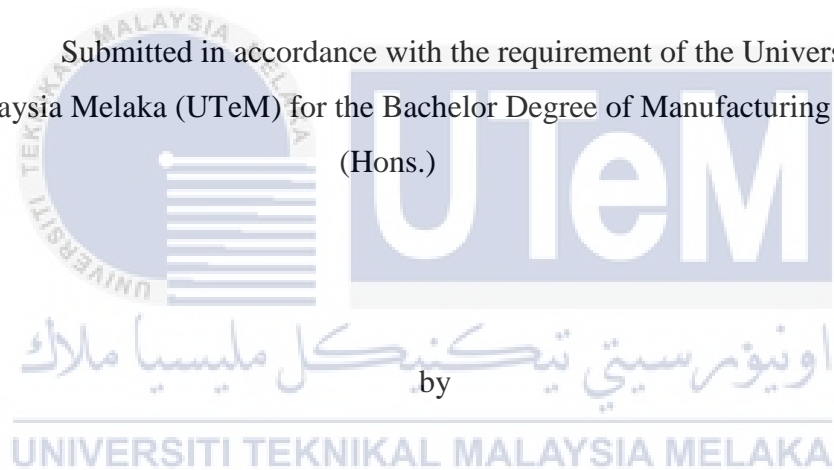




EFFECT OF PROCESS PARAMETERS ON THE OPTICAL PROPERTIES OF CAST POLYPROPYLENE FILM

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)



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2020

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Sesi Pengajian: **2020/2021 Semester 2**

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Tajuk PSM: Effect of Process Parameters on the Optical Properties of Cast Polypropylene Film

Nama Syarikat: San Miguel Yamamura Plastic Film Sdn. Bhd.

Sesi Pengajian: 2020/2021

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DECLARATION

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: 21st September 2021



APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Bachelor Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:



ABSTRAK

Filem Polipropilina Tuang (CPP) terkenal dengan sifat terbaik dalam aspek mekanikal, fizikal, dan optikal terutama kerana keliacauan, kejelasan, dan ketelusannya yang tinggi, menjadikannya umumnya digunakan sebagai filem pembungkusan. Dalam kajian ini, filem CPP yang dikeluarkan oleh San Miguel Yamamura Plastic Film Sdn. Bhd. (SMYPF) melalui proses penyemperitan tuang mengalami dua jenis kecacatan: (i) kehadiran ciri-ciri kulit oren pada permukaan filem dan (ii) variasi ketebalan lapisan filem. Oleh itu, projek ini menyiasat kesan parameter pemprosesan seperti suhu penyemperitan dan kadar ketebalan blok suapan terhadap isu ketelusan dan variasi ketebalan filem CPP. Untuk kecacatan kulit oren, alat kemikroskopan elektron imbasan (SEM) digunakan untuk memeriksa morfologi permukaan filem sebagai fungsi suhu lebur; dan pengukuran kekasaran permukaan filem ditambah dengan teknik mikroskopi kekuatan atom (AFM). Sementara itu, ketebalan keratan rentas filem dikaji penyesuaian blok pasca suapan menggunakan SEM. Hasilnya menunjukkan bahawa ciri kulit oren dapat diminimalkan dengan menyesuaikan suhu leleh pada zon terakhir di penyemperit kerana kenaikan suhu lebur mengakibatkan penurunan kelikatan polimer, yang menyebabkan kadar ricih yang lebih tinggi pada acuan keluar. Sebaliknya, masalah variasi ketebalan berjaya dikurangkan dengan meningkatkan blok suapan pada penyemperit untuk membolehkan lebih banyak laluan bahan dan seterusnya meningkatkan ketebalan lapisan kulit filem.

