International Communications in Heat and Mass Transfer 38 (2011) 1067–1072

Contents lists available at ScienceDirect

International Communications in Heat and Mass Transfer

journal homepage: www.elsevier.com/locate/ichmt

Optimization of injection parameters for mechanical properties of specimens with weld line of polypropylene using Taguchi method ☆

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ARTICLE INFO

Available online 10 May 2011

Keywords:
Plastic injection molding
Weld line
Mechanical properties
Taguchi method
ANOVA
Regression analysis

ABSTRACT

This study optimized effect of injection parameters and weld line on the mechanical properties of polypropylene (PP) moldings. The mold with an insert was designed to create weld line in the experimental specimen. Melt temperature, packing pressure and injection pressure were investigated to study their effects on the mechanical strength of specimens with/without weld lines. Taguchi's L_9 (3^3) orthogonal array design was employed for the experimental plan. Mechanical properties such as maximum tensile load, extension at break and charpy impact strength (notched) of the specimens were measured. Signal to noise ratio for mechanical properties of PP using Taguchi method was calculated and effect of the injection parameters and weld line on mechanical properties was determined using the analysis of variance (ANOVA). Linear models were also created by using regression analysis. The most important parameter affecting the maximum tensile load and the extension at break (for specimen without/with weld line) was injection pressure and melt temperature, and for charpy impact strength (notched) (without/with weld line) was melt temperature and injection pressure, respectively.

1. Introduction

The plastic injection molding is one of the most important methods in the plastic sector. In this method, the plastic products have multi-gated molds and inserts can be produced for industry. Weld lines can be occurred in the plastic product when two flow fronts meet due to either multi-gated molds or inserts. The weld line influences the visual and structural of the products.

The weld lines decrease the mechanical properties of injection molded products. The compensation of this problem can be reduced through optimization of the injection molding parameters and design conditions. It can be minimized the visibility of weld lines by adjusting processing conditions or the locations of gates.

Researches on the mechanical properties of injection molded of weld line and injection molding parameters are realized. Selden investigated the effects of the injection molding process parameters including holding pressure, injection velocity, melt temperature, and mold temperature which could affect weld line, impact strength and flexural strength of injection molded parts (PA 6, PPS, PP with 40% talc, PPO and ABS) [1]. Wu and Liang studied the individual contribution of process parameters on the weld line strength of polypropylene (PP) and high density polyethylene (HDPE), using Taguchi's orthogonal arrays under different conditions of injection molding such as mold temperature, packing pressure, melt temperature, injection speed, injection acceleration, and packing time. In the study, they studied the influence of cross-sectional dimensions on the weld line strength [2]. Li et al. analyzed effect of process parameters namely, melt temperatures, injection speed and injection pressure to determine the influence of weld lines on appearance of PP products using Taguchi experimental design method [3].

Yamada et al. investigated influence of flow behavior at the weld line on the mechanical properties (tensile strength) by applying the surface milling technique for general purpose polystyrene [4]. Chen et al. examined effects of cavity surface coating, melt temperature and mold temperature on weld line strength and the quality of ABS material [5]. Chen et al. investigated the influence of processing conditions on the weld line strength of thin-wall ABS parts for single-gate molded specimens (without weld line) and double-gate molded specimens (with weld line)[6].

In this study, the effect of injection parameters and specimens both with weld line and without weld line on the mechanical properties of PP material was optimized. Taguchi's L_9 (3^3) orthogonal array design was used for experimental plan. Signal to noise ratio (S/N) for mechanical properties was obtained and optimum levels of the injection parameters was determined through S/N values to achieve maximum mechanical results. Influence of injection parameters on mechanical properties of the specimen was carried out using ANOVA. Linear mechanical models were also obtained from regression analysis.

2. Definition of Taguchi method

Taguchi method developed by Taguchi consists of three stages which are system, parameters, and tolerance designs, respectively [7]. The

☆ Communicated by W.J. Minkowycz.

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doi:10.1016/j.icheatmasstransfer.2011.04.025