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Author: Ms. Sridevi Bhat
Indian Space Research Organization (ISRO), Liquid Propulsion Systems Centre (LPSC), India

Mr. Ashish Mishra
Indian Space Research Organization (ISRO), Liquid Propulsion Systems Centre (LPSC), India

ESTIMATION OF CERAMIC LINER EROSION IN STATIONARY PLASMA THRUSTERS USING DEEP NEURAL NETWORKS

Abstract

Electric propulsion has become a popular alternative for chemical propulsion in spacecrafts. The lifetime of operation of a thruster becomes one of the critical parameters for missions demanding longer operation hours. To assess the lifetime of thruster, ideally it would require to undergo a full life time qualification. Such a full-life qualification test is highly time consuming and costly due to fuel costs and facility operation costs. Hence, a more cost effective and quicker approach is required in determining the operational lifetime of these thrusters. With the help of liner erosion measurements many approaches like theoretical models, empirical methods, semi-empirical methods etc., are being currently used to predict the lifetime. Although factors like material deposition on electrodes, shorting, etc., can have an impact on the lifetime, it is highly influenced by the liner erosion caused by ion sputtering on the channel wall. The existing methods for prediction of erosion of liners are not fully accurate and hence active research is being carried out to develop better estimation methods.

DEEP NEURAL NETWORKS FOR LINER EROSION ESTIMATION

This paper attempts to use a new approach in predicting the liner erosion with the help of Deep Neural Networks. The idea is to use measurement of liner profiles for a set of hours of operation and predict the erosion for future hours of operation. In a previously published work of ours, (IEPC-2019-749) for a 300W thruster liner profile measurements were made at 10 unequally spaced time instants throughout all the axial positions for both inner and outer liners. Artificial Neural Networks with two hidden layers and back-propagation algorithm was implemented for predicting liner erosion and results were compared with Non-linear regression method using exponential function. However, for implementation of Deep Neural Networks, large amount of data is required. Since profiles were measured at only few time instants, there is acute shortage of data. Therefore, to mitigate this, augmentation of synthetic data is done for the time stamps in between. Synthetic data is generated from available liner profile measurements for a particular thruster by Non-linear regression using exponential function. The liner profiles are generated at every hour. With larger dataset created, Deep Neural Networks were implemented for both inner and outer liners separately. Using Deep Neural Networks, erosion of liner is predicted for future time instants for inner and outer liners. This method has solved the problem of data shortage and has delivered encouraging results.