Journal of Fiber Bioengineering & Informatics 4:3 (2011) 235–243
http://www.jfbi.org | doi:10.3993/jfbi09201103

# Shape Characterization for Optimisation of Bra Cup Moulding

Long Wu, Kit-Lun Yick*, Sun-Pui Ng, Joanne Yip

*Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong, China*

**Abstract**

Foam cup moulding of seamless and traceless undergarments is an important manufacturing technique for the intimate apparel industry. Nevertheless, there is limited knowledge about the optimization of the main moulding parameters. In this study, Response Surface Methodology (RSM), based on a Box-Behnken Design (BBD), was used to analyze the effects of the three main moulding factors (moulding temperature, dwell time and size of mould head) on the shape conformity of moulded bra cups and formulate a prediction model in a second-order polynomial form. Design and analysis of experimental data were carried out by the Minitab R15.1.30.0. The analyses revealed that moulding temperature greatly affected the shape conformity of moulded bra cup, and the interactions between moulding temperature and dwell time have major influence on the control of bra cup moulding process. The optimal cup shape conformity and the corresponding settings of the selected variables in bra cup moulding process were obtained by solving the quadratic regression model, as well as by analyzing the response surface contour plots. When moulding temperature and dwell time were set as 200° and 140s for a mould head size of 36C, the optimum shape conformity of the moulded bra cup was predicted as 83%. The adopted model was proved reasonably and effectively. This research provided a reference for the intimate apparel manufacturers to improve the control of the bra cup molding process and production efficiency.

*Keywords*: Box-Behnken Design; Response Surface Methodology; Optimization; Foam; Shape Conformity

## 1 Introduction

Foam cup moulding as an advanced technology is widely applied in modern intimate apparel industries since the day it came into being [1]. It is the key process in producing brassieres, determining the resultant shape and appearance of the final product [2]. Fast estimation of process parameters of foam cup moulding has practical significance for shortening testing time, reducing the material loss and labor cost as well as improving efficiency and product quality. Through the study of optimization of bra cup moulding, not only does it quantitatively predict shape conformities of moulded foam cups, but also determines main parameters which directly

*Corresponding author.
*Email address:* tcyick@inet.polyu.edu.hk (Kit-Lun Yick).


September 2011

affect product quality. This will provide basis for disclosing changing tendency of shape conformity and optimizing manufacture process.

The Response Surface Methodology (RSM) is a mathematical statistical method which optimizes experimental conditions. Although orthogonal test and RSM are both based on orthogonal design principle, the latter adopts more reasonable experimental design to conduct an economically comprehensive research with less time and testing number. This method scientifically provides the relationship between the whole and the part [3]. The most extensive application of RSM can be found in the industrial world, in situations where a number of input variables influence some performance measure, called the response, which is not easy or unfeasible to depict with a rigorous mathematical formulation [4].

According to the practical experience in the intimate apparel industry, the three factors: (1) moulding temperature, (2) dwell time, and (3) size of mould head, mainly affect the shape conformity of moulded bra cups with their corresponding standard plastic shot which is a tool traditionally used to inspect cup shape quality by visual examination [1]. The objective of this study is to optimize the process for the production of foam cup moulding using an objective and quantitative approach. This paper presents a research on three main factors, using response surface methodology (RSM), employing a three-level and three-variable Box-Behnken Design (BBD) via Minitab software (version R15.1.30.0, Minitab Inc., Pennsylvania, USA).

# 2 Materials and Methods

## 2.1 Materials

In this study, the material used is a flexible PU foam provided by a commercial bra cup manufacturer. The foam sample has open cell structure which has relatively high water absorption and air permeability. The size of the sample sheets for the test is 50 cm×30 cm×1 cm.

## 2.2 Instruments

A contour moulding machine (New Pads DM-021HP4-2PR, USA) with two pairs of mould heads of the same style was used for foam cup moulding. The PU foam sheet was placed on top of the female head of an aluminum mould which had been heated to a predetermined high temperature under control of thermostats. After the position of the foam sheet was ensured as correct, the pre-heated male mould head was brought down pneumatically and maintained at a certain height for a dwell time. Then, it was released automatically after the specified time period. Specimens were allowed to cool down at room temperature atmosphere for no less than 24 hrs before the cup shape and cup thickness were measured [5]. The shape conformity between moulded foam cups and plastic shot was calculated with a parameterized-based remeshing and registration algorithm via reverse engineering [6].

## 2.3 Box-Behnken Design

The advantages of Box-Behnken Designs include the fact that they are all spherical designs and