IFERP
connecting engineers... developing research

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 5, May 2018

Design and Development of Single Screw Extruding Machine for Bio-Composites

[1] Vinod Kumar Biradar, [2] Akshat Joshi, [3]Aryan Kumar Jaiswal, [4]Nithin S A,[5] Shanthveerayya S H
[1][2][3][4][5] Department of Mechanical Engineering
[1]Asst. Professor, [2][3][4][5] UG Student
[1][2][3][4][5]Sri sairam college of Engineering Anekal Bangalore

Abstract:-- **New advances in screw design and mixing sections have allowed processors to take advantage of new resins, higher production rates and improved product quality. The three main zones – compression, mixing, metering, of extrusion process must be considered while designing the extruder. The L/D ratio plays an important role in designing the screw. Material selection, power required, melt viscosity, and other important parameters are determined/calculated using suitable formulae. This project aims at designing a low- cost, portable single screw extruder. The main objective is to compact the size of the machine without harming its ability to extrude.**

Index Terms— Plastic Extrusion, Single Screw Extruder, Plastics Processing.

1. INTRODUCTION

The 21st century automotive industry is run by composites. Heavy metals are being replaced by light composite materials. Composites outperform metals in almost every aspect; better strength, more rigid, lighter in weight, anti-corrosive and many more, which finally lead to higher efficiency. Not only in automotive industry, are composites replacing metals, but also everywhere else. Composite parts of the previous metal parts have a greater advantage over the later. Not only they perform better, their manufacturing is also simpler – lower temperature, less power requirement etc. The field of composite materials is still in its infant stage. There is a need to come up with materials of different compositions for different purposes in order to optimize the performance of any system.

Key process in manufacturing a composite is – extrusion process.
It is sensible to assume that a regular extruder is not suitable for R&D work, due to its bulkiness, high cost, huge power requirements, noise and vibration it might produce etc. This paper focuses on the design and development of a single screw extruder for bio-composites which is designed for R&D purposes.

II. BACKGROUND

An extruder is used to convert raw plastic products into semi-finished or finished products. A semi-finished product would be material extruded as part of a compounding or mixing operation. Examples of finished products are film, pipe, sheet, profiles, foam products and coated wires.

In single screw extruder the material enters through the feed throat (an opening near the rear of the barrel) and comes into contact with the screw. The rotating screw forces the plastic beads forward into the barrel which is heated to the desired melt temperature of the molten plastic. In most processes, a heating profile is set for the barrel in which three or more independent heater zones gradually increase the temperature of the barrel from the rear (where the plastic enters) to the front. This allows the plastic beads to melt gradually as they are pushed through the barrel and lowers the risk of overheating which may cause degradation in the polymer. The melted plastic polymer is passed through dies attached at the end of the screw to get desired shape [4].

Different types of machines are used for extrusion [3][5].

They can be classified as
a. Single screw extruder
b. Twin screw extruder
c. Multi-screw extruder

The screw is the only working component of an extruder.
The performance of the extruder, such as the output rate, melt temperature, melt quality and stability, depends primarily on the screw design. Extruder consists of hopper, barrel, cylinder, plasticating screw, thrust bearing, breaker plate and die [1]

Three different zone of screw are
a. Feed zone
b. Compression zone
c. Metering zone

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 5, May 2018

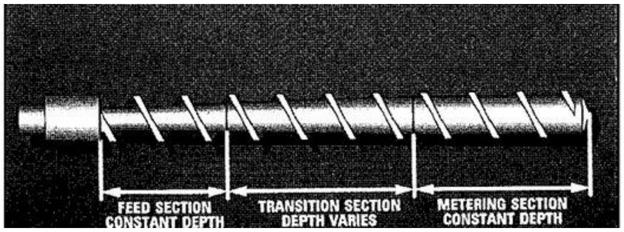

Fig. 1 screw terminology

III. DESIGN

A. Design Methodology

The following design parameters are decided in the screw design, in logical order[2]

- Screw diameter and length
- Screw material, and special surface treatment if necessary
- Cooling bore and its length if necessary
- Single-stage or multiple-stages
- Number of parallel flights
- Pitch (or lead)
- Flight width and radii on the screw root
- Metering section depth and length
- Compression section length (or taper)
- Feeding section depth and length
- Mixing section or head

