A Laboratory Session in Plastics: Effect of Weld Line on Tensile Plastic Specimen

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I. Introduction

Plastic materials have become irreplaceable and are used as adhesives, textiles, packaging, foams, elastomers, biomedical devices, optic elements, and composites. Such potential applications of plastics are so limitless that there is an exciting future in the plastics industry. Plastics technology is a multidisciplinary subject dealing with materials and properties, testing and characterization, production and process control, parts and mold design, assembly and finishing, process automation and simulation, prototyping, and quality control.

Since the versatility of materials with respect to shaping allows such a wide range of science and techniques to be employed. This results in complex problems for technologists, particularly concerning plastics processing interactions. The complex problems reflect a unique field on a new relationship of the structure-property-process in plastics. In this context, the new experience of technology must be accumulated for students to adopt a “practice-in-theory” in materials engineering courses in engineering technology programs.

“Mechanical Engineering Technology Laboratory II” is a materials laboratory course to provide basic principles in plastics testing for junior students in the Mechanical Engineering Program at Rochester Institute of Technology. The primary goal of this course is to introduce not only theories in plastic materials, but also to provide hands-on-experience in ASTM (the American Society for Testing and Materials) standard plastics testing. There is a general agreement that student’s experience is essential in teaching, since experience-based learning can accelerate students’ abilities to perform creativity, problem solving skills, and team cooperation in the field of engineering technology. Thus, this paper describes an effort made to employ an experienced-based learning in plastics testing.

II. Laboratory Experiment

1. Objective

a. To investigate a defect (weld line) of injection molded plastics.
b. To understand the effect of weld line in the tensile properties of plastics.

2. Background

Weld lines, which are visible marks in plastic molded parts, are a result of the convergence of separate flow fronts in plastics injection molding. Weld lines create a weakness and change material strength characteristics where flow fronts meet. The extent of property change depends on the ability of the two melt-flows to knit together homogeneously[1]. The following parameters can affect weld line integrity: base resin type, part thickness, fillers and reinforcements, and molding process conditions (such as temperature and viscosity of the molten plastic when it meets).

Different types of plastic resins exhibit different characteristics of tensile strength retention at the weld line. The effects of the inherent weld line integrity of the base resin on property loss are reported in Polysulfone (PSU), Styrene Acrylonitrile (SAN), Polypropylene (PP), and Polyphenylene Sulfide (PPS)[2]. SAN, PP, and PPS show some tensile strength loss in unfilled state, while PSU exhibits little or no tensile strength loss. Part thickness does not play a major role in weld line strength retention. The experimental results indicate that the fillers, reinforcements, mold design, and molding parameters affect the retention of tensile strength. Also, the gate location and size, mold temperature, and proper venting are important in the tensile strength of molded plastic parts.

With the complexity of part geometry, the identification of weld line should be critical to prevent a failure of plastic parts in service. In design process, the use of computer software is essential to provide a relatively accurate analysis in mold filling. Thus, possible gating and runner scenarios can be consulted to predict the desired properties of the plastic parts.

3. Experimental Procedure

a. Materials:

Tensile bars are made from a commercial grade polypropylene (PP) in accordance with ASTM D5939. Processing parameters in injection molding are also controlled during molding (Table 1).

Table 1: Processing Parameters in Injection Molding

Material	Melt Temp.	Mold Clamp Pressure	Ram Pressure
PP	238-246°C	46.5 Mpa	106.8 kN

b. Gate Configuration:

Gating configurations are altered to create the presence of weld lines in injection molded specimens: i) Side gate (S.G.: material entered the mold cavity at one end preventing the formation of a weld line in Fig.1) and ii) End gates (E.G.: material entered the mold cavity at both ends in order to create a weld line in Fig. 2).

