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Measurement of Tensile Strength on Engineering Polymers Used in Plastic Rail Terminal Parts

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Abstract: Engineering polymers are of great importance in plastic rail terminals used in electrical panels in many sectors. Polyamide is fatigue resistant with a low coefficient of friction and has high tensile strength, is the most important of these polymers. In this study, the mechanical properties of engineering polymers used in the production of these terminals under different ambient conditions will be investigated. Tensile test specimens were obtained by plastic injection molding to determine the optimum injection parameters for these properties. A plastic injection machine (Arburg) and metal mold were been conducted to plastic experiments. Taguchi L_8Experimental design was used to examine the parameters of cooling time, injection speed, mold temperature and runner type. From this study, it can be seen that runner gate way is most effective parameters among four parameters. As a result, the effect of runner gate ways used in plastic injection molds on tensile strength was investigated.

Keywords*:* Engineering polymers, Injection molding, Tensile test, Plastic rail terminals, Taguchi design

Introduction

Polymers are materials composed of large molecules. They can be found in pure form in nature or can be chemically produced in a laboratory environment. Today, they are used in many fields such as packaging, automotive, construction, electricity, electronics, medicine, textile and agriculture sectors. The expected mechanical properties vary according to these areas of use. Polymers are produced in standards suitable for the sector with different test methods (Ezdesir et al., 2006)

In all sectors, electrical connectors are used to provide electronic transmission. There are certain properties that these electrical connectors must have. Polyamides are one of the polymers used to provide them. Polyamides are synthetic polymers. In terms of mechanical properties, polyamide 66 (PA66) is used in plastic rail terminals. It maintains its electrical properties in a wide temperature range, which is an important condition in plastic rail terminals (Akyuz, 2006). Polyamides have high tensile strength and creep resistance. They are resistant to abrasion resistance, fatigue and repeated impact toughness. Polyamides are available in many varieties and can be produced with crushing additives, making them an important choice for recyclability (Yan et al., 2016). However, the ideal ratio of crushing ratio should be determined, otherwise mechanical properties may deteriorate. The melting point of polyamide polymer changes depending on the change in the number of carbon atoms. With the increase in the number of carbon atoms, the melting point decreases (Beaumont et al., 2002).

Mechanical and chemical properties of this polymer should be known for injection molding and production. The viscosity of polyamide is one of the most important properties for the injection molding process (Campo, 2008). The machines and molds used in the injection process must meet the conditions for the production of the relevant polymer. For this reason, many injection parameters come into play. Researchers have examined that cooling time, mold temperature and injection speed are critical injection parameters. They tested the changes in the strength of the parts produced in the light of these parameters (Farotti et al., 2017). Another group studied the variation of tensile strength with the help of fiber reinforcement (Yallew et al., 2020). Different composites were created using various filler materials and their tensile strengths were compared (Liu et al., 2004; Lingesh et al., 2017). In another study, although the optimum values of these parameters are determined from catalogs, they are mostly found by testing during the production process. Depending on the characteristics of the part mold used, the injection parameters selected may have a positive or negative effect on the quality of the resulting part. In order to determine these parameters, simulation programs can be used to have an idea about the parameters related to part and mold design (Mehatet et al., 2011).

In this study, the mechanical properties of PA66 polymer used in plastic rail terminals were investigated according to different injection parameters. These injection conditions are injection speed, mold temperature, cooling time and runner type. With the help of minitab program, tensile and impact test specimens were obtained according to Taguchi L8 experimental design (Minitab Statistical Software, 2007). By using Taguchi method, time and production cost were saved. Tensile tests were performed on the obtained specimens in accordance with ASTM D-638 Standards (2010). According to the test results, the optimum injection parameters were compared. According to the data obtained from this study, it can be said that the most effective parameter is the runner type.