ABSTRACT

Cast Polypropylene (CPP) film is widely known for its best properties in mechanical, physical, and optical aspects especially for its high gloss, clarity, and transparency, leading it to be generally used as packaging film. In this study, the CPP films manufactured by San Miguel Yamamura Plastic Film Sdn. Bhd. (SMYPF) cast co-extrusion process were suffering from two types of defect: (i) the presence of orange peel features on film surface and (ii) variation in film layer thickness. Hence, this project investigated the effect of processing parameters such as extrusion temperature and feed block thickness rate on the transparency and thickness variation issue of the CPP films, respectively. For orange peel defect, scanning electron microscopy (SEM) was used to examine the film surface morphology as a function of melt temperature; and the film surface roughness measurement was supplemented using atomic force microscopy (AFM) technique. Meanwhile, the cross-sectional thickness of the film was studied post feed block adjustment using SEM. The result showed that orange peel features can be minimized by adjusted the melt temperature at the last zone of extruder as the increase in melt temperature resulted in the drop of polymer melt viscosity, leading to higher shear rate at the die exit. On the other hand, thickness variation problem was successfully mitigated by increasing the feed block at the extruder to allow more material throughput and subsequently increased the film skin layer thickness.

DEDICATION

Only

my beloved father, Mohamad Yusof Bin Mei

my appreciated mother, Masnah Binti Sirat

my sister and brother, Yuhanis, Affif, Saifuddin and Athirah

for giving me moral support, money, cooperation, encouragement and also
understandings Thank You So Much & Love You All Forever

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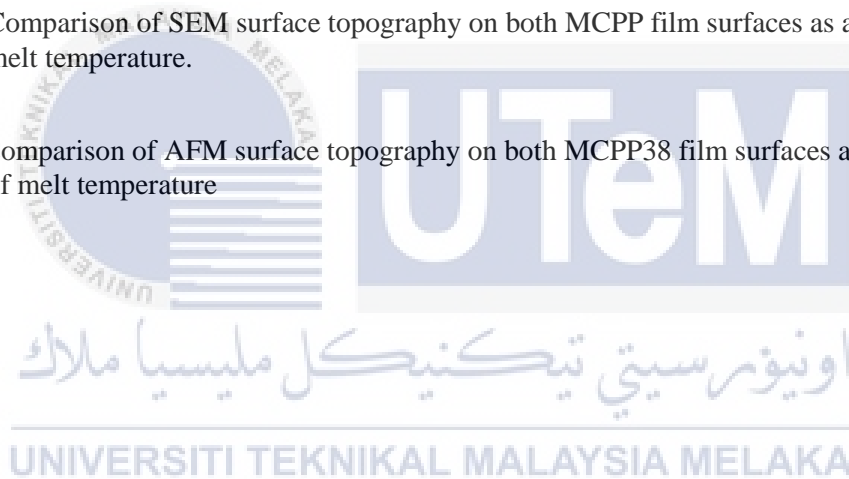
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LIST OF ABBREVIATIONS

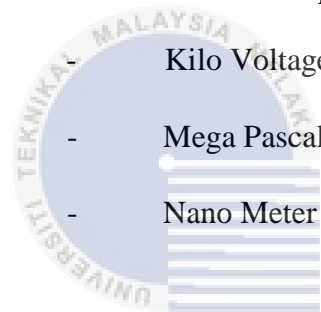
AFM	-	Atomic Force Microscopy
BOPP	-	Biaxially Oriented Polypropylene
COF	-	Coefficient of Friction
COOH	-	Carboxyl
CPP	-	Cast Polypropylene
EVA	-	Ethylene Vinyl Acetate
HDPE	-	High Density Polyethylene
HPP	-	Homo-polymer Polypropylene
iPP	-	isotactic Propylene
LDPE	-	Low Density Polypropylene
MCPP	-	Metallized Cast Polypropylene
MFI	-	Melt Flow Index
OH	-	Hydroxyl
PE	-	Polyethylene
PP	-	Polypropylene
PPR	-	Random Copolymer Polypropylene
SAXS	-	Small Angle X-Ray Scattering
SEM	-	Scanning Electron Microscopy

