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Novel round energy director for use with servo-driven ultrasonic welder

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Abstract

Increasingly stringent process repeatability and precision of assembly requirements are common for high-volume manufacturing for electronic, automotive and especially medical device industries, in which components for disposable medication delivery devices are produced in hundreds of millions annually. Ultrasonic welding, one of the most efficient of plastic welding processes often joins these small plastic parts together, and quite possibly, the one most broadly adopted for high volume assembly.

The very fundamental factor in ultrasonic welding process performance is a proper joint design, the most common of which is a design utilizing an energy director. Keeping the energy director size and shape consistent on a part-to-part basis in high volume, multi-cavity operations presents a constant challenge to molded part vendors, as dimensional variations from cavity to cavity and variations in the molding process are always present. A newly developed concept of energy director design, when the tip of the energy director is round, addresses these problems, as the round energy director is significantly easier to mold and maintain its dimensional consistency. It also eliminates a major source of process variability for assembly operations.

Materializing the benefits of new type of joint design became possible with the introduction of servo-driven ultrasonic welders, which allow an unprecedented control of material flow during the welding cycle and results in significantly improved process repeatability. This article summarizes results of recent studies focused on evaluating performance of round energy director and investigating the main factors responsible for the joint quality.

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Keywords: Ultrasonic Welding; Joint Design; Round Energy Director Process Repeatability

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1. Introduction

One of the most important factors in the ultrasonic welding process optimization is a proper joint design. Parts to be welded are commonly designed to have a small initial contact in the interface area in order to concentrate the ultrasonic energy and initiate melting at the interface (Mike J. Troughton, (2008)). For many applications this is done by means of an energy director (ED), a sharply pointed triangular rib molded onto the surface of one of the parts. As the ED is designed to provide a small pointed initial contact area, its size and shape, or rather its sharpness, roundness, or flatness of the tip, becomes a critical factor in the welding process. The geometrical consistency of the ED, both along a single part and on a part-to-part basis, determines to a large degree the process repeatability, weld joint quality and strength.

Keeping the ED's size and shape consistent on a part-to-part basis in high volume, multi-cavity operations presents a constant challenge to molded part vendors as dimensional variations from cavity to cavity and variations in the molding process are always present. Inconsistencies in ED shape are caused by unavoidable differences in steel machining for different cavities, problems with venting of some cavities, accumulation of debris in the cavities and machine tool and molding machine equipment ageing. As the requirements for part tolerances become more stringent in modern manufacturing these factors translate to increased QA and maintenance cost for molded parts suppliers.

Part-to-part variation in the size and shape of the ED presents a challenge for end-users in maintaining welding process' consistency. For industries like medical device manufacturing, electronics, automotive, and others, a more robust design of an ED that eliminates this source of variability in the joining process could aid manufacturing in meeting strict quality requirements and improved assembly line performance, leading to reduced operations cost and higher efficiencies.

2. Approach

The purpose of series of trials performed at Dukane, EWI and OSU (Alex Savitski et al. (2014), Alex Savitski (2015), Miranda Marcus et al, (2016), Alex Savitski et al. (2016)) was to evaluate and compare the performance of round and sharp EDs, as well as to generate comprehensive performance data for the round ED in a wide range of process settings. Such process settings included the cases where the weld strength was not necessarily maximized, i.e., when using a reduced weld distance and amplitude to identify critical process factors determining the weld quality.

This article summarizes the main findings of these studies and presents a case for a novel joint design, leveraging the benefits of round ED with the advanced process control capabilities provided by servo-driven ultrasonic welding systems.

All experiments were carried out using Dukane ISTeP molded parts (Figures 1, 2 and 3) with a 90˚ (sharp) and R 0.4 mm for round EDs, molded of a common Sabic grade Lexan 121R polycarbonate. This testing part was developed by Dukane to provide a test specimen for ultrasonic welding with changeable joint designs.

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