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Quality Assurance in High Density Plastic Pipes Manufacturing Process by Taguchi Approach

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Abstract - *In this article, our focus is to maximize the productivity and quality of HDPE pipe. During production problems like low tensile strength, centering problem, eccentricity in thickness, cracks in pipe, variation in diameter was observed which results in low productivity. Minitab 18 software was used for calculating the [S/N] Signal to Noise Ratio and Taguchi optimization approach was implemented to improve the tensile strength of 90 mm HDPE pipe. The L9 orthogonal array was selected and Larger is better is preferred for better result. The parameters studied were extrusion speed, melting temperature, winding speed and extrusion pressure. The experiments were performed and tensile strength was checked on different trails and optimum setting was preferred for production.*

Key Words:- **Optimisation**, **Design of Experiment, Taguchi Method, Tensile strength, Minitab**

1. INTRODUCTION

High Density Poly-ethylene (HDPE) pipes are widely used for underground piping ,transportation of water for irrigation purpose from one place to another place, column pipes for submersible pumps, sewerage pumping and effluent disposal systems, lift and gravity water supply systems. Due to its flexibility, strength, large strength to density ratio, chemical resistance, recycle ability, corrosion resistance etc. HDPE Pipe is manufactured by extrusion. The material is forced through a desirable shape orifice, with material solidifying to produce a continuous length of constant cross section.

1.1 Major Process Parameters for Extrusion Process.

It requires controlled process parameters like pressure, temperature, feed rate of machine and relative speeds of connected auxiliaries. Programmable logic controller panel was used for controlling and monitoring parameter. Main parameters on which the plastic pipe extrusion process depends are as follows -

a) Temperature

b) Vacuum Pressure

c) Take off Speed

d) Relative speed of auxiliaries

1.2 Methodology for the Research Work.

For the optimization of process parameters in the extrusion process following methodology is followed.

1. Selected a plastic pipe manufacturing industry.
2. Collected data for all parameters which controls product quality.
3. Analyzed these data and concluded the parameters responsible for the defects.
4. Applied the experimental design approach, Taguchi Method.
5. Analyzed the data of process parameters and achieved an optimized set of new parameters, and then compared them with previous data.

1.3 Defects in the plastic pipe

Common defects which are observed in the plastic pipe extrusion process are caused due to these three, (a) Mold Design, (b) Material Selection, and (c) Machining Operations. Followings are the defects found in the extruded parts.

- Low tensile strength
- Off – Center (Centering Problem)
- Uneven Wall Thickness
- Cracks
- Diameter Variation.

It has been found that majority of defects in an extruded part occurred during machining process. These are due to the poor understanding of processing criterion, use of machine inadequately, untrained workers, break down of machines, and the inappropriate working environment.

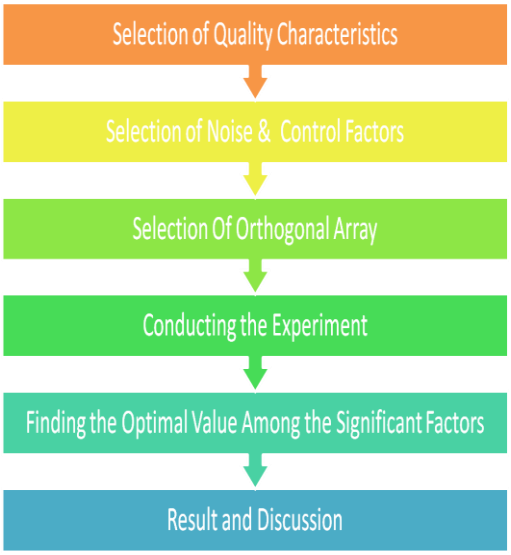
Table -1: Design of Experiment

S No.	Defect in Production Process	Frequency Of Defects
1	Low tensile strength	800
2	Centering problem	600
3	Eccentric wall thickness	600
4	Diameter variation	600
5	Crack	102
Total		**2702**

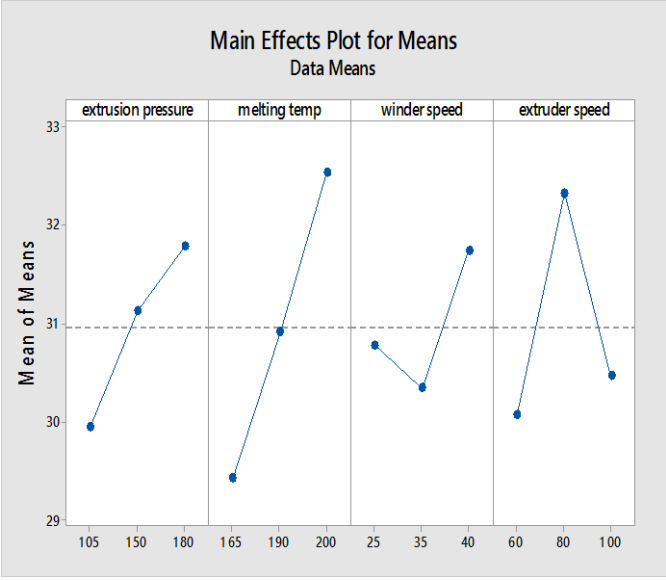
Table -2: Selected Values of Process Parameters

