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Experimental Characterization of Polyurethane Foam Deformation During Bra Cup Moulding

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Abstract

The paper develops a novel method to explore a suitable scanning installation to reduce deformation effect of foam cups under different moulding conditions, and proposes a quantitative assessment index for the geometric shape of foam cups via non-contact three-dimensional scanning. Two kinds of foams with different performance behaviour were selected for moulding test. Depending on the Box-Behnken design, a total of 12 foam cups in size 34B, 36C and 36DD for each type of foam material were scanned in the bird-view and upward-view positions for comparative purposes. Through a two tailed paired t-test and Pearson's correlation testing results, the most effective foam deformation index was confirmed firstly to assess the quality of the foam cups. The result shows that the deformation between moulded cup and its plastic shot scanned in the bird-view position is consistently less than that in the upward-view position. The amount of dwell time significantly affects the deformation for the two types of foam cups.

Keywords: Moulding; Foam; Bra Cup; Deformation

1 Introduction

During the second half of 2008, the growth in global intimate apparel increased by approximately 3%, while the growth in the Asian lingerie market exceeded by 8% [1]. Recently the market shares of seamless bras have increased at an alarming rate from about only 1% in 1997 to about 40% in 2007 [2]. The bra cup moulding process technique is seen as a revolutionary innovation for seamless bras in the intimate apparel industry. With the advent of bra cup moulding process technique, it was considered to be great revolutionary innovation for seamless bras in the intimate apparel industry. The process of bra cup moulding is an irreversible reaction which makes it more compact and dense [3]. The final cup shape is simultaneously subjected to heat-set and

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compression during the moulding process. Moreover, the post shrinkage of the moulded cup is caused by the influence of the resilience of the Polyurethane (PU) elastomer [4].

Traditionally, plastic shots are used as a quality inspection standard for the visual examination of shape deformation and conformity in moulded foam cups [5]. Nevertheless, it is a subjective approach where the quality and deformation of moulded foam cups are assessed based on the experience of individual quality inspectors [6]. This method fails to provide sufficient objective information about shape deformation of a foam cup and can be easily influenced by many external factors, such as the experience of an operator and the consistency of technique, etc.

Recently, 3D scanning as a technology has been increasingly applied in the intimate apparel industry to realize rapid prototyping, making it possible to acquire an accurate 3D geometry of brassieres [7]. Ying et al. attempted to build the parametric modeling by 3D scanning through the features of definition of moulded bra cup [8, 9]. A non-contact 3D digitising apparatus is proposed in this study to evaluate the deformations of moulded foam cups. This comprises a simple low-cost 3D desktop scanner with the use of its support software to capture the surface coordinates of cup samples, plastic shots, and mould heads. The surface of the scanned cup samples are then constructed and rebuilt from point clouds [10]. The differences in the 3D shape between the fitting surface of the moulded foam cups and the plastic shots can be objectively quantified and an appropriate indicator for foam cup deformation can be acquired. Moreover, significant foam deformation that results from the cup position during scanning in relation to various moulding parameters can be identified.

2 Experimental

In this study, two types of PU foam sheets with a thickness of 10 mm (namely, Foams I and II) are used. They are commonly used for cup moulding and are sourced from a large bra cup moulding company. A series of moulded foam cups were prepared by using Foams I and II respectively which represents two different foam densities and performance behavior (viz., tensile strength, compression stress and hardness). The sample sheet size used for the testing is 50 cm × 30 cm × 1 cm and the specifications of the flexible PU foam tested in this study are shown in Table 1 in which all the data was obtained by standard testing methods.

Table 1: Foam material properties used for experiments and corresponding test standards

Style	Test standard	Foam I	Foam II	Unit
Density	ISO845-1988	45.07	28.23	(kg/m^3)
Cell Count	AS2282.5-1999	44.3	46.2	(cells per 25 mm)
Tensile strength at 8% strain	ISO1798-1983	4.8	2.8	(kPa)
Compression stress at 40% strain	ISO3386/1-1986	4.27	2.16	(kPa)
Hardness	ASTM D2240-05	43.98	21.96	(°ShD)

For each type of foam material, a total of 12 foam cups in 3 different sizes (sizes 34B, 36C and 36DD) were prepared based on a three-level, three-factorial Box-Behnken design (BBD) [11]. This is an experimental design that will result in an economically comprehensive piece of research with less time and testing numbers [12].