

Modelling Phase Change in a 3D Thermal Transient Analysis

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ABSTRACT

A 3D thermal transient analysis of a gap profiling technique which utilises phase change material (plasticine) is conducted in ANSYS. Phase change is modelled by assigning enthalpy of fusion over a wide temperature range based on Differential Scanning Calorimetry (DSC) results. Temperature dependent convection is approximated using Nusselt number correlations. A parametric study is conducted on the thermal contact conductance value between the profiling device (polymer) and adjacent (metal) surfaces. Initial temperatures are established using a linear extrapolation based on experimental data. Results yield good correlation with experimental data.

Key words: Transient thermal analysis, Phase change, Gap profiling

1. INTRODUCTION

Manufacture and assembly of structures is a complex process wherein the final stages of assembly gaps may be found between mating surfaces of components that are to be mechanically-fastened[1]. This fact is inherent in all manufacturing and assembly processes as the control over such processes are always finite[2], however the variations are reported to be larger in components manufactured using composites as opposed to traditional engineering alloys[3]. The gaps arise due to an individual component's manufacturing tolerances, which when placed in their respective final positions present significant deviations from their nominal dimensions due to the summation of the individual variations. These gap heights typically range from 0 to 2.5 mm.

The Gap Sachet (Figure 1) is a device created for the purpose of profiling gaps arising between mating faces of components and is intended for use in conjunction with one of the many 3D surface digitizing technologies for digital mapping[4]. The device works by injecting a moulding material, plasticine (in its liquid state), into a fabricated thin plastic film (nylon) retainer which is placed into the gap to be profiled. The injection is achieved by a heated motorised-extruder unit, having fixed mass flow rate and injection temperature. The plasticine within the Gap Sachet is allowed to cool and upon hardening it is removed providing a sectional profile of the gap.

This paper aims to model in ANSYS v11.0, the various transient thermal processes involved during the cooling of the Gap Sachet, including the phase change of plasticine and the effect of thermal contact conductance between a polymer-metal interface. The thermal effects taking place during the injection process is approximated and applied as a time dependent thermal load to describe the initial conditions. The results obtained are compared with experimental data.

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