Method and Materials

Fabrication of the Mold Parts

In this study, plastic mold design was carried out by determining the test specimens according to the standards in the injection mold of PA66 natural polymer material. Mold parts were produced on a CNC machine to inject the plastic specimen (Figure 1). Another feature of the plastic mold is that the runner inlets are interchangeable. With these mold features, it was designed to take specimens for tensile, bending and impact tests in the mold.

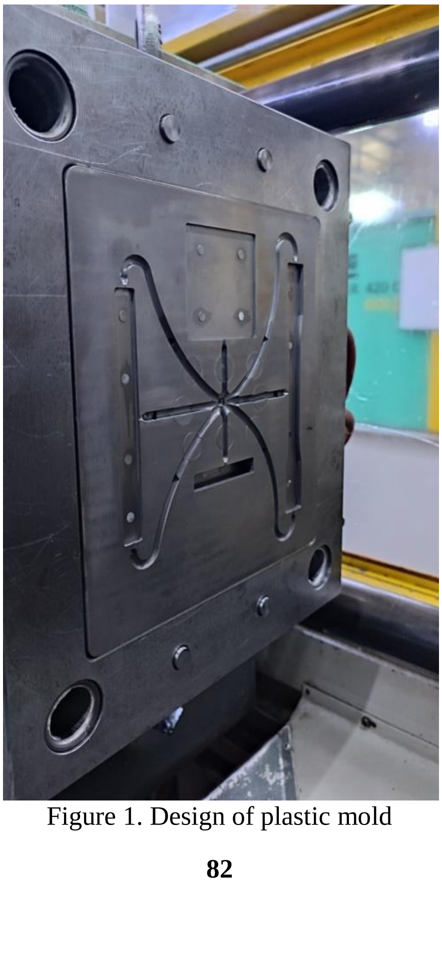

Figure 1. Design of plastic mold

Tensile test specimens were injected from the produced mold. There are differences between these specimens depending on the production parameters. In the light of these differences, many test specimens were produced. Many injection parameters and runner inlet types were used to ensure the diversity of the test specimens. By closing and opening the runners, different specimens were obtained with the same injection parameters.

Materials and Parameters

The properties of the raw material from which the specimens used in the tests were taken are given in Table 1. The trade name of the raw material used in this study is Zytel EFE1068 NC010T.

Table 1. Process conditions

Property	Units	Values
Melt temperature	℃	280 - 300
Mold temperature	℃	50 - 90
Density	g/cm^3	1.14
Drying temperature	℃	80

For the tests to be performed, the injection molding parameters of the specimens to be taken with polyamide 66 raw materials were determined. Many values were used to determine the most effective of these parameters. Apart from these injection parameters, runner types were created as single runner inlet and double runner inlet according to the runner types. Thus, the effect of the filling type of the raw material while forming the test was also examined. The tests were produced as horizontal plastic injection molding on an Arburg injection machine (Figure 2). It is a preferred plastic injection molding machine brand in the sector for many years.

Figure 2. Injection molding machine

The injection parameters used to inject the test specimen in this study are selected from the manufacturer's catalog and given in Table 2.

Table 2. Injection molding process parameters

Parameters	Units	Values
Melt temperature	℃	270 - 280 - 290
Cooling time	s	8 - 10 - 12
Injection time	s	1 - 2 - 3

Tensile Tests

In this study, the mechanical properties of PA66 material were tried to be determined by applying tensile strength test. The aim here is to prepare for the experiments to be carried out later. 8 specimens were subjected to tensile tests using different injection parameters. The tensile speed of the specimens in these tests was span rate 50 mm/min. Tensile tests were performed with a Time brand WDW series machine as shown in Figure 3.

Figure 3. Tensile compression testing machine

Results and Discussion

In this chapter, the results of tensile strength and elongation values obtained from 8 tests performed on plastic specimeninjected from injection molded PA66 material are analyzed and evaluated. The effect of the applied process parameters on the results is also discussed. Displacement was evaluated using an extensometer(Farotti et al., 2017). Table 3 shows the tensile strength and elongation values obtained from the tests. Tensile strength in test 1 are the highest. On the other hand, the tensile strength in specimen 6 are low. On the other hand, the lowest elongation are obtained in specimen 7, while the highest elongation value are obtained in specimen 8.This shows that by optimizing the injection process parameters, the mechanical properties are improved (Yallew et al., 2020).

