CHARACTERIZATION OF BIAXIALLY ORIENTED POLYPROPYLENE (BOPP) FILMS CONTAINING BAGGY WEB DEFECT

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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Sesi Pengajian: **2020/2022 Semester 2**

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Tajuk PSM: Characterization of Biaxially Oriented Polypropylene (BOPP) Films Containing Baggy Web Defect

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

Sesi Pengajian: 2021/2022

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.

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DECLARATION

I hereby, declared this report entitled "Characterization of Biaxially Oriented Polypropylene (BOPP) Films Containing Baggy Web Defect" is the result of my own research except as cited in references.

Signature : ....

Author's Name : CHOIR YEK GUAN

Date :

APPROVAL

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

……………………..................................

(Dr. Chang Siang Yee)

ABSTRAK

Filem Polipropilena Berorientasikan Dwipaksi (BOPP) terkenal dengan kualiti mekanikal dan fizikal yang sangat baik, dan ia sering digunakan sebagai filem pembungkusan. Filem BOPP yang dibuat oleh San Miguel Yamamura Plastic Film Sdn. Bhd. (SMYPF) didapati mempunyai kecacatan jaringan yang longgar ("*baggy web*"). Projek ini memberi tumpuan kepada pencirian filem yang rosak. Dua jenis sampel telah disediakan oleh industri iaitu sampel biasa dan rosak. Untuk mencapai analisis variasi ketebalan filem objektif pertama pada filem BOPP yang mengandungi kecacatan *baggy web*, mikroskop elektron pengimbasan (SEM) telah digunakan untuk menggambarkan ketebalan filem keratan rentas. Objektif kedua kerja ini adalah untuk menyiasat kehabluran filem,yang mana pembelauan sinar-X (XRD) telah digunakan. Keputusan SEM menunjukkan ketebalan filem yang mengandungi kecacatan *baggy web* adalah lebih tinggi daripada sampel biasa, ini membuktikan kecacatan web baggy adalah berkorelasi dengan variasi ketebalan pada filem BOPP. Di samping itu, keputusan XRD menunjukkan bahawa kehabluran filem adalah berkadar terus dengan suhu pengeluaran. Suhu pengeluaran yang lebih rendah akan menyebabkan pembentukan kristal berbentuk beta yang membawa kepada kehabluran yang lebih rendah Adalah didapati bahawa kawasan kecacatan biasanya mempunyai kehabluran 3-5 peratus lebih tinggi berbanding dengan kawasan biasa pada filem. Ini kerana pengaliran haba yang tidak seragam di penyemperit menyebabkan pertumbuhan kristal dengan kadar yang berbeza pada keseluruhan pemukaan filem.

ABSTRACT

Biaxially-Oriented Polypropylene (BOPP) film is well-known for its excellent mechanical and physical qualities, and it is frequently used as a packaging film. The BOPP films made by San Miguel Yamamura Plastic Film Sdn. Bhd. (SMYPF) are found to have a baggy web flaw. This project focused on the characterization of defective film. Two types of sample were provided by industry which are normal and defective sample. To achieve the first objective on film thickness variation analysis on BOPP films containing baggy web defect, a scanning electron microscope (SEM) was employed to visualize the thickness of cross-sectioned films. Second objective of this work was to investigate the crystallinity of film, where X-ray diffraction (XRD) was used. The SEM results show that the thickness of film containing baggy web defect is higher than normal samples, hence it is proven that the baggy web defect is correlated with the thickness variation on BOPP film. On the other hand, XRD results show that the crystallinity of film is directly proportional to the production temperature. Reducing the production temperature causes formation of beta form crystal in the film, which leads to lower crystallinities. It was found that the defect region normally has 3-5 percent higher crystallinity compared to normal region on the same films. This is because non-uniform heat flow of extruder causes the crystalline growth at different rate throughout the film surface.

