

# Experimental Investigations of the Influence of Process Parameters for Extrusion Machine during Expanded Polystyrene Foam Manufacturing

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**Abstract:** The effects of the processing parameters different base parameter of polymer extruder like temperature, speed and rpm. Increasing temperature reduces the color deviation for these particular highly adjusted grades. Similar results were observed for feed-rate, where increasing the feed-rate decreased the amount of color deviation. By increasing rpm, color deviation also increases; however, the effect of rpm is not very significant as compared to temperature and feed-rate. In general, there are hundreds of variables involved in color deviation, but a proper understanding of formulation on a given production line and proper processing parameters leads to proper color production feed-rate.

By using Minitab software to optimization parameter in full factorial method and ANOVA then concluded the effect of different parameters over other parameters and results seem useful to set in the machine concerning the quality of the final product. By using Solid works 2020 which more user-friendly software check geometrical parameters of each product. In Solid works 2020 having a simulation module that having capabilities to the simulation of real practical data put and find out the result concerning static and thermal analysis. There is a different product like a flat plate, circular plate, pocket plate, food plate, egg plate, bowl, and fruit bowl check geometric and strength parameter each product and check the outcome of the parameter of simulation likes Von mises Stress, Deformation, and Strain, also thermal analysis gives the result of temperature and thermal flux sustaining in the product. The optimization data of all results of the simulation are satisfied concerning static analysis and thermal analysis.

**Index Terms**– ANOVA, Solid works 2020, Parameters, Feed rate, Speed, Temperature.

## 1. Introduction



**Fig. 1 Different Types of Plastic Sheet Extrusion Machines**

As shown in Figure 4.1 in which different extrusion machines which having capabilities different types of plastic sheets as per thickness and sizes that useful for different applications. The company name is Essen Specially Films Pvt. Ltd is located at Shapar, near Rajkot, Gujarat. The company had good capabilities and lead manufacturing of different types of extrusion machinery as customer requirements from range application as per small or medium scale industries requirements

ESSFOARM disposable products are manufactured from highly compacted expanded polystyrene (XPS) foam by unique extrusion technology designed and developed indigenously. ESSFOAM plates are designed comfortably to handle the heaviest food serving. The special manufacturing process makes the material serve as a thermal barrier that allows hot-cold items to maintain their temperatures for longer periods. Highly compacted foam polystyrene does not allow substances to travel through it keeping bacteria from penetrating and proliferating in the contents thus preventing contamination of contents.

## 1.1 Features

- Highly compacted XPS results in strong and tough plates.
- Strong enough to hold heavy food stuffing at one time.
- Available in various colors and designs.
- One time use hence eliminating washing and storing problems.
- Made from FDA approved food-grade materials.
- Hygienic and neat tableware for anytime use.
- The multi-compartment helps food from mixing.

## 1.2 Application

- Single-use disposable tableware.
- Fruits, cut vegetables, and meat packaging trays.
- All types of take away food containers.
- All types of plates and bowls for regular use.
- They have over 40 different product categories of tableware on the shelf to serve the customer requirement. (As shown in Figure 2 and 3)

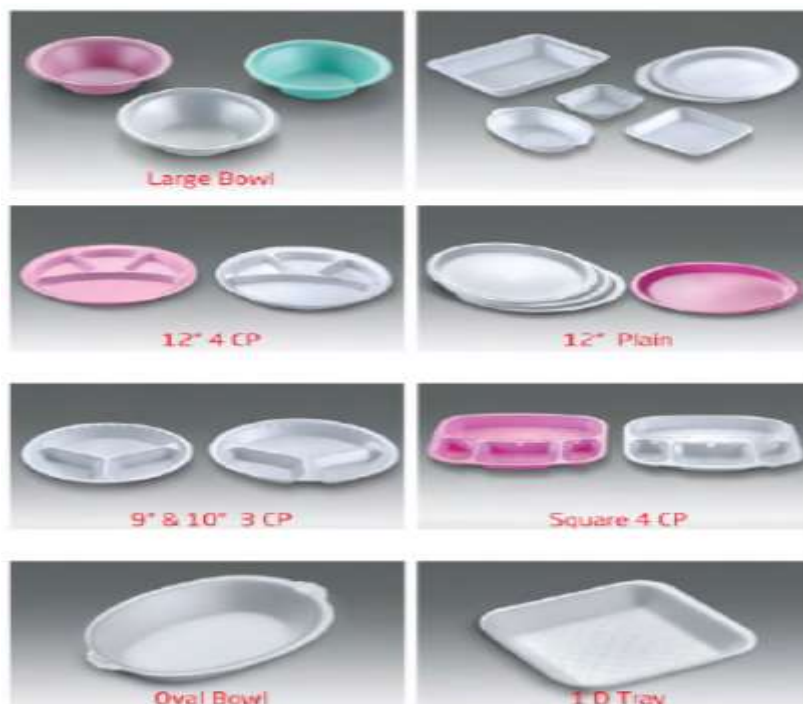


Fig. 2 Different Types of Product as per Customer requirements



Fig. 3 Different Types of Product for the special application of industries

## 2. Experiment Design

Based on the historical data provided by Essen Speciality Films Pvt. Ltd and the properties of selected grades, experiments were carried out to study the effects of the processing parameters on the tristimulus values and the dE. Three processing parameters were chosen for the study, namely barrel zone temperatures (measured in °C), rpm, and feed-rate (measured in kg/hr).

