Pilot Study for Injection Molding

Wyatt Clegg

Executive Summary

We determined the number of runs needed in a list of experiments to detect significant effects of various factors in an injection molding process. We performed 16 runs of an injection molding process at the same settings to determine the standard deviation of our process. We evaluated the standard deviation and estimated that at least 27 runs are needed in any list of experiments to find a difference of more than 5% shrinkage in our injection molding process.

1 Introduction

An injection molding process is used to form plastic into novel objects. As the plastic is cooled down after the injection molding process, the plastic shrinks. The shrinkage is not uniform, and we want to eventually find the settings of our injection molding process that, on average, minimize the plastic shrinkage in the injection molding process. The following report determines the minimal number of trials needed detect a significant difference between machine settings. We plan on changing the 7 settings for our injection molding process in Table 1 for our planned experiments.

We ran a pilot study to determine the standard deviation of experimental runs at constant settings. We then used a formula to determine the minimal number of runs that are needed to find an experimental difference of 5% in order to reduce shrinkage from 18 to 13 percent.

2 Methods

We'd like to know if there's a change of five percent or greater in our injection molding process shrinkage when we change the settings. Furthermore, we'd like to have power of 0.95 on our experiment, or be able to detect a real difference between machine settings 95% of the time if the process were repeated.

We expect that the data will be normally distributed. Because of this we can use Equation (1) to determine the number of runs we need to achieve power equal to 0.95. N is the number of runs needed for our experiment, σ is the standard deviation of experimental runs, and Δ is the minimum effect we'd like to detect when changing the injection molding process settings.

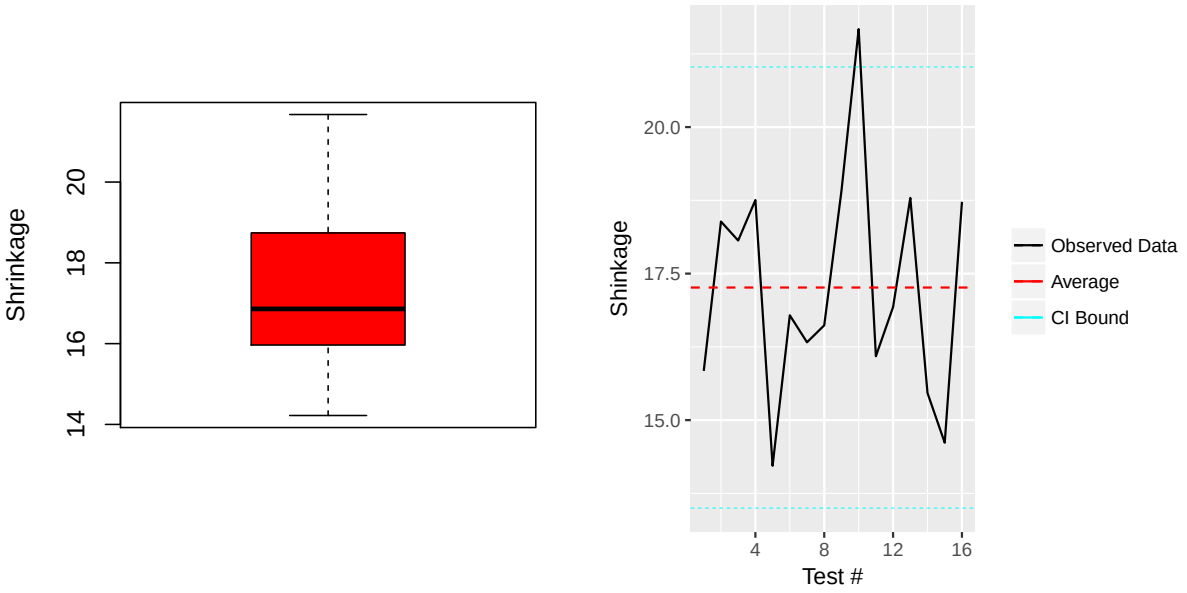
$$N = ((8\sigma)/\Delta)^2. \tag{1}$$

Table 1: Experiment Variables

Variable	Factor Name	Levels
x_1	Mold Temperature (MT)	(High, Low)
x_2	Moisture Content (MC)	(High, Low)
x_3	Holding Pressure (HP)	(High, Low)
x_4	Screw Speed (SS)	(High, Low)
x_5	Booster Presure (BP)	(High, Low)
x_6	Cycle Time (CT)	(High, Low)
x_7	Gate Size (GS)	(High, Low)

Table 2: Summary Statistics for Pilot Study

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.	s
14.2209	16.0276	16.8594	17.2624	18.7324	21.6718	1.9201



(a) Distribution of Pilot Study Responses When All Conditions Held Constant

(b) Pilot Study Data Listed Sequentially

Figure 1: Graphical Representations of Pilot Data

3 Results

We ran the injection molding process 16 times at the current setting. A summary is shown in Table 2, including the sample standard deviation of our sample s. Before applying Equation (1) we checked to see if outliers existed or a linear trend was present.

Figure 1a shows the distribution of the data in a box plot. Notice that no outliers exist, such that we have no reason to believe that the data are non-normal.

There does not appear to be a linear trend within our data. Figure 1b shows the trend of our sampling across time and shows that the response data bounce around the average over time, confirming that there are no time trends in the data.

We can then apply Equation (1). For our equation, we defined $\Delta = 3$ and our estimated sample standard deviation $s = 1.9201$. We defined $\Delta = 3$ because we'd like to see a difference in shrinkage of 5%, and multiple factors presumably will contribute to that difference. We'd like to see a significant effect if it changes shrinkage by more than 3%. Then

$$((8\sigma)/\Delta)^2 = (8(1.9201)/3)^2 = 26.21713.$$

We need about 27 runs to achieve 0.95 power.

4 Conclusions and Recommendations

For our proposed experiment, we'll need to do at least $N = 27$ experiment runs. We are considering 7 factors, such that the full factorial will be $2^7 = 128$. The next step of our experimental process will be designing a list of experiments to find important factors and determine the optimal settings to minimize injection molding shrinkage.