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Abstract

The emergence of the Hall thruster concept from the jealously guarded arena of the former Soviet Union to the worldwide space technology scene around the early 1990s triggered a revolution. It was decisive in allowing Electric Propulsion as a whole to unchain from the stigma of research-bound, ever-immature technology that had characterized it for almost fifty years, and gain the role of key enabler of future in-space propulsion applications. When the Hall thruster concept took hold in western countries it started undergoing a new evolutionary phase. Simple replications of the SPT 100 archetype that had served as a reference in this migration, left the floor to early attempts to explore novel implementations of the concept, especially in terms of extension of thruster power level. For several years the standard remained focused around the 1.35 kW of the SPT 100. Then, the emphasis gradually shifted towards the 4-to-5 kW range intended for all-electric Telecom satellites; then up to the 10-to-15 kW that might find use in early deep-space forays and more recently to levels in excess of 20 kW to be possibly employed in future exploration missions. It is interesting to see how this process developed. For many years since the beginning of the worldwide spreading of Hall thruster technology, the design of new thrusters was based on the so-called scaling approach. The scaling methodology was based on the basic criterion to try and preserve as far as possible, in the discharge channel, the set of intensive [local] parameters that had proved to be effective and guarantee stable operation in the reference thruster. This methodology was particularly studied in Pisa since the early 2000s and subsequently improved through a series of theoretical refinements and practical implementations. Unfortunately, this approach cannot be retained beyond certain limits; if the thruster physical dimensions are increased as required to accommodate larger power levels, the increase of the thruster dimensions according to geometrical similarity would necessarily entail accepting larger and larger values of Specific Impulse. Alternatively, one could abandon geometrical similarity to keep the Specific Impulse at the desired level, at the price of accepting larger values of the channel width-to-length ratios, with obvious consequences in terms of plume configuration and divergence. In other words, for any desired level of Specific Impulse, the method shows that it is practically impossible to retain at a larger scale the same values of the intensive parameters typical of smaller devices while remaining close to geometrical similarity. Thus, larger thrusters of practical design would only be feasible upon adopting adequately modified physical conditions. This approach would consist in identifying – through modeling and testing – a different combination of intensive parameters that can guarantee efficient performance and stable operation in thrusters intended for much higher power levels within reduced physical dimensions with respect to the current standard. Considering how long it took for the legion of scientists of the former USSR to optimize the SPT type Hall thruster that has served as a reference ever since, it may be understood that such an approach might prove not trivial, despite the improved expertise, the larger specialists community and the more advanced means available nowadays. In the long run, the capability to develop Hall-type single thruster units capable to process larger power levels will prove essential. This is the challenge we will have to face.