S. No.	Process Parameter	Units	Level 1	Level 2	Level 3
1	(A) Extrusion Pressure	MPa	105	160	180
2	(B) Melting Temperature	°C	165	190	260
3	(C) Winder Speed	RPM	25	35	40
4	(D) Extruder Speed	RPM	60	80	105

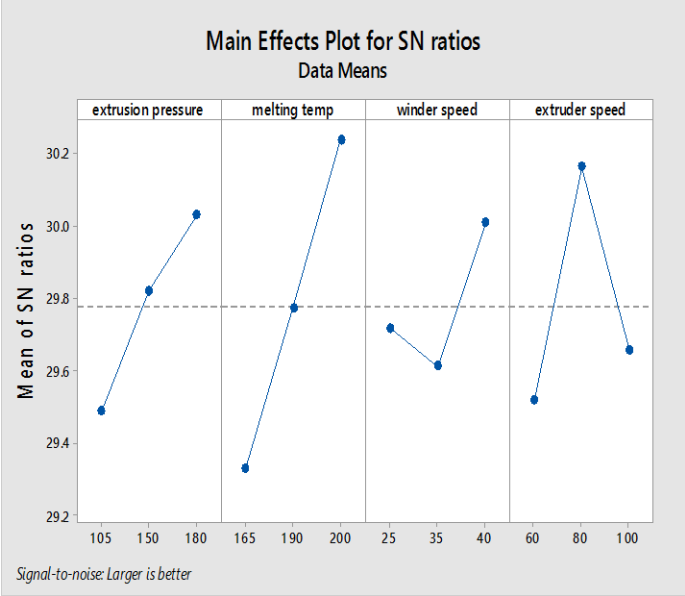
Table 1 : Experimental result for Tensile strength [TS1 ,TS2,TS3] and S/N Ratio



S. No	Pressure A MPa	Temp. B °C	W S C rpm	E S D rpm	TS1 MPa	TS2 MPa	TS3 MPa	Signal To Noise Ratio (S/N)	Mean
1	105	165	25	60	25.5	27.8	28.8	28.71	27.36
2	105	190	35	80	31.5	32.0	28.5	29.69	30.66
3	105	200	40	105	32.0	32.5	31.0	30.05	31.83
4	160	165	35	105	28.0	35.0	27.5	29.07	28.50
5	160	190	40	60	28.5	32.5	32.0	29.78	31.0
6	160	200	25	80	33.5	34.0	34.2	30.60	33.90
7	180	165	40	80	34.0	32.0	31.2	30.19	32.40
8	180	190	25	105	32.0	31.0	35.2	29.84	31.06
9	180	200	35	60	32.0	31.0	32.6	30.06	31.86



Graph 1



Graph 2

Formula Used

For *larger is better* quality characteristics ;

$$S/N = -10*\log(\Sigma(1/Y^2) / n)$$

Where

Y = mean responses for the given factor level combination

n = number of responses in the factor level combination.

Table 4 - MEAN RESPONSE TABLE

Level	A	B	C	D
1	29.96	29.42	30.78	30.08
2	31.13	30.91	30.34	32.32
3	31.78	32.53	31.74	30.47
Delta	1.82	3.11	1.40	2.24
Rank	III	I	IV	II

Parameters like (a) Extrusion pressure, (b) Melting temperature,(c)Extruder speed ,(d) Winder speed are focused for L9 orthogonal array and feed into the design system of minitab18 software .In the table 4 response table of focused parameter S/N ratio was calculated and plotted in graph and ***Larger is better*** is preferred.

3. CONCLUSIONS

To maximize the tensile strength of HDPE pipe (control factor with highest impact on S/N ratio) was determined and from above graph and mean response table, it was concluded that delta of B was maximum i.e **3.11**,so Ist rank and C was IVth. Proper planning and team work is important part of productivity of plastic pipe industry and help in reduction of wastage at the starting and stopping time of extrusion machine.

1. For crack problems, vacuum pressure, water flow rate manual setting was adjusted and cleaning of sizer with diesel was preferred because diesel washouts the undesirable tiny particles from sizer .

2. When the axis of mandrel and die axis is not concentric, it will affect the eccentricity in thickness, diameter variation and centric problem, so by proper alignment setting of mandrel and die problem can be solved.

3. Best quality in terms of strength is obtained when virgin material with proper mixing proportion was used.

In future, machine with machine intelligence can be used for fully automation of machine which will reduce the scrap quality and breakdown period, so production per unit cost increases.

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