DEDICATION

Only
my beloved father, Choir Yu Keong
my appreciated mother, Tan Teu Sewong
for providing me with moral support, financial assistance, tolerance, motivation, and compassion
thank you so much

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LIST OF ABBREVIATIONS

AFM	-	Atomic force microscope
ASTM	-	American society for testing and materials
BOPP	-	Biaxially oriented polypropylene
CPP	-	Cast unoriented polypropylene
DIC	-	Digital image correlation
DMA	-	Dynamic mechanical analysis
HDPE	-	High density polyethylene
LDPE	-	Low density polyethylene
PP	-	Polypropylene
PE	-	Polyethylene
SEM	-	Scanning electron microscope
SOP	-	Standard operation procedure
SMYPF	-	San Miguel Yamamura Plastic Film Sdn. Bhd.
TDO	-	Transverse direction oriented
XRD	-	X-ray Diffraction

LIST OF SYMBOLS

°C		Celsius
cm	-	Centimetre
m	-	Metre
%	-	Percent
g/cm^3	-	Grams per centimetre cube
mm	-	Millimetre
MPa	-	Mega Pascal
GPa	-	Giga Pascal
°C	-	Degree Celsius
µm	-	Micrometre

CHAPTER 1
INTRODUCTION

1.1 Research Background

The market for plastic films and sheets is being driven by rising consumer disposable income and increased demand for packaged foods. The most common type of packing film is plastic. Some of the most important include high-density polyethylene (HDPE), low-density polyethylene (LDPE), cast polypropylene (CPP), and biaxially orientated film (BOPP). The food segment of the BOPP film market is expected to develop at the quickest rate. The goal of modern industrial manufacturing is to produce high-quality items in less time and at a lower cost. Since multilayer co-extrusion, corona discharge treatment, innovative polymers and coating technologies are growing at a rapid rate, the usage of BOPP films in industry market also rising at an alarming rate.

BOPP films are made from stretching that polypropylene film in both machine and transverse directions. A tubular process, or a tenter frame technique, where heating a thick extruded sheet until its softening point and stretched physically are the process used to manufacture that film. BOPP films are created from materials that are extensively sterilized. These materials serve to keep items safe from infection, making them excellent for food and beverage packaging. Packaging, labelling, and laminating are just few of the applications for BOPP films.

These films are the preferred substrate for food packaging across the world due to its superior mechanical, physical, and graphical characteristics. BOPP films have a strong heat seal strength, good machinability on the packing line. Besides that, it also has a good moisture barrier and superior oxygen barrier in its metallized form. Transparent BOPP films provide outstanding transparency, allowing for a high level of aesthetic appeal in product packaging.

Since BOPP film is commonly used in the food industry for packaging purposes, the film flatness, thickness, and tensile strength are some of the significant features required by the food manufacturers. As a result, issues impacting these characteristics for packaging applications have received a lot of attention. One of plastic film industries in Melaka San Miguel Yamamura Plastic Film Sdn. Bhd. (SMYPF) is suffering from a baggy web issue in the BOPP film production line during the slitting process. This event has resulting in severe material wastage and financial loss.

1.2 Problem Statement

One of the improvements required to enhance the performance of BOPP film is reduce the bagginess web on the surface of film during the manufacturing process. Current system did not have any effective way to track or detect the bagginess problem of BOPP plastic film.

Based on the information provided by SMYPF, surface defects such as baggy web can be detected on BOPP films after the slitting process. SYMPF manufactured 24-kilometre-long BOPP films that will be slitted into three sheets of 8 kilometer wide. Only at the third slitted plastic films, which is the final slitting operation, will these faults appear. Figure 1.1 displays a web with a cross web variation in machine direction length produced by SMYPF. Some of the areas indicated out by the arrow were impacted by the baggy web issue.

Figure 1.1: Baggy web defect on BOPP films.

SMYPF was currently lacking a defined approach for detecting these problems. They are mystified as to how this baggy web issue occurs. Existing mitigation plan is to employ physical identification approach with naked eye of operator to notify the problem. A study of the nature of this occurrence is suggested to identify a potential solution to this problem and minimize production waste .Hence, this project focused on investigating e some of the features of plastic film, such as thickness and crystallinity properties of the problematic sample, in accordance with industry requirements.

1.3 Objectives

The objectives are as follows:

a) To analyse the thickness variation on the BOPP film containing baggy web defect

b) To investigate the crystallinity of BOPP film containing baggy web defect

1.4 Scopes of research

The goal of this project is to investigate the abnormalities in the defective BOPP film provided by SMYPF. There are two type of film thickness for these faulty sample: (i) 20 µm thick BOPP film, and (ii) 38 µm thick BOPP film. Apart from the failed sample, SMYPF also provides a normal sample for comparison of thickness and crystallinity properties. Scanning electron microscope (SEM) was used to visualize (i) the cross-sectional thickness of normal sample and (ii) cross sectional thickness of sample containing baggy web defect in order to achieve the first objectives of film thickness variation analysis. To accomplish the second goal of this project, degree of crystallinity was determined using a X-ray Diffraction (XRD) spectroscopy. Both normal and defective sample with different thickness were investigated for the crystallinity of BOPP films which contains baggy lane defect.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction of Packaging Film

The packaging film sector is growing at a significant rate. Plastic films are mostly in high demand for a variety of uses, including packaged foods, printing, laminate, and sealing. Since most individuals consider of plastic film, they think of it as a single type of material. Packaging film is made out of a number of materials of varying degrees of complexity based on the product's requirements. High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Cast Polypropylene (CPP) film, and Biaxially Oriented Polypropylene (BOPP) film are examples of common plastic materials used in packaging film (Emblem, 2012). The features and characteristics of packaging film are described in Table 2.1.

