THE EFFECT OF THERMOFORMING TEMPERATURE AND MOULD VENT HOLE TO THE THERMOPLASTIC CONTAINER MADE OF 1 MM POLYPROPYLENE (PP) SHEET

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Report submitted in partial fulfillment of the requirements

for the award of the degree of

Bachelor of Engineering in Manufacturing Engineering

Faculty of Manufacturing Engineering

UNIVERSITI MALAYSIA PAHANG

June 2016

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ABSTRACT

Polypropylene is in a category of thermoplastic polymer resin. It is a part of both the average household and is in commercial and industrial applications. This plastic is regularly used for food containers because it needs to be dishwasher safe. Although the thermoforming process has been developed for over two decades but there are still some unsolved problems found in this technology. In the development commercial polypropylene grades, there are several critical problems addressed such as sheet quality, part uniformity and wall thickness, regrind use and dimensional stability. This project starts with searching various types of journal that related to the topic of designing and fabricating thermoplastic container using polypropylene (PP) sheet via thermoforming process. Read and understand all the journals are the element in the effort to make this project. This study aims to design and fabricate plastic container using polypropylene (PP) sheet with thickness 1 mm via thermoforming process. CATIA P3 V5R21 software by Dassault Systemes was used to design the plastic container and its mould. Design consideration for the plastic product and its mould is important as to reduce the defects. For example fillet was added to avoid sharp edge. Draft angle also was used at the wall side of mould which is 3° to ease the process of absorption. Round shape plastic container was selected to be design as it has smooth shape that allows the pliable polypropylene sheet to form according to the shape of the mould. An aluminum block with dimension 100 mm x 100 mm x 50 mm was used as the female cavity been cut using band saw machine. The aluminum blocks was machined using Makino KE55 CNC Milling Machine located at the Machining Laboratory. High Speed Drilling machine was used to drill the hole at the bottom of the female mould. 1 mm and 6 mm diameter of drill bits was used to make the holes at the bottom of aluminum mould. Moreover, this project studies the effect of thermoforming temperature and number of mould vent hole to 1 mm PP sheet. Two types of vent holes used on the aluminum mould which are 1 vent and 5 vent holes. There were two parameters used to fabricate polypropylene plastic container. The first parameter is the different degree of temperature used to heat the 1 mm polypropylene plastic sheet. The degree of temperature used is 160°C, 165°C, 170°C, and 175°C. The second parameter that was used is different number of vent holes on the mould to fabricate the plastic

container. The first one is 1 hole and secondly 5 holes, both ways was used same diameter of the vent hole which is 1mm. Lastly the process to investigate the hardness property on the fabricated polypropylene plastic container was conducted using the *Vickers Micro Hardness Tester* to obtained the hardness value. Lowest value of HV range shows that the polypropylene plastic containers have uniform hardness. Based on the research conducted, the appearance of polypropylene plastic container at temperature 165°C for 5 vent holes on mould almost goods compare to others temperature used. The appearance for other temperature was showed some defects such like wrinkles and overheated.

ABSTRAK

Polypropylene adalah dalam kategori resin polimer termoplastik. Ia adalah sebahagian daripada kedua-dua purata isi rumah dan dalam aplikasi komersil dan perindustrian. Plastik ini kerap digunakan untuk bekas makanan kerana ia perlu mesin basuh pinggan mangkuk. Walaupun proses termopembentukan telah dibangunkan selama lebih dua dekad tetapi masih terdapat beberapa masalah yang tidak dapat diselesaikan dijumpai di dalam teknologi ini. Dalam perkembangan gred polipropilena komersial, terdapat beberapa masalah kritikal ditangani seperti kualiti lembaran, sebahagian keseragaman dan ketebalan dinding, penggunaan regrind dan kestabilan dimensi. Projek ini bermula dengan mencari pelbagai jenis jurnal yang berkaitan dengan topik mereka bentuk dan reka bekas termoplastik menggunakan polypropylene lembaran (PP) melalui proses termopembentukan. Membaca dan memahami semua jurnal unsur dalam usaha menjadikan projek ini. Kajian ini bertujuan untuk mereka bentuk dan reka bekas plastik menggunakan polypropylene lembaran (PP) dengan ketebalan 1 mm melalui proses termopembentukan. CATIA P3 V5R21 perisian oleh Dassault Systemes telah digunakan untuk mereka bentuk bekas plastik dan acuan. Pertimbangan rekabentuk untuk produk plastik dan acuan adalah penting untuk mengurangkan kecacatan. Sebagai contoh fillet telah ditambah untuk mengelakkan sudut yang tajam. Sudut draf juga digunakan di sebelah dinding acuan iaitu 3 ° untuk memudahkan proses penyerapan. Bekas plastic bentuk bulat telah dipilih untuk menjadi reka bentuk kerana ia mempunyai bentuk licin yang membolehkan polipropilena mudah dibentuk untuk membentuk mengikut bentuk acuan. Blok aluminium dengan dimensi 100 mm x 100 mm x 50 mm telah digunakan sebagai rongga perempuan telah dipotong menggunakan mesin band saw. Blok aluminium dimesin menggunakan Mesin Makino KE55 CNC Milling bertempat di Makmal Pemesinan. Mesin penggerudian kelajuan tinggi digunakan untuk menggerudi lubang di bahagian bawah acuan wanita. 1 mm dan 6 mm diameter bit gerudi digunakan untuk membuat lubang di bahagian bawah acuan aluminium. Selain itu, projek ini mengkaji kesan suhu termopembentukan dan bilangan acuan lubang bolong kepada lembaran PP 1 mm. Dua jenis lubang bolong digunakan pada acuan aluminium yang 1 bolong dan 5 lubang bolong. Terdapat dua parameter yang digunakan untuk fabrikasi bekas polipropilena plastik. Parameter pertama adalah