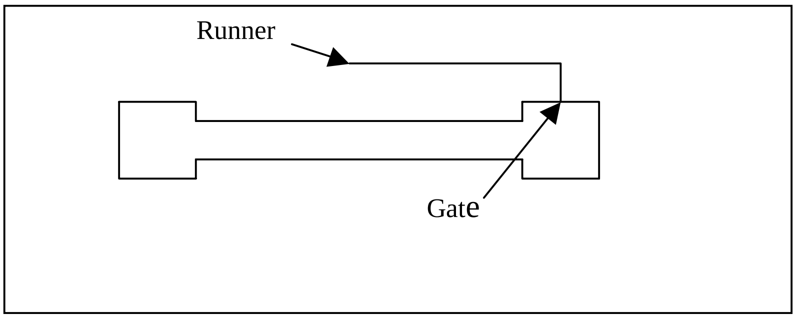

Figure 1: Side gate (S.G.) configuration of a mold cavity for tensile bar

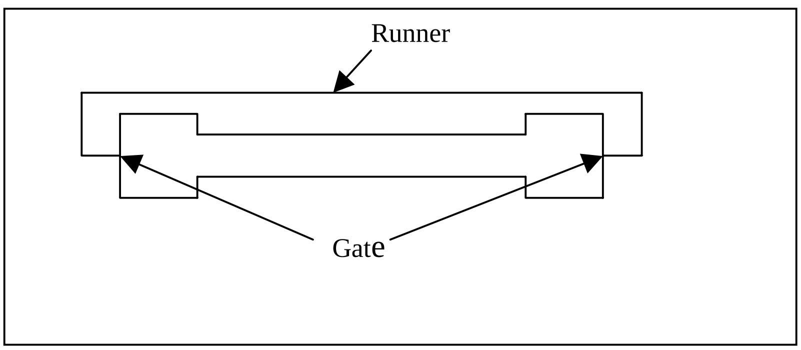

Figure 2: End gate (E.G.) configuration of a mold cavity for tensile bar

c. Tensile Testing:

Tensile testing is performed in accordance with ASTM D638. Ten injection-molded specimens of PP in two different gating configurations are tested at 5 mm/minute (.2 in./min.).

4. Results and Discussion

The average ultimate tensile strength (UTS) values of PP specimens are shown in Table 2: the UTS of PP in E.G. and S.G is 28.4 MPa and 30.4, respectively.

Table 2: UTS of PP Specimens in Two Gate-configurations

Material	UTS (MPa)	UTS (MPa) in Published Data
PP in E.G.	28.4	30*
PP in S.G.	30.4	

Note: The UTS of a commercial grade is used for comparison[3].

The result shows that the configuration of gate does not greatly affect the UTS of PP, although the UTS of PP in E.G. is a little higher than that of PP in S.G. Also, the presence of weld line does not play a major role to influence the tensile behavior of PP. The specimens of PP in E.G. and S.G. gradually elongate and fracture in ductile manner at 5mm/min under tensile loading (Fig. 3). The presence of weld lines induced by such different gate configurations may not affect the tensile behavior of PP under the experimental conditions. Thus, the processing parameters of injection molding may contribute to the results of this experiment.

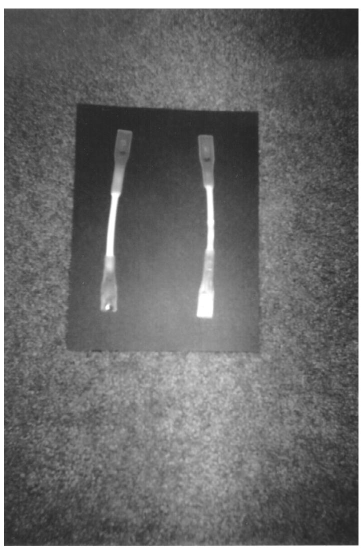

Figure 3: Typical PP specimens of E.G. (left) and S.G. (right) after tensile loading

III. Expectation from Students

This laboratory experiment is specifically concerned with the following outcomes from students:

- Comprehension: To help students comprehend theoretical concepts in plastic materials and injection molding process.

- Motivation: To motivate students for enhancing principles in plastics testing.
- Synthesis: To encourage students for synthesizing knowledge and experience in problem solving.

Conclusion

There are many laboratory projects that can compliment material engineering courses for engineering technology students. This paper presents an attempt to develop a laboratory exercise in the basis of a "practice-in-theory." This laboratory exercise also provides a guide to approach a real world problem for solving. However, the relationship between weld line and tensile strength loss (or retention) should be analyzed using a mold filling software: we will report more details in the conference.

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