Table 3. Results of tensile strengthandstrain

Number of tests	Tensile strength MPa	Elongation at yield %
1	77	24
2	76	10
3	75	20
4	74	14
5	73	8
6	73	16
7	72	7
8	76	26

In specimen 8, the reason for the highest elongation is the change in the runner gate type. The mechanical strength increased with the change in the flow direction with the runner gate type.

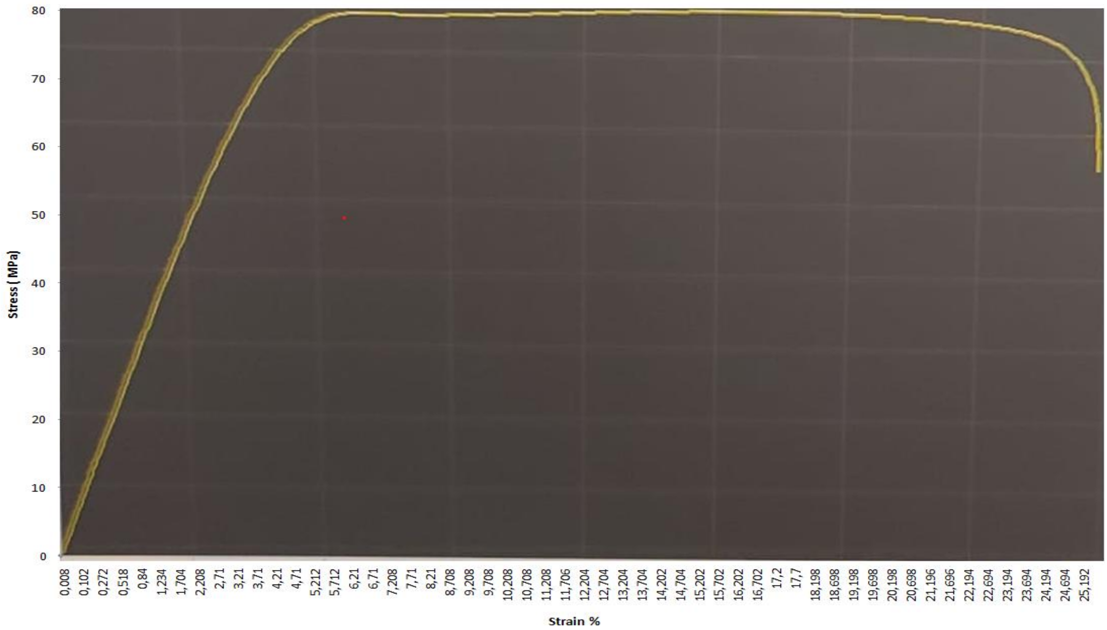

Figure 4. Tensile strengthwithstrain

Conclusions

In this study, the mechanical properties of PA66 polymer used in rail terminals were investigated. The results obtained as a result of tests performed on injected plastic specimens.

- The effect of the injection parameters selected during production is analyzed. Among these parameters, the runner gate type is found to be the most effective.
- In the tests performed without additives, strength change with injection parameters is observed. It is thought to increase the strength by using a certain amount of additives (Ogi et al., 2007).
- The use of the material as a recycling material would be expected to result in a reduction in mechanical properties. (Sen et al., 2020).
- This study has enabled to find the optimum values of the selected injection parameters during the production of PA66 polymer material.
- The PA66 polymer material has a higher strength when compared to high performance polymers. (Yılmaz, 2018)
- A range of three injection parameters has been used for the improvement of mechanical properties.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the authors.

Acknowledgements or Notes

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