SMYPF - San Miguel Yamamura Plastic Film Sdn. Bhd.
WAXS - Wide Angle X-Ray Scattering



LIST OF SYMBOLS

°C	-	Degree Celsius
µm	-	Micro Meter
g/min	-	Gram per Minute
kg/m ³	-	Kilogram per Meter Cube
KPsi	-	Kilo Pound per Square Inch
Kv	-	Kilo Voltage
MPa	-	Mega Pascal
nm	-	Nano Meter



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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Plastic film is the main material used in packaging film. High-density polyethylene (HDPE), low-density polyethylene (LDPE), cast polypropylene (CPP), and biaxially oriented film (BOPP) are some of the most significant ones. CPP films are one of the most commonly used films on the market among all of these materials. The main usage of CPP film is to act as a sealant in multilayer packaging structures as it has high heat seal strength.

Generally, the CPP film is produced from polypropylene resin through extrusion process where a T-die is employed to shape the raw material into a sheet form. CPP film is widely known of their best properties in mechanical, physical and optical aspect. Mechanically, CPP films have high heat seal strength, good machinability on packaging line and good resistance to tears and puncture. Also, CPP film is recognized by industry for how the film is such a good moisture barrier and good resistant to grease and oil in terms of its physical performance. More importantly, as a packaging film, CPP film has high gloss, clarity and transparency.

In packaging applications, the optical properties of films are key properties; high visibility is desirable to allow the packaged product to be viewed clearly through the film (Maia *et al.*, 2017). For example, in food packaging, in order to determine edibility, we can make subtle visual judgments of the packaged food condition through its packaging to

determine whether it is still in edible condition or not (Fleming, 2014). Optical properties are crucial in single-layer applications such as tissue wrap and packaging with a window design. It would not be an exaggeration to say that optical properties are the most critical of the three properties because there are cases where a high level of consumer appeal in the display of products is required. In any case, they have to pay more attention towards the optical properties on the CPP film but at the same time, they still have to produce the best quality of the CPP film.

The disruptions affecting the optical properties of melted processed film may cause from many factors such as machine and processing parameters, environmental condition, material performance, and personnel competency. The most critical factors affecting the cast during the extrusion process are melt temperature (Barborik & Zatloukal, 2019; Rytöluoto, Gitsas, *et al.*, 2017; Ruijie Xu *et al.*, 2015), and screw motors speed (Domenech *et al.*, 2013; Gocek & Adanur, 2012). To improve the appearance of CPP films, the first thing to do is to understand the factors that contribute to visual defects so that improvements can be made to produce CPP films with very low haze, high gloss, and good transparency. Not to mention, the mechanical properties of the CPP films are critical to ensuring that they can serve their intended applications.

1.2 Problem Statement

Generally, food industries mostly use Cast Polypropylene film for packaging purposes. Optical properties such as haze, clarity, and transparency are undeniably important for the products. Therefore, factors affecting the optical properties of melt-processed polypropylene films for packaging applications have gained noticeable attention. According to the industry San Miguel Yamamura Plastic Film Sdn. Bhd (SMYPF), typical optical defects such as flow marks, surface melt fracture (sharkskin), and orange peel features could be observed on the CPP films after the extrusion process. Orange peel is one kind of defect where some uneven coarse surface present on the film, which affects the clarity of CPP film as shown in Figure 1.1. Meanwhile, sharkskin is a viscoelastic surface defect developed at

the die exit by melt fracture and consists of curled ridges that are normal to the film's machine direction. West (2005) have observed that if the melted polymer took a longer time to cool, the film will become hazier and duller, which is also referred to as lower gloss. This is where melt temperature plays a vital role in controlling the melted polymer viscosity rate that comes out through the T-die from the extrusion process.



Figure 1.1: Sample with orange peel features received from SMYPF.

