RESEARCH ARTICLE OPEN ACCESS

Analysis of Process Parameters for Optimization of Plastic Extrusion in Pipe Manufacturing

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Abstract
The objective of this paper is to study the defects in the plastic pipe, to optimize the plastic pipe manufacturing process. It is very essential to learn the process parameter and the defect in the plastic pipe manufacturing process to optimize it. For the optimization Taguchi techniques is used in this paper. For the research work Shivraj HY-Tech Drip Irrigation pipe manufacturing, Company was selected. This paper is specifically design for the optimization in the current process. The experiment was analyzed using commercial Minitab16 software, interpretation has made, and optimized factor settings were chosen. After prediction of result the quality loss is calculated and it is compare with before implementation of DOE. The research works has improves the Production, quality and optimizes the process.
Key word: Taguchi method, Design of experiment, Taguchi loss function, orthogonal array.

I. INTRODUCTION

Extrusion is any process in which a material is force through a shaped orifice, with the material solidifying to produce a continuous length of constant cross section. Squeezing toothpaste from a tube is a familiar example. In plastic extrusion, thermoplastic were softened by heating prior to extrusion and, for the shape to be held; the thermoplastics must be quickly chilled and, usually, supported while cooling. Some large extruders in polymerization plants are fed hot melts, so their main duty is generating enough pressure to force the melt through spider die. In most extrusion operations, however, the plastics arrive as powders or pellets at room temperature, and the extrusion process must melt the plastic and homogenize it before it enters the die. Therefore, heating and melting the feedstock, converting it from a cold solid to a hot viscous liquid, accounts for about 93% of the energy required. The work done in pumping the melt through the die is only 5-10% of the total [1].

II. Importantprocess parameters in extrusion process-

Effective extrusion process requires that the machine and tool operating in well conditions. This requires control over the process parameters such as temperature, pressure, machine speed, and the relative speeds of the auxiliary [1]**.** As these manufacturing processes involve steady state conditions, any action that can stabilize any parameter or condition is beneficial to the process [2]. Mainly the plastic pipe extrusion process is depend on the following parameters

- Take off Speed
- Temperatures
- Vacuum Pressure
- And Relative speed of auxiliary

III. Defects in the plastic pipe Making process

The common failure or defect which are normally occurring in plastic extrusion process are due to three main causes are part and mold design, material selection, and processing. In many cases, the failures occur during the processing and these failures cause some defects that canfound in extruded part. Following are the defects found in the extrusion process

- Uneven Wall thickness
- Centering problem(off-center)
- Diameter variation
- Crack
- Discontinuity in drilling
- Rough surface finishing

In the extrusion product the defect are become during the production due to poor understanding of the processing method, use of inadequate or machines, lack of trained staff Machine Break Down, and inappropriate working environments.

IV. Need of the optimization of the process parameters.

Plastic pipe extrusion process is the most widely pipe manufacturing process use in the industry. In the extrusion process as discuss above the various defects are frequently occurs and hampers the productivity. If we need to enhance the production rate, it is very essential to optimize the process parameters and improve the productivity; following are the reason to optimize the process parameters

- Improve the product quality production rate
- Minimize the variations.
- Design and develop the product for robust component.

V. Methodology for research work

To optimize the process parameters in extrusion process following methodology followed.

- Select the plastic pipe manufacturing industry.
- Collection of data regarding the various defects in extrusion process.
- Finding out the parameter responsible for the defects and their causes.
- Apply the Taguchi's method
- Predict the process parameters', which is optimized.Compare the data with previous

VI. Planning of experiment

6.1 Selection of industry

For research work Shivraj HY-Tech Drip Irrigation Company was selected this company is situated in MIDC Khamgaon, in Buldhana district of Maharashtra state in India.

