

# **Quality Analysis on PVC Extrusion Machine**

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## **Abstract**

Extrusion is very challenging process for maintaining the desired product quality for the manufacturers. To get required quality of the pvc pipes, we have to identify, control and regular monitoring of quality parameters. Some of the important parameters on which product quality depends are working conditions, temperatures, pressure, die surface and material used. The defects in the product quality affects the cost of the production and product life cycle. Till date, manufacturer faces problems in the extrusion process which impacts on the product quality. The purpose of this review paper is to analyze the defects in the pvc pipes during extrusion process, its impact on the product quality and to suggest the remedies for better quality of the pvc pipes.

## **Keywords**

Extrusion, PVC, Product Quality, Quality parameters, Die Surface, and Defects.

## **1. Introduction**

Due to its strength and resilience to damage from extreme weather conditions, polyvinyl chloride (PVC) is a versatile material that is frequently employed in the building industry. One essential piece of equipment utilized in the production of PVC products is the PVC extrusion machine. The material is heated and melted in a machine, then forced through a die to take on the required shape during the extrusion process.

To meet the rising demand for PVC products, the PVC extrusion machine has experienced a number of technological developments in recent years. These developments have made it feasible to create PVC goods more precisely, more effectively, and with higher quality. The PVC extrusion machine is made up of a hopper, barrel, screw, and die, among other parts. The PVC material is supplied into the machine through the hopper. After that, the material is heated and melted inside the heated barrel using a variety of heating devices. The melted PVC material is pushed by the screw into the barrel and into the die, where it assumes the required shape.

The need for effective, dependable, and cutting-edge PVC extrusion equipment is increasing along with the demand for PVC products. To meet these needs and maintain their competitiveness in the market, manufacturers are constantly innovating and enhancing their PVC extrusion machines (Figure 1).



Figure 1. PVC Extrusion Line

Materials are permitted to pass through an aperture with the desired form during the extrusion process. The materials must be deformed in their entirety. Thermoplastic (PVC) is heated to soften it before being extruded, and it is then chilled to harden the appropriate shape. Machine must function properly in order to produce extruded parts that are defect-free. Temperature, pressure, and feed rate are the primary process variables that influence the extrusion process. Defects in the extrusion process are typically brought on by incorrect machine settings, a lack of staff ability, an inadequate atmosphere, or a lack of understanding of how the machine works (Shrikrishna et al. 2019).

### **1.1 Objectives**

Most of the plastic industry manufacturer uses extrusion process for PVC pipes. During this process, many defects occurs which impacts product quality of pvc pipes. In order to get better quality pvc pipes, we have focused on the process parameters and their input values in the manufacturing process and analyzed product quality defects like chatter marks on pvc pipes and after observing these defect, we have die surface fault for chatter marks on pipes and suggested remedies to improve the product quality of PVC pipes.

### **1.2 Major Process Parameters**

In the extrusion process, materials must first be heated to a softening temperature before being pressurized through the orifice at a specific speed and chilled in chillers. The operator must choose the input values for the process, which he enters using a control panel controlled by a programmable logical controller (PLC). Additionally, it aids in the process parameter monitoring (Krunpal et al, 2018).

We identify the important factors for improving product quality of PVC pipes on the extrusion machine line which are:-

- Extruder die Surface and Temperature
- Extruder Pressure
- Barrel Temperature
- Feed Rate(Take off Speed)

## **2. Literature Review**

Ritesh Gajjar and Mr. Divy Patel presented a systematic approach for product defect in polyvinyl chloride (PVC) pipe and solved the problem to get required product quality for the applications during the extrusion process. We have analyzed the important process parameters for the extrusion process which affects the product quality. The different methods and study had been carried to solve the problems during the process by noting the parameters at different levels and checking the result of output product of the machine. PVC is known for its long durability and long lasting which can be used in many applications and it is widely manufactured with the help of extrusion machine. Extrusion machine may have many defects during processing which affects product quality. The major defects in the extrusion are due to wrong selection of System Engineering or its installation, wrong Operation, Defects in resin, Materials Addition of material, Surging, Poor blending, fracture or toughness of melt, Overheating, Moisture release, Trapped air, Contamination. The main processing-related flaws are rough product surfaces, extruder surges, thickness