On top of the optical defects, the extruded CPP film also suffered from thickness variation within the layers of film as shown in Figure 1.2. CPP film consists of three layers, i.e., two sides of the skin layer and one core layer in the middle. Thickness variation is critical for the film properties such as coefficient of friction (COF), haze evenness, and heat seal strength. The defects are observed because the thickness of the skin layer is thinner than the expected value. Figure 1.3 shows the illustration of theoretical thickness cross section of CPP film with 40 μ m of overall thickness. Several researchers studied that feed block plays a significant role in controlling thickness on every layer of material in the polymer film (Anukiruthika *et al.*, 2020). Hence, in this work, the effect of processing parameters such as melt temperature and feed block adjustment on the transparency and glossiness of the CPP film have been studied.

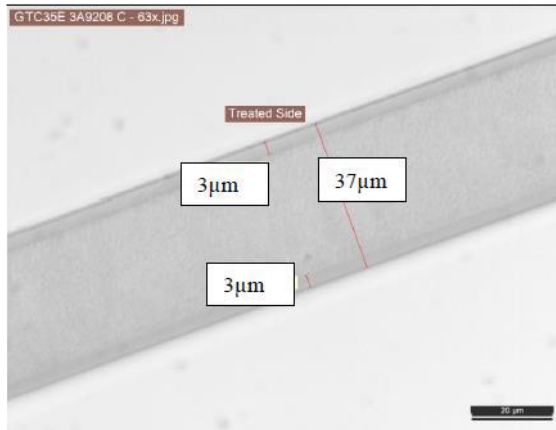


Figure 1.2: Sample with thickness variation received from SMYPF.

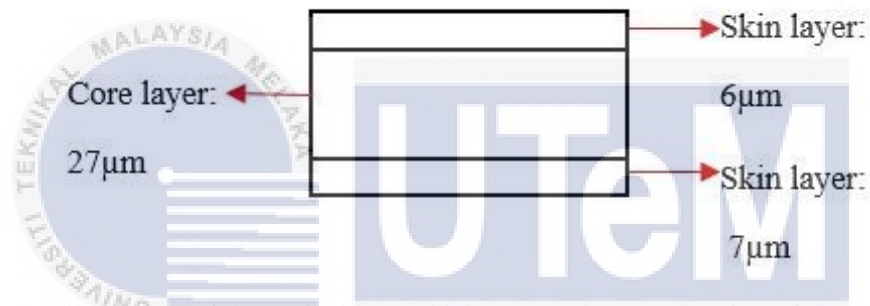


Figure 1.3: Illustration of theoretical layer thickness on the cross section of CPP film with an overall thickness of 40 μm .

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1.3 Objectives

The objectives of this work are:

- a) To investigate the effect of extrusion temperature on the orange peel features of CPP film produced at San Miguel Yamamura Plastic Film Sdn. Bhd.
- b) To mitigate the film thickness variation problem in CPP film production at San Miguel Yamamura Plastic Film Sdn. Bhd.

1.4 Scope of Research

This project focused on analyzing the defects that occurred on the extruded CPP film received from SMYPF. There are two types of defective samples, i.e. the sample with orange peel features and the sample with thickness variation problem. In general, the CPP films produced in SMYPF are a three-layers-coextruded film having two different surfaces, which are the non-treated surface and the Corona-treated surface (a.k.a treated surface in the subsequent part of this report). Corona treatment creates the polarity on the surface, thus improving the surface energy to build a strong bond with ink/adhesion/coating, etc. For orange peel defects film, it is important to identify (i) the film surface which contributed to the orange peel feature and (ii) the appropriate melt temperature to overcome the orange peel defect. Hence, the samples were characterized using Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) to observe the surface topography of the film as well as to measure the film surface roughness, as a function of melt temperature. As for film thickness variation problem, SEM were employed to visualize the thickness of cross-sectioned films. Since the CPP film consists of three-layers, it is essential to identify the location of the defect because each layer of film comes from different extruders.