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Optimization of PVC Pipes Production Process

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Abstract - In this industrial research work we have considered the significant process parameters that are associated with fabrication of PVC pipe of 4 inches. The extrusion process is carried out, afterwards many deformities have been noticed such as low strength, thickness of wall, surface roughness, non uniform diameter. The study focuses mainly on the process parameters related to the thickness of pipes using the strategy proposed by Taguchi. The analysis is done with Minitab – 20 and L9 orthogonal arrays. The limitations of process boundaries are obtained which are further helpful in the reduction of defects, thereby enhancing productivity.

Key Words **:** Optimization, Taguchi , PVC Pipe, Production Process

1. Introduction

Poly Vinyl Chloride (PVC) pipes are widely used in the domain of farming, construction of buildings, for the transportation of water, slurry and sewage from one end to another, under the variable environmental circumstances. PVC is ordinarily accessible solid thermo-plastic which is light in weight. The PVC pipes are softened and made more flexible with the plasticizer. The PVCs are classified as CPVC (Chlorinated PVC) and uPVC (Unplasticized PVC). The development of the inflexible type of PVC Pipes is done with an extrusion machine. In this process, material undergoes bulk deformation after passing through a hole of the desired shape. Thermoplastic (PVC) are heated until it softens and after that it goes through extrusion. Later, it is chilled so that it can set to the desired shape. For the imperfection free expelled parts, machines must work properly without interruptions. The process parameters that for the most part influence the extrusion process are temperature, pressure, and feed rate. In the extrusion process, defects mostly occur due to improper machine settings or because of mishandling machines or absence of expertise in staff and an unfavorable climate.

2. Problem Description

A large portion of the Pipe fabricating industry utilizes the extrusion process for line fabricating. Mass twisting of materials is done with its consistent progression under factor interior or on the other hand outer circumstances. These circumstances rely upon process boundaries, so in this exploration work, we centered ourselves on the optimization of process parameters. Subsequent to noticing these insights, we found that pipe wall thickness is the important parameter for defects in deserted parts creation. Therefore, the study mainly focuses on the parameters affecting the pipe wall thickness significantly and reducing waste.

Table-1: Frequencies in a pipe manufacturing industry.

S. No.	Defects after extrusion	Frequency of defects
1.	Wall thickness	660
2.	Centering problem	560
3.	Surface cracks	350
4.	Diameter variation	490
	Total	**2060**

3. Production Process Parameter

Major process parameter in the extrusion process, which affects the wall thickness are;

- Barrel temperature,
- Extruder die temperature,
- Extruder pressure, and
- Feed Rate (Take off Speed)

In the extrusion process materials are softened with heat. Afterwards, it was extruded and passed across the hole with a predetermined speed and afterwards cooled in chillers. The administrator of the machine needs to choose the input values for further processing with the aid of a Programmable consistent regulator (PLC). It additionally supports observing the process parameter. It also helps in monitoring the Process parameter.

4. METHODOLOGY FOR THE EXPERIMENT (TAGUCHI APPROACH)

In this analysis, various process parameters are consolidated to give a particular result; in this way it

creates a huge number of possible combinations. The Taguchi method is used for statistical evaluation. It involves a symmetrical cluster for the most ideal blends. The study is done by the following procedure :

- PVC pipe industry Study the entire manufacturing process, and look for process parameters leading to productive working of machines. Here we have defined our problem on the basis of waste production.
- Gathered information and data which straightforwardly or by implication controls the quality of the item and examined them.
- On the basis of information obtained, the Taguchi approach is observed to be appropriate for investigation.
- We set the degrees of process parameters consisting of four factors. Further, the L9 orthogonal array helps in obtaining a possible set of experiments.
- The experiments were performed cautiously with the guidance of authority, and estimated the thickness of wall, each result by utilizing gauge meters and micrometers. Furthermore, statistical investigation is done.
- Minitab-21 is used for investigation. Here we got the Means and sign to commotion proportion (SN-ratio), for the **Nominal is the best** condition.
- Mean response table is obtained with optimized values of process parameters..