variations, uneven wall thicknesses, chatter marks, diameter variations, and centering flaws. Processing errors are mostly caused by a lack of understanding of the processing procedure, the use of ineffective or outdated equipment, unskilled personnel, equipment failure, and an unsuitable work environment. At Extrutech, we got opportunity to explore a twin screw barrel pvc extrusion machine which have defect of product quality of chatter marks in the pipes after production. We have studied main parts such as feeder, twin screw barrel (extruder), heating and cooling zones, compression zones, die zone and their functions in the machine during production. After analyzing the various process parameters we come to main parameters are: Extruder Die surface and temperature, Extruder pressure, Barrel Temperatures and feed rate to obtain maximum product quality and eliminate chatter marks in the pipes. By examining each of these process parameters separately, we learn that the die surface has a flaw. Because of this flaw, there were chatter marks on the pvc pipes. A method is used to solve this flaw was Hard Chrome Plating inside the die surface to get desired product quality of the pipes. In this process, a layer of chromium is deposited on the surface of die part to increase corrosion and abrasion resistance, decrease friction and strengthen the life of parts in wear-tear environments (Figure 2).



Figure 2. Extrusion Die Head (Product from Shree, 2020)

By examining process variables and the method's viability for the industry, a higher authority has been approached with the idea of fixing this fault in the extrusion process. The machine which is used for project work has output of 280 kg/hr. of pvc pipes of  $\text{Ø}$  45mm and die is of 110mm sent for hard chrome plating by electroplating process. By optimizing the extrusion machine process parameters and hard chrome plating of die, we achieve the highest level of product quality and eliminate chatter marks on the pvc pipes. The numerical results were finally evaluated by practical testing, and the comparison proved that the hard chrome plating process created in this work could provide effective direction for actual production. This brought the entire project to a successful conclusion (Geo, 2014).

### **3. Methodology**

This experiment involves a variety of variables (Process Parameters), which when combined yield a certain result, leading to an enormous number of possible combinations. In order to eliminate chatter marks on the pvc pipes we have selected to hard chrome plating method to the die surface to get desired product quality of the pipes.

- Selected PVC Extrusion machine with the practical applications.
- Look for the whole production processes and pinpoint the process variables that affect how well a machine operates. Here, we discovered waste generation and identified our issue.
- Collected and analyzed data and information that is directly or indirectly related to product quality.
- Detected the flaw in the die surface and studied the methods to solve this flaw in the machine.
- After researching practical approaches for die flaw, we have proposed hard chrome plating method to the die surface to get optimum product quality.
- Using this technique and optimizing the process parameters will result in better pvc pipes.
- Under the supervision of the appropriate authority, the trials were carefully carried out and checked the product quality of the pvc pipes.

- Finally it gave us required pvc pipes without the chatter marks on it with considering the major process parameters in the machine.

#### **4. Data Collection**

The following measures were done to obtain data using tick sheets.

1. The defects that must be noted are clearly stated.
2. All problems are documented and discussed with the individual who will be recording the data.
3. A one-month period is chosen for data collection.
4. A check sheet is intended to be utilized during data collection, with space allotted for documenting each defect (Table 1).

Table 1. Defects occurred during extrusion

Sr. No.	Type of Defects	Total No. of defects
1	Chatter marks	45
2	Voids	12
3	Gels	17
4	Longitudinal streaks	15
5	Dimensional variations	20
6	Shark skin	22
	Total	131

#### **5. Results and Discussion**

Extrusion machine is complex process to manufacture pvc pipes with the optimum process parameters, we have found many defects in this process and major concern was chatter marks on the pipes and eliminated this flaw with the help of hard chrome plating method inside the die surface and testing the major process parameters at different levels which is shown in Table 2. By implementing this method in the industry, we got optimum product quality of pvc pipes with the economical and practical approach for mass production (Table 2).

