Chapter I

Introduction

Plastics are part of everyday life of the human and play an important role in several industrial fields. Many types of plastics have reached the status of commodity materials.

The plastic industry has a rapid growth rate and high competition. So all processors must pay attention to improving both plastic product properties and processing costs to attract the customer interest. Compounding of additives into a base polymer is one of the indispensable processes of upgrading the properties of the polymer product, such as optical appearance, mechanical strength, electrical conductivity, chemical resistance and so on. Typically, each additive is used in a small limited amount. In order to exert beneficial influence on the polymer properties, the additives must be well dispersed therein. One way of improving the dispersion can be accomplished by using a suitable type of compounding equipment. Multi-screw compounder or kneader is well known for its advantages in compounding plastics. It has been recognized as an efficient mixer, which allows the extruder geometry to be optimized for specific tasks and provides high shear stress and uniform heat history without serious degradation of the resin and additives. In addition, good dispersion allows a decrease in the amount of additives required, thus lowering additives costs.

Colorant additives are widely used for both aesthetic and functional purposes depending on the utilization purpose as well as the characteristics of the resin to be compounded. Colorants can be classified in two basic types, pigments and dyes. Since dyes in plastics are limited by their properties, pigments are more commonly used to produce color. However, pigments are not soluble in the resin but must be dispersed. So all manufacturers must pay attention on how to produce an uniform dispersion of pigments in plastics to increase the quality of the products.

Pigments are distinguished by their chemical nature as being organic of inorganic. Generally, organic pigments tend to produce brighter, cleaner colors and more tinting strength than inorganic pigments, including a variety of hue. Carbon black has the largest utilization volume, by far, of all organic pigments. Among quinacridone pigments, which are another important group of high performance organic pigments, the most well known type being quinacridone violet. In addition, both of them are widely used colorants for cellulose and phenolic resins, including polyethylene and other thermosetting plastics.

Polyethylene (PE) is the world most important commodity plastic with many excellent characteristics. Typically, before the forming process, PE is blended and kneaded with numerous additives to improve its physical properties. Since PE is colorless, colorants are often added.

This work is focussed on studying the effects of factors influencing the dispersion of organic pigments in polyethylene upon using a continuous twin-screw kneader. High density polyethylene and certain organic pigments (carbon black and quinacridone violet) are chosen. A novel analytical method of fractal analysis is used to evaluate the degree of organic pigments dispersion in the kneaded resin.

The novel fractal analysis method is based on the concept of fractal geometry. Beyond the realm of Euclidean geometry, fractal geometry can be applied to characterize an object or material of complex morphology with an guantitative index called the fractal dimension. Ordinary methods to evaluate the degree of dispersion of an interested additive either rely on experience or employ statistical methods (for example, the sample variance of the composition of the additive of interest obtained from random sampling). The obtained information is generally at the mesoscale (semi-macroscale) level. However, since fractal analysis yields information down to the microscale level, it could provide a quantitative index that can distinguish whether the resulting mixture is simply a perfect random mixture or an ordered mixture, and differentiate between the intensity levels of kneading by indicating the absence or presence of as well as the degree of breaking-up of clusters or secondary particles during the operation.

This study applies the concept of fractal to analyze the degree of dispersion of pigments in HDPE resins. Factors influencing the dispersion of organic pigments in the kneaded HDPE resin are also studied.

1.1 Objectives of the thesis

In the present study, the effect of major factors influencing the dispersion of organic pigments in polyethylene using a continuous twin-screw kneader are to be inventigated. High Density Polyethylene is used. As representatives of organic pigments, carbon black and quindo violet RV-6926 (quinacridone violet pigment) are chosen. The main objectives are the following:

1.1.1 To study experimentally factors that affect the dispersion of organic pigments in polyethylene using a continuous kneader with the aid of the fractal dimension.

1.1.2 To determine the suitable kneading conditions for the dispersion of the two organic pigments in polyethylene.

1.2 Scope of the present work

1.2.1 Investigating the principal factors that are expected to influence the dispersion of the two selected organic pigments in polyethylene. The factors of interest are as follows.

1) Type of organic pigments: Carbon black and Quindo Violet RV-6926 (Quinacridone pigment)

2) Premixed time using a V-type mixer: 0-30 minutes.

3) Feed rate of polyethylene-organic pigment mixture: 30-90 g/min.

4) Rotational speed of screw: 81-340 rpm.

5) Kneading temperature: 140-240 ^{0}C

1.2.2 Analyzing the dispersion results of the organic pigments in polyethylene by applying the fractal analysis.

1.2.3 Discussion, comparison and conclusions based on the experimental results.