Table 2.1: Properties and characteristic of packaging film.

Properties	Characteristic
Physical properties	Colour, weight, thickness, moisture content, water solubility, and barrier ability are all factors to consider.(Yong & Liu, 2020).
Mechanical properties	Tensile and elongation strength, tear strength, and impact strength (Emblem, 2012).
Thermal properties	Heat capacity, melting temperature, thermal conductivity, and glass transition temperature (Siracusa, 2016).
Optical properties	Gloss, transparency, haze, clarity.

2.1 Types of Packaging Film

In this section, several types of packaging film commonly used in packaging business are discussed. When developing packaging for goods or products, there are various variables and qualities to consider to adequately serve and exhibit the goods or products. Different materials are used for different types of packaging, depending on their properties. The most common types of packing films are described below.

2.1.1 High Density Polyethylene (HDPE)

HDPE is made using a low-pressure process, and it has the highest degree of crystallinity and is the most flexible of all the PEs. It is also the most stable PE because it has fewer short branches, which means the chains pack very tightly into the crystal structure, as shown in Figure 2.1 (Graziano et al., 2019). HDPE is used most commonly in hard packaging, such as milk bottles and household chemicals (Emblem, 2012). HDPE offers a moisture barrier and is commonly used in the packaging of dry goods due to its characteristics (Butler & Morris, 2016). HDPE offers the highest oil resistance because to its strong crystallinity.

Figure 2.1: HDPE structure ($C_2 H_4$) (Graziano et al., 2019).

2.1.2 Low Density Polyethylene (LDPE)

Because HDPE is made using a low-pressure technique, LDPE is made using a high-pressure method and contains both short and long branching chains, as well as roughly 50-65 percent crystallinity, giving it a clear look as illustrated in Figure 2.2. LDPE is extensively utilized as a vital packaging material because of its great qualities, such as high elasticity, impact strength, and chemical resistance. (Butler & Morris, 2016) It also has a good moisture barrier but a weak oxygen barrier and softens at roughly 100°C (may be lower for some grades, depending on the polymer resin grades), making it a cost-effective polymer to process and heat seal, but unsuitable for cook-in packs (Emblem, 2012).

It is pretty easy to work with and may be combined with a range of components to change its core qualities, such as EVA, other polyolefins, fillers, and pigment. Bread packaging, frozen food packaging, and textile packaging are all common uses for LDPE plastic film. (Serranti & Bonifazi, 2019).

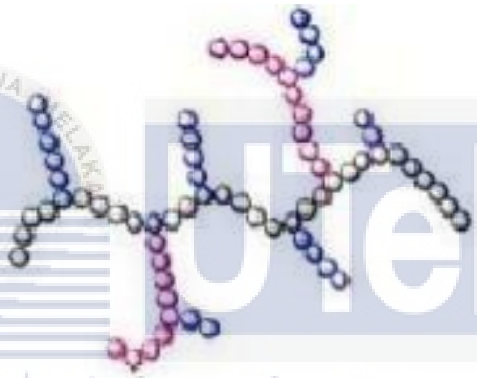

Figure 2.2: LDPE structure (C_2 H_4) (Graziano et al., 2019).

2.1.3 Polypropylene (PP)

Polypropylene, a thermoplastic polymer that may be processed and used in a variety of ways, is a commercially available material (Maier et al. 1998). Because of its cost-effectiveness, polypropylene (PP) is a widely utilized thermoplastic in geosynthetic. With a market share rise of 6–7% per year, polypropylene is one of the fastest-growing commodity thermoplastics, with only polyethylene and polyvinyl chlorides surpassing it in terms of volume produced (Maier et al. 1998).

PP is comparable to HDPE in many ways. The polypropylene molecule, on other hand, contains a sequence of CH_3 groups that dangle off the primary carbon backbone, rather than creating a lengthy polymer chain made up of repeated CH_2-