Tables 1 to 3 shows the values of processing parameters on which experiments have been performed according to general trends.

**Table 1 Variation of Temperature (°C)**

Sr. No.	Temperature (°C)	rpm	Feed rate (kg/h)
1	230	750	25
2	240	750	25
3	255	750	25
4	270	750	25
5	280	750	25

**Table 2 Variation of rpm**

Sr. No.	Temperature (°C)	rpm	Feed rate (kg/h)
1	255	750	25
2	255	725	25
3	255	750	25
4	255	775	25
5	255	800	25

**Table 3 Variation of Feed rate (kg/h)**

Sr. No.	Temperature (°C)	rpm	Feed rate (kg/h)
1	255	750	25
2	255	750	23
3	255	750	25
4	255	750	27
5	255	750	30

Where set point. Actual values for temperatures were recorded within  $\pm 3$  °C of the set point temperature, while the set point for rpm and feed-rate matches perfectly.

### 3. Optimization Result of Full Factorial Method and ANOVA

**Table 4 Coded Coefficients**

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		25.375	0.673	37.70	0.000	
Temperature	-2.750	-1.375	0.673	-2.04	0.111	1.00
rpm	0.250	0.125	0.673	0.19	0.862	1.00
Temperature*rpm	1.750	0.875	0.673	1.30	0.263	1.00

#### 3.1 Model Summary

**Table 5 Model Summary**

S	R-sq	R-sq(adj)	R-sq(pred)
1.90394	59.58%	29.27%	0.00%

#### 3.2 Analysis of Variance

**Table 6 Analysis of Variance**

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	21.3750	7.1250	1.97	0.261
Linear	2	15.2500	7.6250	2.10	0.238
Temperature	1	15.1250	15.1250	4.17	0.111
rpm	1	0.1250	0.1250	0.03	0.862
2-Way Interactions	1	6.1250	6.1250	1.69	0.263
Temperature*rpm	1	6.1250	6.1250	1.69	0.263
Error	4	14.5000	3.6250		
Total	7	35.8750			

### 3.3 Regression Equation in Uncoded Units

$$\text{Feedrate} = 171 - 0.580 \text{ Temperature} - 0.176 \text{ rpm} + 0.000700 \text{ Temperature} * \text{rpm}$$

