion chamber with diameter d_c, length L, and wall thickness Δ as shown in Figure 1. The model consists of three main parts: (1) detonation, (2) expansion in the combustion chamber, and (3) expansion in the nozzle. The parametric analysis is mainly focused on the effects of the variation of several input parameters such as the injection pressure, mixture ratio, and combustor geometry. Then, a design case study is done to assess the potential performance advantage of a CDWE as the core or upper stage engine of a launch vehicle. An initial estimation of the performance gain achieved when integrating a CDWE in the upper stage of the Ariane 5 ESC-B is done based on previous models from other authors [3]. From theoretical considerations it is expected that, for similar injection conditions and exit pressure as those of the Vinci engine, an increase in specific impulse of nearly 15 seconds can be achieved with a geometrically smaller nozzle.

In the proposed paper the model and the results obtained from the design case study will be presented.

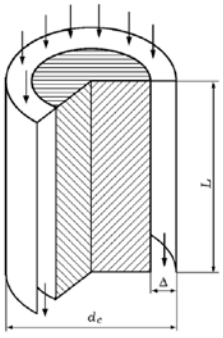

Fig. 1 Schematic of a CDWE combustion chamber [4]

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