tahap suhu yang berbeza yang digunakan untuk memanaskan 1 mm lembaran polipropilena plastik. Darjah suhu yang digunakan adalah 160 ° C, 165 ° C, 170 ° C, dan 175 ° C. Parameter kedua yang digunakan adalah nombor yang berbeza lubang bolong pada acuan untuk mereka-reka bekas plastik.. Yang pertama adalah 1 lubang dan kedua 5 lubang, kedua-dua cara telah digunakan diamete lubang bolong yang sama iaitu 1mm. Akhir sekali proses untuk menyiasat nilai kekerasan pada polypropylene bekas plastik yang direka telah dijalankan menggunakan *Vickers Micro Hardness Tester* untuk memperoleh nilai kekerasan. Nilai terendah bagi HV Range menunjukkan bahawa bekas polipropilena plastik mempunyai kekerasan yang seragam. Berdasarkan kajian yang dijalankan, kemunculan polypropylene bekas plastik pada suhu 165 ° C dengan 5 lubang bolong pada acuan hampir bgus berbanding dengan orang suhu lain yang digunakan. Kemunculan untuk suhu yang lain telah menunjukkan beberapa kecacatan seperti seperti kedutan dan terlebih panas.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Polypropylene is in a category of thermoplastic polymer resin. The molecular formula is C_3H_6. It is a part of both the average household and is in commercial and industrial applications. Commonly, product made of polypropylene can be used in various operations including as a structural plastic or as a fiber-type plastic. This plastic is regularly used for food containers because it needs to be dishwasher safe. PP also does not contain BPA which is not a secure choice for food packaging since this chemical has been shown to leach into the food products. It has been linked to numerous health problems, especially in children.

Compared to other thermoplastics, the melting point of polypropylene is very high which is at 160°C. Dishware made from this type of thermoplastic unable to sear when high temperature of water used when washing acted on it. Unlike with the popular polyethylene plastic container which has a much lower melting point. This type of thermoplastic is also very easy to add coloring agent, and it is often used as a fiber in carpeting that needs to be rugged and durable, such as that on futsal courts or in mini garden. Unlike nylon, polypropylene is an ideal selection used as a fiber for rugged carpeting because it doesn’t soak up water and suitable with moisture condition.

Polypropylene (PP) sheet is suitable to be form with the thermoforming process rather than other process. The thermoforming can be defined as a process of heating and form plastic sheet until it become malleable into a desired shape in a mould under pressure and temperature. Lately, it is higher growing process in the industry due to its economic advantages and the improvement of the process variable although thermoforming use less technique to produce plastic objects. The techniques include the clamping, heating, shaping, cooling and trimming of unwanted or excess parts.

1.2 PROBLEM STATEMENT

Firstly, thermoforming polypropylene (PP) plastic container requires more attention to mould design. Besides, ideal temperature is important to produce functional thermoplastic container using polypropylene (PP) sheet with thickness of 1 mm. Although the thermoforming process has been developed for over two decades but there are still some unsolved problems found in this technology. In the development commercial polypropylene grades, there are several critical problems addressed such as sheet quality, part uniformity and wall thickness, regrind use and dimensional stability. In this project, thermoforming temperature will be the main parameter used to investigate the effect to the final product, which is plastic container

1.3 PROJECT OBJECTIVE

i. To design and fabricate plastic container using polypropylene (PP) sheet with thickness 1 mm via thermoforming process.
ii. To study the effect of thermoforming temperature and number of mould vent hole to 1 mm PP sheet
iii. To investigate the hardness property on the fabricated polypropylene plastic container

1.4 SCOPE OF THE PROJECT

This project needs someone to design and fabricate functional thermoplastic container using polypropylene (PP) sheet with thickness 1 mm via thermoforming process. This project starts with searching various types of journal that related to the topic. Read and understand all the journals is the element in the effort to make this project. Design consideration for the plastic product and its mould important as well as can help reduce the defect. Thermoforming process with ideal temperature will be investigated in this project. This study will focus on suitable thermoforming methods for polypropylene (PP) and types of design to be used. Performing physical test and hardness test on the plastic container needed as to verify the result whether it is valid, reproducible and unquestionable.

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