ANALYSIS OF INJECTION MOULDING PARAMETERS

MUNENDRA KOLI[a1] AND VINEET GUPTA[b]

[a]Bharitya Skill Development University, Rajasthan, India
[b]Department of Mechanical Engineering, Dr. K.N. Modi University, Rajasthan, India

ABSTRACT

This research paper is about injection moulding. In this paper the study is done on the factors which are most responsible for the cycle time. These factors are cooling time, injection pressure, demoulding temperature, robust design, pack pressure, shot size while we only considered the three factors, cooling time, injection pressure & demoulding temperature. As cooling time is only responsible almost 50-60 % of total cycle time. To optimize the cycle time by balancing the same parameters, the taguchi and Anova was used. After reviewing of various previous researches, this has been seen that these parts almost not covered or no analysis was done for the cycle time optimization. The experiment was performed on injection moulding machine Milacron 80to and the product business card holder was produced. The material considered for this research is propylene.

KEYWORDS: Cycle Time, Injection Moulding, Injection Pressure, Anova, Taguchi, Regression Analysis, Filling Time, etc.

Injection moulding is an industrial technology first used in the 1872.the injection moulding machine was invented JOHN WESLEY HYTT with his brother ISAIAH. The companies that use injection moulding machines will have a need for optimizing the machine to decrease cycle time and increase as productivity as well profits. This research paper has some desired objectives and analytical data. Injection moulding process involves plastic material, mould and injection moulding machine. In additional to these, the MAN behind the operation is very important, as he should have good understanding of this subject. The advance version of the injection moulding is 3D printing.

Plastic Injection moulding is a manufacturing process which deals with the plastic material. This convert the plastic raw material into the finished product. this process has a use at very large scale. We can observe injection moulding has a scope in industrial as well domestic area. By using this all kind of product can be produced in few seconds.

Main components of the injection moulding machine:

(A) Injection Unit	(B) Clamping Unit
1. Hopper	1. Mould
2. Barrel	2. Ejector plate
3. Heater	3. Clamping motor drive
4. Screw	4. Tie bar
5. Nozzle	

The hopper is the parts where raw material is kept and it is fed into the barrel then it goes nozzle through the heater. There are three temperature zone in the heater.by the scree it moves through the heater. afterward it is fed into the mold. While filling is completed, then cooling starts, afar compilation of all the injection process, the product is ejected by the ejector plate or pin

Figure 1*:* Injection moulding machine

Objectives of The Research

- The main objective of the paper is to analyze cycle time over the different parameters.
- To determine the best suitable cycle time for the product, business card holder
- Experimental analyses for the same product.
- Use the taguchi and Anova methods for the analysis
- To study about the regression methods and find the correlation among the parameters which are responsible for the cycle time.

[1]Corresponding author

- To study about the defects found during the process while optimization of cycle time.

EXPERIMENT

Machine Specification

- IIM Milacron 80to
- Power pack- 20 HP
- 80to injection screw stroke
- Inj. Cap. Max. (GPPS)- 64 gm.
- Number of pyrometer (Barrel & nozzle) –3+1
- Total heat capacity- 6.4KW rpm
- Screw diameter -28mm
- Injection rate- 107 cc/sec
- Screw speed – 40

Raw material

Poly propylene –

- Density of PP-0.91 grams per cubic centimeter (g/cm3
- Melting temp.: 200-300 °C
- Mold temp.: 10-80°C
- No need for drying if stored properly

Figure 0: Raw material

Design of Experiments

The basic need of this research is to analysed the cycle time and to find the statically result. In this, the Taguchi method is most popular and effective for the design of experiments, this is a method to reduce number of experiment required for reaching the research objectives. Taguchi design and the Anova analysis is an 'engineering methodologies for enhancing the quality of work at low cost.

The steps for the analysing the taguchi methods:

- To select the quality characteristics
- To select the signal factors (control factors)
- Selection of noise factors
- Orthogonal array
- Analysis of result
- Report

RESULTS

To reach the objectives of this paper a no. of tests was conducted according to the taguchi methods or L9. The experimental works were done on Injection Moulding machine "Milacron IMM 80to". Different settings of cooling time, Injection Pressure, demoulding temperature as shown in Table 3.1. The size of the product is 100 × 60 ×3 mm is produced in the experiments.

Figure 0: Product-business card holder

Each combination of control factor of the orthogonal array has a total of three tests. The experimental results are shown in Table 1 The performance of each experimental arrangement is evaluated by computing their S/N ratio. For the data analysis, the software MINITAB-18 is used. The software MINITAB -18 is first confirmed for its accuracy by matching the results of similar types of problems in the literature. The flow chart for the calculation of S/N ratio as well as ANOVA. The taguchi and Anova analysis was done successfully using the software.

Table 1: L9 Orthogonal array

Cooling time	Injection pressure	Demoulding temp	Cycle time	remarks	SNRA1	MEAN1
9.5	90	115	20.4	Bad	-26.1926033	20.4
9.5	120	92	19.6	Bad	-25.8451214	19.6
9.5	140	85	21	Bad	-26.4443859	21
7.5	90	92	18	Bad	-25.1054501	18
7.5	120	85	17.5	Good	-24.860761	17.5
7.5	140	115	16.3	Bad	-24.2437521	16.3
3	90	85	14.2	Bad	-23.0457669	14.2
3	120	115	12.7	Bad	-22.0760744	12.7
3	140	92	12	Bad	-21.5836249	12

Calculation of S/N ratio

The SN ratio is calculated by using the following equation

S/N = - 10 log10 (MSD)

For the S/N ratio to be large, MSC must have a value that is small.

For the present work, smaller is the best quality characteristic;

$$MSD = Y1^2 + Y2^2 + - - - + Yn^2/N$$

Where, Y1, Y2 ---------- Yn, are the quality characteristic.