Table-2 Levels of Parameters

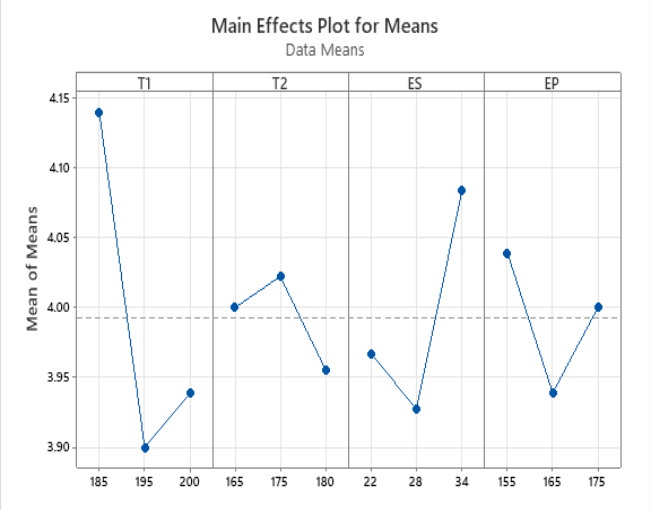
S.No.	Process parameters	Units	Leve11 1	Level 2	Level 3
1.	BarrelTemp (T1)	0_C	185	195	200
2.	Die Temp. (T2)	0_C	165	175	180
3.	Extruder Speed (ES)	RPM	22	28	34
4.	Extruder Pressure (EP)	MPa	155	165	175

The following factors control production of pipes –Barrel temperature (T1), Die Temperature (T2), Extruder Speed (ES), and Extruder Pressure (EP). After detailed analysis of standard data with concerned authorities, Engineers and laborers, the degree of process parameters are chosen for further optimization .Design of Experiment (DOE) is implemented according to the Taguchi Method. Minitab – 21 creates the orthogonal array. Three level Design is utilized with L9 symmetrical arrays and four factors. The experiments are done and the obtained data is further applied in Minitab . The values of Means and SN-ratio are acquired.

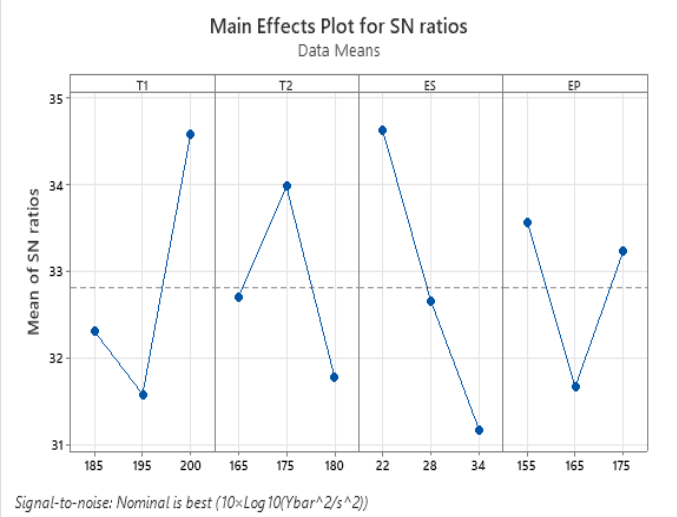
Table-3 Wall thickness (WT) at different operating Conditions

S. No.	T1	T2	ES	EP	WT1	WT2	WT3	SNRA	MEAN
1	185	165	22	155	4.15	4.22	4.10	22.3408	4.15667
2	185	175	28	165	3.95	4.15	4.05	20.0000	4.05000
3	185	180	34	175	4.22	4.28	4.05	17.5696	4.20000
4	195	165	28	175	3.75	3.85	3.95	20.0000	3.85000
5	195	175	34	155	4.10	3.95	4.15	19.6524	4.06667
6	195	180	22	165	3.70	3.90	3.75	19.6524	3.78333
7	200	165	34	165	3.95	4.10	3.90	19.6524	3.98333
8	200	175	22	175	3.90	4.00	3.95	26.0206	3.95000
9	200	180	28	155	3.80	3.95	3.90	22.3408	3.88333

Graph1: Plot for Means



Graph 2 Plot for SN-ratio



The above information has been acquired by progressive paths, and this information has been taken care of in the Minitab for additional examination. Plots indicating important effects for means and SN-ratios have been created utilizing the minitab-21, showing a variety of process parameters with desired output.

5. FORMULA USED

The thickness of pipe walls can neither be thin nor too thick, moderate value is preferred for its proper functioning. Here, the criteria '**Nominal is best**' is followed for determining SN-ratio using the Taguchi method.

SN-Ratio= 10 *($\log_{10}(s^2)$)

where **s** is standard deviation.

6. RESULTS AND CONCLUSIONS

The highest value of SN- ratio is 26.02**.** The nominal value of wall thickness can be attained with the following values :

- Barrel temperature (T_1) - 200 °C
- Bite the dust Temperature (T_2) - 175 °C,
- Extruder Speed (ES) - 22 Rpm, and,
- Extruder Pressure (EP) - 175 MPa

The outcomes of the study observed that the optimisation of Process parameters can be enhanced by utilizing advanced technology. It is inferenced that Taguchi Method is an extremely useful technique in these investigations. The timely assessment of machines is needed for its regular maintenance. Consequently, the process parameters are set and further enhances the associated company's productivity.

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