B. Detail Design

1) Screw: The size of the machine had to be as much as an office table. Hence the Screw length was calculated as-
Sc = 0.5(total length).
The shank length of the screw was calculated as-
Sl = 0.2(Sc)
Flighted length was calculated as-
L = Sc –Sl
The Flighted length or the working length of the screw was found out to be-
L= 600mm.
L/D ratio was chosen to be 12:1 and diameter was calculated using the ratio and Length
Based on these dimensions other dimensions were calculated. Feed section depth H_f, Metering section depth H_m, Land width e, Helix Angle ϕ, Channel width W, RPM were respectively calculated using these formulae[7][12] –

H_f = 0.2D
H_m = H_f / C.R
e = 0.1*D
Φ = tan-1 (p/πD)
W = (π*D*tanϕ-e)cosϕ
Rate = 2.3*D2*H_m*SG*N

Where D – Major Diameter; p – Pitch, N – RPM, SG- Specific Gravity, C.R – Compression Ratio

2) Barrel: Barrel is a essentially a hollow cylinder. Its dimensions depend upon the dimensions of the screw. The inner diameter of the barrel is one or two millimeter more them the screw major diameter.
Therefore ID = 2+D.

3) Hopper: Hopper is another important part of the extruder it resembles a funnel, and facilitates the feeding the screw. Hopper should be designed such that it should supply raw material at an appropriate rate. Although there is no design methodology for designing a hopper. A hopper with a proportionate size to the machine is adequate.

4) Die: Die is another part of an extruder. It's important to design an appropriate die as it determines the shape and size of the extrude. The die was produced from a hollow cylinder whose inside diameter was just greater than barrel outside diameter. And a circular plate was fastened at the other end.

5) Motor: Motor specifications are determined by the RPM of the screw and power required. Power in hp for a motor is given by -
Power in hp = 0.00053 * (lb/hr) * (sp.heat) * (temperature in barrel)

6) Heater: Heaters are requires to melt the plastic. Different temperatures are maintained at different zones. Hence one heater per zone is used. Also one heater is used on the die to aid uniform extrusion.

7) Frame: Frame is the base on which the whole machine is mounted. Frame must be properly designed to withstand the both static and dynamic loads.

IV. TESTING

The Extruder machine was fabricated as per the design and was tested in the following criteria –
i. Functionality of the machine
ii. Quality of the Extrudate
iii. Flow of the Extrudate

A. Testing Methodology

Five samples were extruded from the machine. Each sample was evaluated against the above mentioned criteria. Attribute type of evaluation was carried out. Experienced workers in the field were asked to rate the machine based on the criteria. A sample of the evaluation sheet is shown in figure 2. Finally the average score for each criteria was calculated and the overall performance of the machine was determined.

V. RESULTS AND DISCUSSIONS

From the readings obtained from testing, average values for the three parameters were calculate as shown in table 1.

Table 1: Average ratings of the tests

Criteria	Grand Average
Melt Quality	2.85
Melt Viscosity	3.1
Melt Flow	3.05

The results obtained from the evaluation can be interpreted as follows –

• Melt Quality: of the extruder is nearly satisfactory.
With a few changes in the design a better melt quality can be achieved
• Melt Viscosity: The viscosity of the is moderate, which suitable for the extrusion
• Melt Flow: Melt flow has a satisfactory continuity.

VI. CONCLUSIONS

The extruder machine was designed as per the guidelines and is functioning satisfactorily. The machine has been designed within the scope and objectives. As there is always a scope for improvement, the machine can be still improved and optimized. With the applications of sensors and other electronics, the machine can be automated which will improve its functionality and enhance its efficiency.

REFERENCES

[1] Timothy W. Womer, Xaloy Inc. Basic screw geometry

[2] Chung textbook on Extrusion of polymer –theory and practice

[3] Lou Piffer, Fundamental Concept of Extrusion Design

[4] Carlos Buitrago, Introduction to Polymers

[5] A. W. Birley, B. Haworth and J. Batchelor, The Extruder Characteristic, Physics of Plastics: Processing, Properties and Materials Engineering, Hanser

[6]Caroline Schauer, prof. Drexel University Textbook on Extrusion part-1

[7]James M. Margolis, Engineering Plastics Handbook

[8] Andrew W. Christie Screw Design Basic

[9] Lou Piffer, Davis Standard Corp Concepts of Extrusion Design

[10] A. Gaspar-Cunha and J. A. Covas, The Design Of Extrusion Screws: An Optimization Approach

[11]Walter S. Smith Robert A. Sickles ,Luke A. Miller,Timothy W. Womer ,Xaloy Corporation, New Castle, PA An Experimental Investigation Into Solids Feeding, Characteristics Of A Single Piece Barrel With Integral Feedport, Design Vs A Standard Two Piece Water Cooled Feedblock And Barrel Configuration

[12] Guidelines for the Extrusion, SARLINK