

Chapter 9

The Impact of FEM Modeling Parameters on the Computed Thermo–Mechanical Behavior of SLA Copper Shelled Electrodes

Vassilios Iakovakis

Technological Educational Institute of Larissa, Greece

John Kechagias

Technological Educational Institute of Larissa, Greece

George Petropoulos

University of Thessaly, Greece

Stergios Maropoulos

Technological Educational Institute of West Macedonia, Greece

ABSTRACT

In this study, the authors use the finite element method to model and analyse a cylindrical copper shelled SLA electrode for EDM operations, which is investigated experimentally in literature. A uniform silver paint thickness and copper shell thickness is assumed around the SLA epoxy core. In the experiment, 2-D analysis was used due to the axissymmetric shape, and steady state and transient die sink EDMing simulations were followed. Modelling parameters are varied and their impact on the resulting temperature and stress fields is evaluated. The intermittent nature of the electrode thermal loading is also simulated with FEM transient analysis. It is shown that, using the finite element method, the influence of the copper shelled SLA electrode manufacturing and EDM-process parameters can be studied.

DOI: 10.4018/978-1-4666-1867-1.ch009

INTRODUCTION

Electro-Discharge Machining (EDM), one of the most extensively used non-conventional material removal processes, has been studied extensively by a number of researchers (Ho & Newman, 2003; Kechagias et al., 2008). In addition, EDM electrode fabrication attempts, using Stereo-Lithography Apparatus (SLA) prototypes or patterns, were made (Jacobs, 1996; Björke, 1992; Arthur et al., 1996), in parallel to RP development. It was proposed that an investigation of the electro-deposition of metal coatings, especially if it is applied on a complex geometry, is required.

An investigation of heat distribution and the associated failure modes of the above electrodes was conducted (Arthur & Dickens, 1998). It was concluded that the electrode failure occurs through a combination of thermal effects which lead to several failure modes. Moreover, attempts to improve electroplated electrode efficiency were made using copper pyrophosphate electrolyte instead of acid copper in the stage of secondary metallization of the electrode (Bocking et al., 1997). Although good pore closure properties were achieved in this way, the shear stresses between the epoxy core and the copper increased due to the operating temperature (55 °C) resulting in distortions of the electrode shell.

A finite elements analysis was performed in an electrode with simple cylindrical form (Mathew, 2005) in order to identify the failure mechanism of electroformed stereo-lithography electrodes using LSDYNA-970. The FEM model is validated by comparing calculated temperatures to measured ones. It was concluded that the temperature distribution and coefficient of thermal expansion mismatches are the main reasons for high stresses, which in turn could cause the premature failures experienced in these types of electrodes. Some design modifications including heat conduction channels and stress relaxation notches did notably alter the temperature and stress distribution in the electrode (Iakovakis et al., 2009), that was

modeled using ANSYS. Mesh refinement, which was done in the latter work, has some significant influence on the calculated stresses but not on the temperature distribution.

In the present work thermo-mechanical simulations were applied in the same cylindrical copper shelled SLA electrode using again the ANSYS FEM commercial code. The electrode consists of an SLA epoxy core surrounded by a copper shell. A thin layer of silver paint is inserted between them. The thicknesses of the silver paint and the copper shell are assumed as uniform and constant around the SLA epoxy core. Due to the axis-symmetric shape, a 2-D analysis was used, and simulations mainly in steady state die sink EDMing conditions were followed. Emphasis was given this time on the dominant simulation parameters such as the value of the thermal load, the influence of the ambient and the dielectric fluid temperature and the need of the incorporation of the silver paint layer in the FE model. The ability of the used software to handle the intermittent loading of the electrode during real EDMing was also tested.

It is clearly stated, that the scope of this work is the investigation of the impact of the modelling parameters on the computed temperature and stress distribution. Accompanying the simulation with some evidence of its validity, the FE analysis could be a powerful tool not only for the prediction of the premature failure of the copper shelled SLA electrodes but also for the improvement of their performance.

THERMOMECHANICAL SIMULATIONS

As aforementioned, the thermal load generated during EDM (Figure 1) causes failure of the SLA electrodes. The very unlike response to heat of the resin core and the copper shell is the main reason for most failure modes (Arthur & Dickens, 1998). This is justified as it is well known that heat affects distortions, which depend on the physical

8 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/impact-fem-modeling-parameters-computed/67780

Related Content

Retrofitting of R404a Commercial Refrigeration Systems with R410a and R407f HFCs Refrigerants

Mauro Gamberi, Marco Bortolini, Alessandro Graziani and Riccardo Manzini (2015). *Handbook of Research on Advances and Applications in Refrigeration Systems and Technologies* (pp. 260-294).

www.irma-international.org/chapter/retrofitting-of-r404a-commercial-refrigeration-systems-with-r410a-and-r407f-hfcs-refrigerants/136751

Effect of Variable Gravity on the Thermal Convection in a Layer of Maxwellian Visco-Elastic Nanofluid

(2017). *Nanofluid Technologies and Thermal Convection Techniques* (pp. 124-140).

www.irma-international.org/chapter/effect-of-variable-gravity-on-the-thermal-convection-in-a-layer-of-maxwellian-visco-elastic-nanofluid/175601

Electroless Nickel-Phosphorus Composite Coatings: A Review

Prasanna Gadhari and Prasanta Sahoo (2016). *International Journal of Manufacturing, Materials, and Mechanical Engineering* (pp. 14-50).

www.irma-international.org/article/electroless-nickel-phosphorus-composite-coatings/143058

A Review on Fabricating Procedures in Rapid Prototyping

Ganzi Suresh and K. L. Narayana (2016). *International Journal of Manufacturing, Materials, and Mechanical Engineering* (pp. 23-40).

www.irma-international.org/article/a-review-on-fabricating-procedures-in-rapid-prototyping/146821

The Offset Model of a Hexapod Robot and the Effect of the Offset Parameter

Kazi Mostafa, Innchyn Her and Yi-Hsien Wu (2012). *International Journal of Manufacturing, Materials, and Mechanical Engineering* (pp. 52-59).

www.irma-international.org/article/offset-model-hexapod-robot-effect/68869