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ANALYTICAL AND NUMERICAL INVESTIGATIONS OF HOT WIRE FOAM CUTTER FOR AEROSPACE SYSTEMS APPLICATIONS

Abstract

There is currently an ambitious spread of aerospace and space industry on nongovernmental levels. Some space applications are now attainable by universities and small size institutions and companies. In addition, the material used in manufacturing space products is usually expensive. Thus, the ability of prototyping with a cheap material like EPS foam is very useful. The technique of using a hot wire to cut foam in different shapes is already defined in the literature. In aerospace applications it has important use of cutting foam sheets to produce aircraft wings with certain airfoil cross section. The bowing or deflection of the wire makes a precise cut of the airfoil a difficult process. In space products with parts of exact sizes and perfect surface finishing, the deflection of the hot wire during foam cut becomes a very critical parameter. In this research a parametric study to investigate possible ways to minimize the bow of the hot wire during the foam cutting process is carried out. A mathematical analysis of the wire deflection and bowing during cutting process is introduced. A set of dimensionless variables can be introduced to obtain a normalized equation of wire deflection. Then, mathematical modelling of all resisting forces on the wire in one collective model is reviewed seeking modifications to include other effects. A numerical investigation to simulate the real cutting conditions is conducted. The relation between wire temperature and feed rate at normal operating points for Nichrome wire with half millimeter thickness is represented. It shows that when temperature of the wire increases the feed rate can increase. However, at the highest temperature the relation ceases to be monotonic. At this narrow interval there are two possible feed rates at the same temperature. One explanation is that at high temperature the wire material becomes nonlinear after start melting. To complete our research, experimental setup is planned to include measuring the tension in the wire at the steady state cutting condition in case of bowing of the wire. Based on this intended experimental work, the analytical form of wire deflection will be updated as well as the form of resisting force as a function of temperature. When a steady state situation is reached the neat external forces given by the motors are equal to the total resisting force on the wire including all effects. Experimental results are then compared with the numerical results and the mathematical analysis.