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.)

by

NUR IZZATI BINTI MOHAMAD YUSOF

B051710189

961222-12-5320

FACULTY OF MANUFACTURING ENGINEERING

2020

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **EFFECT OF PROCESS PARAMETERS ON THE OPTICAL PROPERTIES OF CAST POLYPROPYLENE FILM**

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

Saya **NUR IZZATI BINTI MOHAMAD YUSOF (961222-12-5320)**

mengaku membenarkan Laporan Projek Sarjana Muda (PSM) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. *Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysiasebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
√	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/ badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

Alamat Tetap:
Lot 630A, Jalan Jaya,
Kampung Batu Laut,
42800, Tanjung Sepat, Selangor

Tarikh: 21/9/2021

Cop Rasmi:
DR. CHANG SIANG YEE
Senior Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 22/9/2021

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

FAKULTI KEJURUTERAAN PEMBUATAN

BORANG PENGESAHAN TAJUK INDUSTRI BAGI PROJEK SARJANA MUDA

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

Adalah saya dengan ini memperakui dan bersetuju bahawa Projek Sarjana Muda (PSM) yang bertajuk seperti di atas adalah merupakan satu projek yang dijalankan berdasarkan situasi sebenar yang berlaku di syarikat kami sepertimana yang telah dipersetujui bersama oleh wakil syarikat kami dan penyelia serta pelajar dari Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka yang menjalankan projek ini.

Tandangan Wakil Syarikat: Cop Rasmi:

SAN MIGUEL YAMAMURA PLASTIC FILMS SDN BHD
Admin.
38438-P

Nama Pegawai: Alecia Tan

Jawatan: Senior Technical Manager

Tarikh: 21/10/2020

Tandatangan Pelajar:

Nama Pelajar: Nur Izzati Binti Mohamad Yusof

No Matriks: B051710189

Tarikh: 21/10/2020

Tandatangan Penyelia:

Cop Rasmi:

DR. CHANG SIANG YEE
Senior Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Nama Penyelia: Dr. Chang Siang Yee

Jawatan: Pensyarah Kanan

Tarikh: 21/10/2020

DECLARATION

I hereby, declared this report entitled "Effect of Process Parameters on the Optical Properties of Cast Polypropylene Film" is the result of my own research except as cited in references.

Signature :

Author's Name : NUR IZZATI BINTI MOHAMAD YUSOF

Date : 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:

………………………………………………………

(Dr. Chang Siang Yee)

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 oforange peel features on film surface and (ii) variation in film layer thickness. Hence, this project investigated on 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

ACKNOWLEDGMENT

First and foremost, I am very thankful to the almighty ALLAH S.W.T for allowing me complete my Final Year Project II and for giving me the strength I need to fulfil my duty as a student of the Bachelor of Manufacturing Engineering.

I would like to express my sincere gratitude to several individuals throughout my final year project for supporting me. I would like to take this opportunity to express my sincere appreciation for her patience, enthusiasm, insightful comments, invaluable suggestions, helpful information, and practical advice to my supervisor, Dr. Chang Siang Yee, which have helped me tremendously in my research and writing of this thesis at all times. I am thankful to her for her precious time in guiding me, answering my queries, correcting and improving the English in my report. Without her guidance and relentless help, this report would not have been possible.

I express my deepest thanks to Ms. Alecia Tan, Senior Technical Manager from San Miguel Yamamura Plastic Film Sdn. Bhd. as my industrial supervisor in this research. I choose this moment to acknowledge her contribution gratefully for taking part in giving necessary information and guidance.

I am also grateful to the lecturers for their kindness, hospitality and technical support. In particular, I would like to thank all the staff and technicians, indirectly or directly, for their assistance while completing my Final Year Project II.

I also wish to express to my parents my deepest gratitude. My pillar of strength is their unwavering love and encouragement. I am grateful to all my friends as well. They always there caring for me, cheering me up, moral support, and advice.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

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 40µm 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.

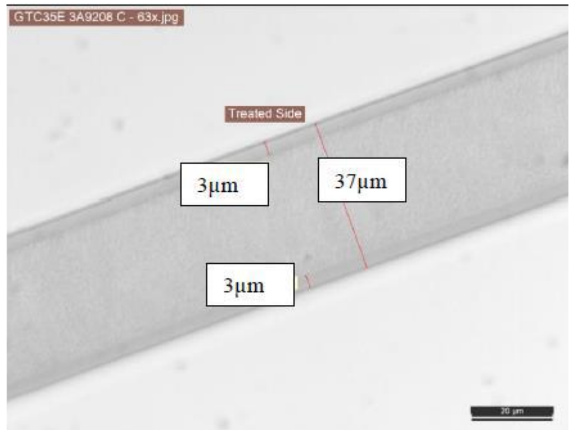

Figure 1.2: Sample with thickness variation received from SMYPF.

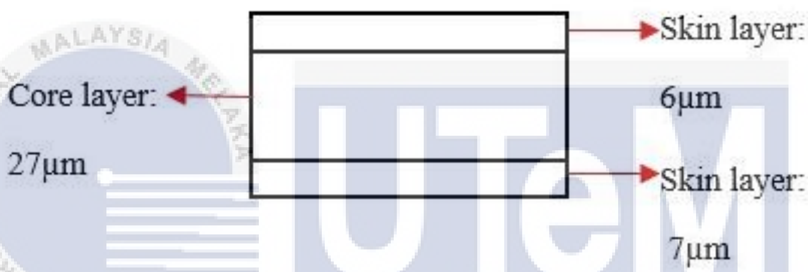

Figure 1.3: Illustration of theoretical layer thickness on the cross section of CPP film with an overall thickness of 40 µm.

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.