### 3.4 Alias Structure

Factor	Name
A	Temperature
B	rpm
Aliases	
I	
A	
B	
AB	

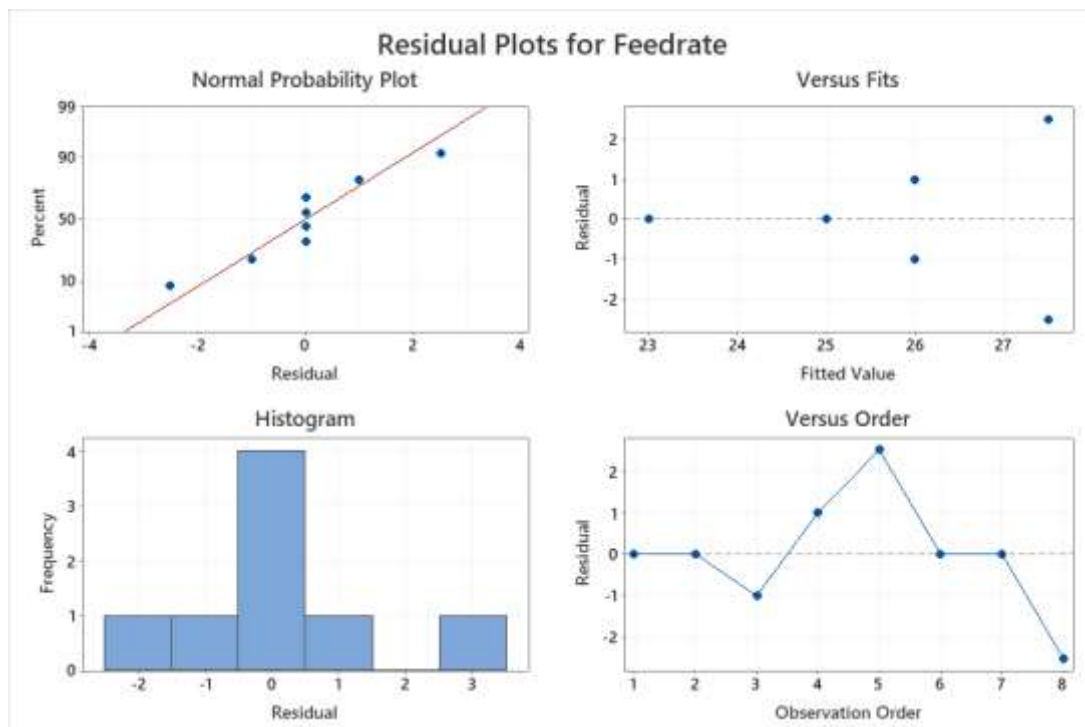


Fig. 4 Residual Plots for Feed rate

### 3.5 One way ANOVA: Temperature, rpm, and Feed rate

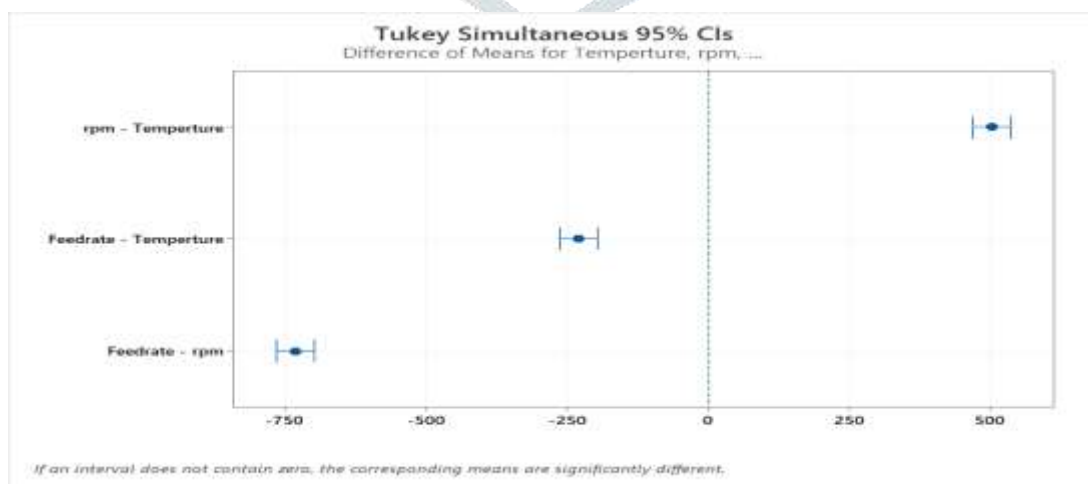


Fig. 5 Difference of Means for Temperature, rpm, and feed rate

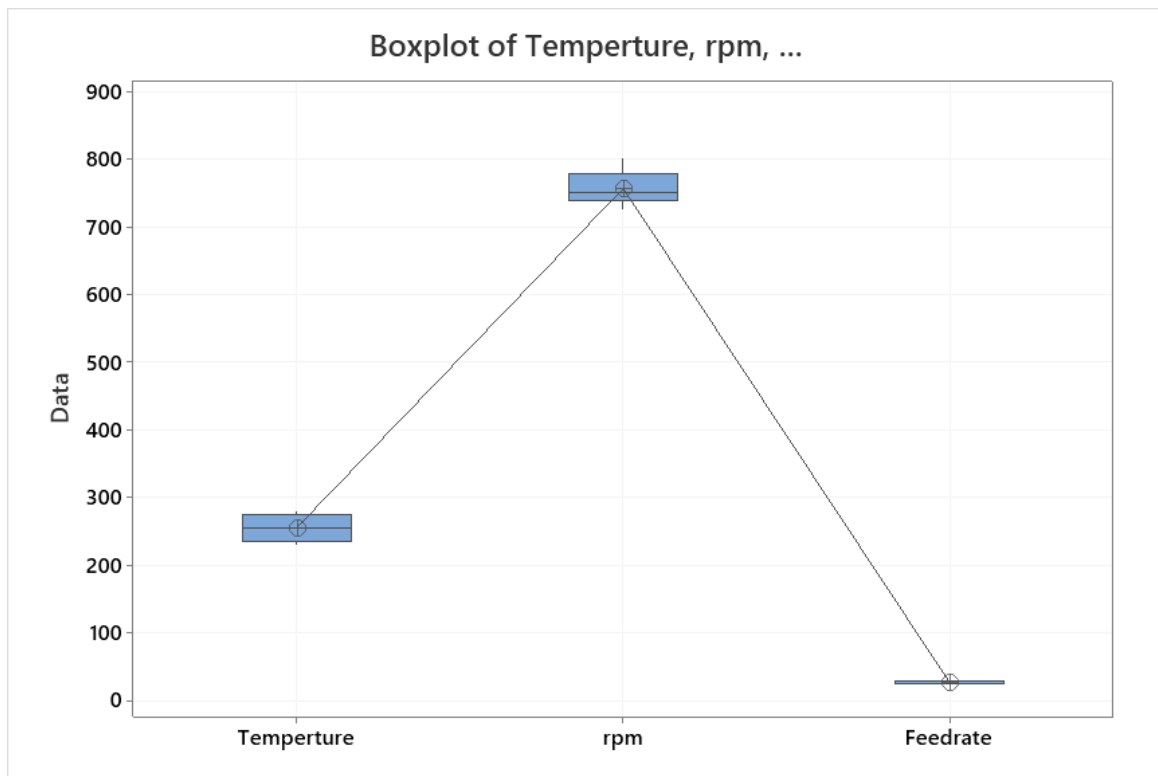


Fig. 6 Box plot of Temperature, rpm, and Feed rate

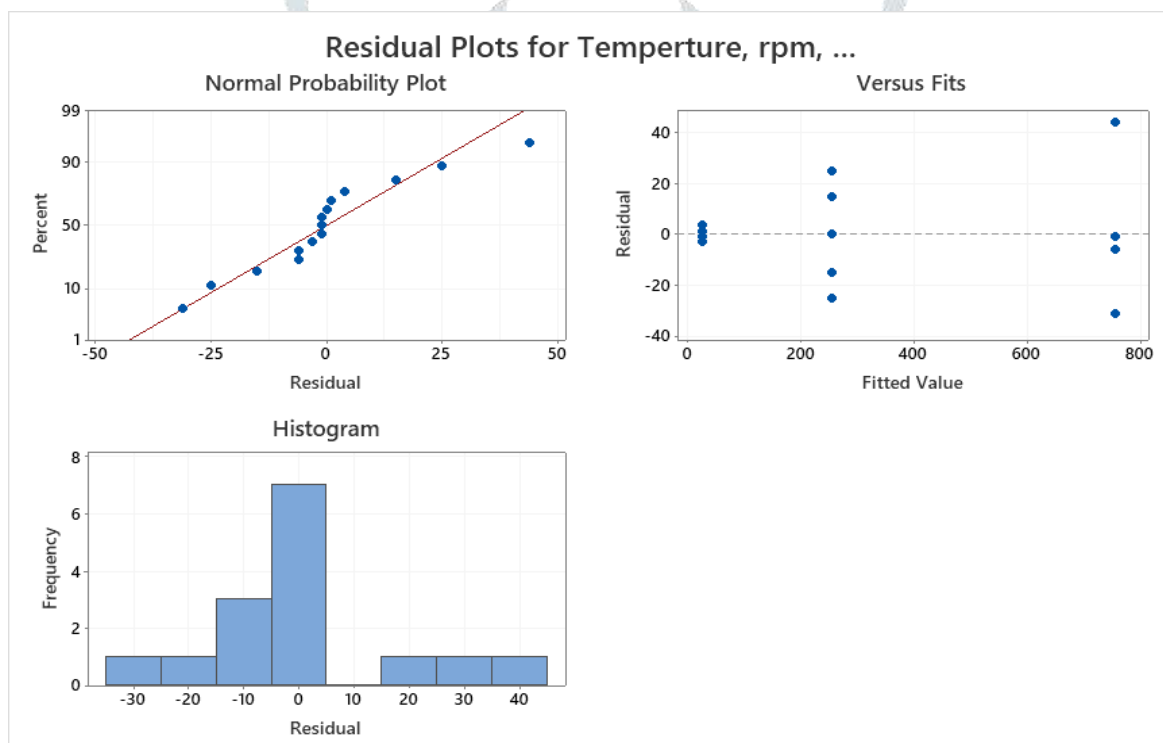


Fig. 7 Residual Plots of Temperature, rpm and Feed rate

#### 4. Conclusion

In general, there are hundreds of variables involved in color deviation, but a proper understanding of formulation on a given production line and proper processing parameters leads to proper color production feed-rate.

By using Minitab software to optimization parameter in full factorial method and ANOVA then concluded the effect of different parameters over other parameters and results seem useful to set in the machine concerning the quality of the final product.

By using Solid works 2020 which more user-friendly software check geometrical parameters of each product. In Solid works 2020 having a simulation module that having capabilities to the simulation of real practical data put and find out the result concerning static and thermal analysis. There is a different product like a flat plate, circular plate, pocket plate, food plate, egg plate, bowl, and fruit bowl check geometric and strength parameter each product and check the outcome of the parameter of simulation likes Von mises Stress, Deformation, and Strain, also thermal analysis gives the result of temperature and thermal flux sustaining in the product. The optimization data of all results of the simulation are satisfied concerning static analysis and thermal analysis.



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