6.2 Collection of data

Table1 Data collection for1-month observation

S.No	Type of quality defects	Frequency of defect
1	Uneven Wall thickness (A)	3000
2	Centering problem(off-center) (B)	300
3	Diameter variation (C)	2400
4	Crack (D)	900
5	Discontinuity in drilling (E)	1200
6	Rough surface finishing (F)	600
7	**Total**	**8400**

6.3 Data analysis-

From the above observation, it is conclude that the uneven wall thickness is most important parameter, which affect the process and we concentrating on the same in this paper

6.4 Apply Taguchi Method

6.4.1 Taguchi technique for optimization:

Taguchi and Konashi developed Taguchi techniques [2]; these techniques have been utilized widely in engineering analysis to optimize the performance characteristics within the combination of design parameters. Taguchi technique is also optimization power tool for the design of quality system. It introduced an integrated that is simple and efficient to find the optimum range of design for quality performance, and computational cost[3].

Following are the Taguchi method steps:

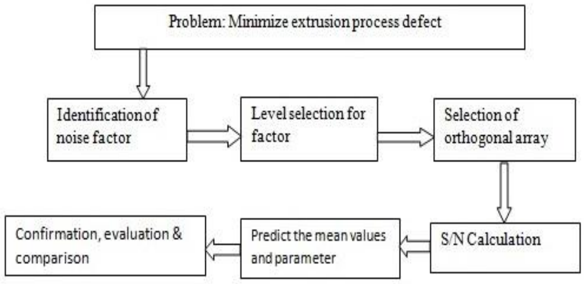


Figure 1: Taguchi's method

a)Identification of influencing factors

Take off Speed
Temperatures
Vacuum Pressure
Relative speed of auxiliary

b)Level Selection for factor

HDPE Pipe ø14smm/1.0.				
Control factors (Temperature zones in°C , Take-off speed in m/min)	L e v e l			
	Unit	1	2	3
Take-off speed	m/min	18	20	22
Temperature1	in°c	172	178	180
Temperature2	in°c	169	173	165

c) Selection of orthogonal array

The choice of a suitable OA design is critical for the success of experiment design and this depends upon number of process parameters and their level. In this, work L_9 OA was select with the help of Minitab-15 software and following calculations ware adopted.

d) S/N Calculation

SNRA	MEAN
51.1228	13.9955
38.5829	13.9955
35.0237	14.0350
39.9747	14.1010
65.1097	14.0075
36.0364	14.0680
37.4455	14.1220
39.0221	14.0895
35.2488	14.1580

Table 2 Mean response and S/N ratio analysis Flexible conduit (F/CØ14mm)

For this product L9rthogonal array is chosen and Taguchi's design is used. The mean response value and S/N response value is shown in the table

Table-3
Table 3Response Table for Means of F/C Ø14mm

Level	Take off Speed	Temp1	Temp2
1	14.06	14.07	14.05
2	14.01	14.03	14.05
3	14.12	14.09	14.08
Delta	0.11	0.06	0.03
Rank	1	2	3

Table 4
Analysis of variance for means of F/C 14mm

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Take-Off	2	0.019766	0.019766	0.009883	27.97	0.035
Temp1	2	0.005119	0.005119	0.002560	7.24	0.121
Temp2	2	0.002059	0.002059	0.01030	2.91	0.255
Residual	2	0.000707	0.000707	0.000353		
Total	8	0.027651				

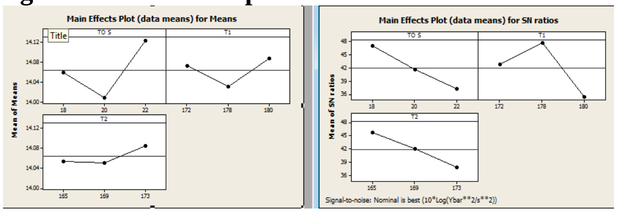
Table 5
Response Table for S/N Ratio of F/C 14mm

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Take-Off Speed	2	144.74	144.74	72.37	0.44	0.694
Temp1	2	224.51	224.51	112.25	0.68	0.594
Temp2	2	94.24	94.24	47.12	0.29	0.777
Residual Error	2	328.98	328.98	164.49		
Total	8	792.46				