Table 2. Extrusion process parameters and their levels

Levels	Extruder Die Temperature( <sup>0</sup> C)	Extruder Pressure (bar)	Barrel Temperature( <sup>0</sup> C)	Feed Rate (rpm)
1	160	68	155	30
2	172	74	180	40
3	180	80	222	45

Scatter diagram is used to show co-relation between the number of chatter marks with the distance of the pipes in mm to cause a significant flaw in the extrusion machine which shown below.

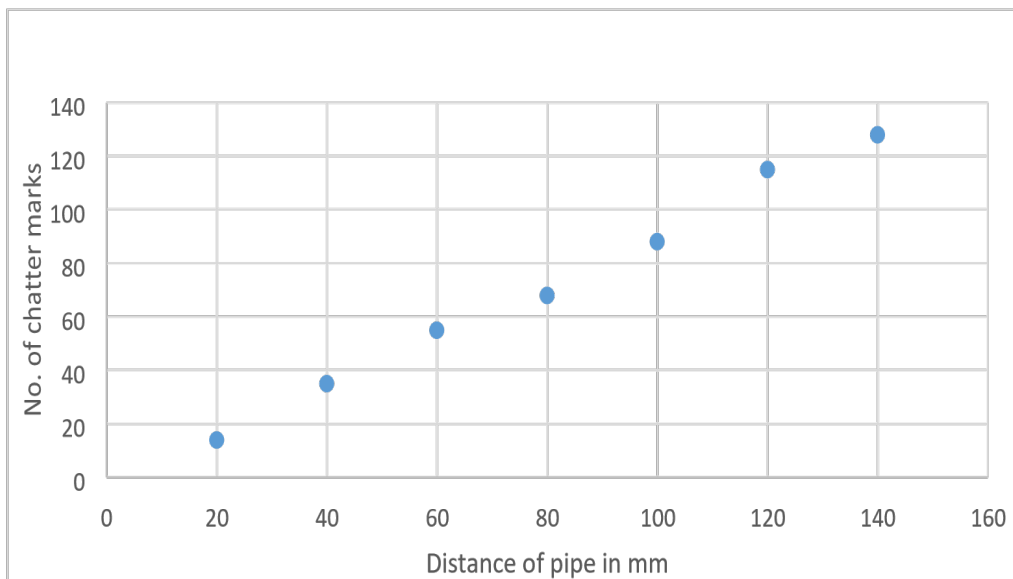


Figure 3. Graph of defects [15]

In order to achieve the highest possible product quality and get rid of chatter marks on PVC pipes, we set important parameters for the PVC extrusion line with the assistance of Industry Mentor and his team. These parameters include the extruder die temperature (180 °C), extruder pressure (80bar), barrel temperature ranges from 155-200(°C) between zones, and feed rate (45rpm) (Narasimha & Rejikumar, 2013).

## 6. Conclusions

Every manufacturing company needs to get rid of the things that might lead to production issues. Product flaws could result in significant and immaterial losses for the business. There are numerous ways to address the causes of faults that result from people, equipment, materials, and techniques. In order to lessen the impact of fatigue on other employees, these flaws can be fixed by hiring fresh personnel. Regular maintenance can also lessen the likelihood of faults. The government has set requirements for the raw materials to be used, and it is advised that high-quality materials be used. Extrusion is a high-volume processing technique in which plastic material is heated until it melts, then forced through a die to take on the required shape. The barrel contains a cylindrical spinning screw that pushes plastic material made of molten metal through a die. Takeoff speed, transition temperature, and metering zone are important factors that determine the quality of the products.

Based on the study and analysis of the numerous papers on the fault and the observation of the researchers' opinions in the papers, it should be necessary to reduce its causes for the best extrusion product. According to observation, these quality issues (Causes) result in improper operational parameter setting. By application of above remedies, we can remove the flaw of chatter marks on pvc pipes and get optimum product quality during the extrusion process (Rao, 2019)

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