Level average response analysis

The level average analysis is based upon the experimental and observed data or the SN values. The S/N data at each level of each factor is shown in Table 2.

Table 2: selection of levels and their factors

Experimental variables and their levels	Level 1	Level 2	Level 3
Cooling time (sec)	9.5	7.5	3
Injection Pressure	90	120	140
Demoulding temp.(degree)	115	92	85

The level average responses from the raw data help in analysing the trend of the quality characteristic with respect to the variation of the factors under study. The level average response plots based on the S/N data help in optimizing the objective function under study. The peak points in these plots correspond to the optimum condition. The level average responses of Cycle Time in for the same product based upon the S/N ratios. (Table 3)

Table 3: Response table for SN ratio

Level	Cooling time	Injection pressure	Demoulding temp
1	-22.24	-24.78	-24.78
2	-24.74	-24.26	-24.18
3	-26.16	-24.09	-24.17
Delta	3.93	0.69	0.61
Rank	1	2	3

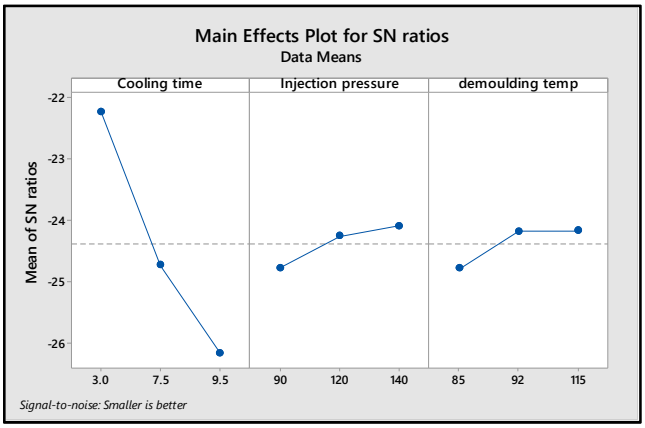

Figure 4: Main Effects plot for SN ratios

It is clear by figure 4 that "Cooling factor is the most effecting factor (Dealt-3.93) for the cycle time and "injection pressure" with (Delta-o.69) is second most important factor. From table 3.3 it is clear that

"Demoulding temperature" (rank -3) has least effect on cycle time.

Analysis of Variance (ANOVA)

Table 4: Significance level

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Table 5: ANOVA analysis

Source	DF	Adj SS	Adj MS	F Value	P Value
cooling time	2	9.6200	4.8100	29.45	0.001
Error	6	0.9800	0.1633		
Total	8	10.6000			

Regression Analysis

Regression analysis is a statistical method for approaching the relationships between variables. It is a method for modelling different variables. It helps to understand how the dependent variable turns when any one of the independent variables is changed. Regression analysis were carried out for cycle time taking Cooling time (Sec.) Injection Pressure(sec), Demoulding Temperature as independent variables and Cycle time will be the dependent variable. Normal probability of regression equation was also plotted in figure 5 for Cycle Time

Cycle time=14.90+ 1.1033 Cooling time-
0.0227 Injection pressure- 0.0283 demolding temp.

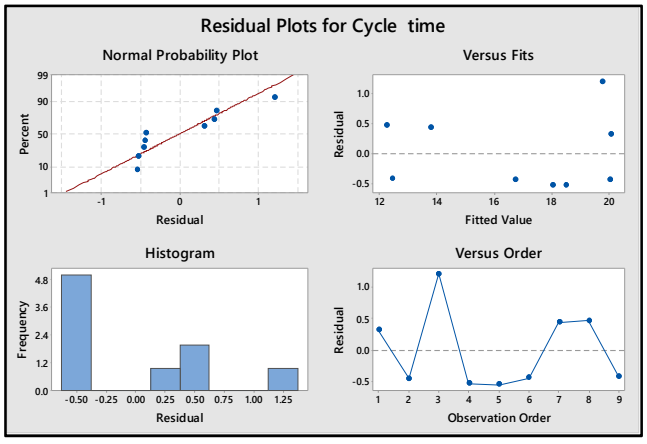

Figure 5: Residual plots for cycle time

DISCUSSION AND CONCLUSION

Experimental investigation on Milacron IMM 80to) has been done using Taguchi method and Anova analysis. Taguchi method has been successfully applied for analysing the contribution of the factors to optimize the cycle time. The following conclusions are made:

- The most important factors that influences the injection moulding cycle time have been identified as Cooling time and the injection pressure.
- The best result was found, Cooling time 7 sec, Injection pressure, 120 bar Demoulding temperature, (85 ^{o}C).
- Theoretically as well as experimentally results are nearly equal therefore it conforms the success of this research.

The experimental results confirmed the validity of the used Taguchi method for enhancing the machining performance and optimizing the machining parameters in injection moulding.

REFERENCES

K. Palanikumar. "Experimental Investigation and Analysis on Delamination in Drilling of Wood Composite Medium Density Fiber Boards", Materials and Manufacturing Processes, 12/2009

Sanjeev Kumar Singh Yadav, Vinod Yadav, V, Lakshmi Narayana. "Experimental study and

parameter design of electro-discharge diamond grinding", The International Journal of Advanced Manufacturing Technology,2006

K.K. Wang, "A System Approach to Injection Molding Process", Polymer and Plastic Technology Engineering", Vol.14 (1), pp75-93, 1980

Arnav Prakash, Gautam Sarkhel, Kaushik Kumar. "Strength Optimization for Kaolin Reinforced Epoxy

Composite Using Taguchi Method", Materials Today: Proceedings, 2015

Josef Dillinger, Metal Engineering textbook, 1st edition 2016.