Table 6 Analysis of variance for S/N ratio of F/C 14mm

Level	Take off Speed	Temp1	Temp2
1	47.04	42.85	45.86
2	41.58	47.57	42.06
3	37.24	35.44	37.94
Delta	9.80	12.14	7.92
Rank	2	1	3

Graph no.1 the all factors main effect plot for the means and Signal to noise ratio is shown in the figures below for the product F/C14mm



Graph 1(a)data means for means (b) data means for SN ratio

The target value required to be produced 14mm and the mean response graph above sows that on the take off speed 2 setting 20m/min, temperature 2 setting 178, temperature 3 setting 169 produce the product with the value close to target value. But to select setting its effect on the S/N ratio should be considered. The response S/N ratio is required to be large or should not be significantly minimized for any type of design of experiment analysis, and from the response S/N ration above figure is Take off speed 1 setting 18, temperature 2 setting 178, temperature 3 setting 165 makes the response S/N ratio large.

To select optimum setting of temperature values, the setting that results in a mean response value closing to the target value and that has a large or not significantly reduced S/N ratio is advised be considered.

From the analysis before and the main effects plot in the previous figures, factors and their respective levels selected for this product are:
Take off speed-------------------------18 (level 1)
Temperature 2------------------------172 (level 1)
Temperature 3------------------------165 (level 1)

In addition, the predicted value of the response parameter at these temperature settings is
Mean value---------------------------14.059mm
S/N ratio value-----------------------51.84db
Standard deviation-------------------0.0821

Summary of factor setting selected using the design of experiment

Controlled Factor	Unit	1,2,3
Take-off speed	m/min	18 (level 1)
Temperature1	in°C	172 (level 1)
Temperature2	in°C	165 (level 1)

e) Predict the mean value

Table 7 Predicted and Actual mean value of the product

Product type	**Predicted values**			**Target value (mm)**	**Actual mean value (mm)**	**Predicted mean value (mm)**
	Mean		**Standard Deviation**			
	Diameter /width	**wall thickness**				
F/C ø 14mm	14.059	Accepted	0.0821	14	13.933	14.059

f) Result and discussion

Signal-to-noise (S/N) ratios andresponse characteristic for selected factor setting can be predicted using the model from Taguchi experiment analysis above.

1. Examine the response tables and main effects plot to identify the factors and setting that have the greatest effect on the mean, S/N ratio or standard deviation.
2. Choose several combinations of setting from the other factors.
3. From the prediction results, determine which combination of factor setting comes closest to the desired mean without significantly reducing the S/N ratio.

Average quality loss before experiment for this product is

$L= K (S^2 + (\mu\text{-}m)^2)$

$L=64.577*(0.12^2+ (13.933-14)^2$

L=1.21 Rs/pc

Average quality loss after experiment for this product is

$L= K (S^2+ (\mu\text{-}m)^2)$

$L= 51.84*((0.082^2 + (14.059-14)^2)$

L = 0.52 Rs/pc

Table 8Annual loss before and after experiment due deviation of Performance of the products

Type of Product	**Loss due to deviation (Rs/Pc)**		**Annual Production (Kg)**	**Annual production in piece**	**Annual loss due to deviation (Rs)**		**Saving in Rs.**
	Before	After			Before	After	
F/C Ø14	1.21 Rs/pc	0.52 Rs/pc	126000	1629000	1971090/-	977400/-	993600/-

% of Improvement

$$= \frac{(1.21-0.52)}{1.21} \times 100\%$$

% of Improvement = 57.70%

VII. Conclusion

On the platform of the study being made in the company, the following conclusion were done , the reasons for the waste in the company are improper setting of operational parameters, mixing raw material with wrong proportion, old machineries, poor testing and inspection of incoming raw material. The study in the process shows that improper setting of operational parameters kept on a large share of the reason for scrap and non-conformance of the product and the study being conducted shows that setting of optimum operational parameters using Taguchi's method of design of experiment is a good technique in minimizing scrap rates. In addition, it was shown that by application of loss due tonon-conformance of product could be reduce about 57.70 %.

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