Analysis of Molding Process Parameters of Bra Cup

Han-Yan Wu[1,*], Xin Zhang[1], Bo-An Ying[1], Quan Pan[2], Jing Han[1]

[1]*Apparel & Art Design College, Xi'an Polytechnic University, Xi'an, Shaanxi,710048, China*
[2]*China National Heavy Machinery Research Institute, Xi'an, Shaanxi, 710048, China*

Abstract: Polyurethane foam is the material most widely used in bra cup production. From the main factors affecting the molding process of molded cup, this article analyzed the properties of polyurethane foam, and elaborated the principle of molding from the molecular structure of polyurethane foam. Then, a set of molding experiments has been done for three different parameters of materials. The results of the experiment analyzed the molding process parameters of the polyurethane foam, and summarized the main factors affecting the same. The work aims to develop a quantitative control method for bra cup modelling process.

Keywords: polyurethane foam, molding principle, molding processing parameters

1. Introduction

With the increased awareness and requirements to clothing, people have gradually shifted their focus from the coat to the underwear. As a typical representative of underwear, bra has been an essential thing in women's life. In recent years, molded-bras are booming as they can conform the breast contours for gap-free custom fit and mimic the breast shapes.

Bra cup molding poses various technical problems for the manufacturers. The response of complex polymer molecules to the tension, temperature, and time variables used in the molding processes is not well understood. At present, there is no objective way of specifying these three-dimensional products .The industry uses "trial and error" methods to determine the most appropriate molding conditions for each type of foam material. When manufacturers experience some problems concerning material quality or processing conditions, there is no common language to communicate with each other in the absence of objective measurement date.

Now Bra-related research is almost focused on the whole processing line and the use of fabrics and accessories of the underwear. And a few studies regard molded cup as an independent entity to analyze the material and generalize the molding process. To the materials applied in molded cup, as a result of the processing conditions, in the intimate apparel industry, polyurethane (PU) foam is mostly used in making bra cups because of its soft and flexible nature, which suits well for intimate apparel applications [1, 4].In recent years, some researchers have researched on the spacer fabrics, analyzed the properties and the molding processing parameters of it, trying to find materials instead of polyurethane foam. [6, 8]However, the spacer fabric can't be cut into any thickness according to different requirements, and dislocation easily happens in the internal spacer yarn, which will impact the shape of the molded cup. All these confined that, at present, the spacer fabric can't replace the most widely used polyurethane (PU) foam in molded cup.

This paper took polyurethane foam as the research object, from the characteristics of the molecular structure of polyurethane, analyzed the molding principle of polyurethane foam; and from the performance of the molding processing of molded cup, designed a set of experiments of different polyurethane foams, then analyzed the processing parameters of the polyurethane foam, summarized the main factors affecting the molding process parameters of molded material.

* Corresponding author's email: xianzhangxin@sina.com

2. The Polyurethane Foam and Molding Principle

2.1 The Polyurethane Foam

Due to processing conditions, the application materials of molded-cup must have the following characteristics: performance of resistance to yellowing, excellent thermoplastic nature, good shape maintenance, softness when felt and a certain thickness. All above conditions indicate that there are a few materials that can be applied for a molded-cup; the most commonly used is polyurethane foam.

The chemical composition of sponge is polyurethane. Polyurethane (PU) resin is a urethane containing repeated chain segment of carbamate reflected by isocyanate monomer and polyols. Because of its opening structure, flexible polyurethane foam has properties such as low density, good elastic recovery, heat retention, favorable stereotype. Besides these, it can be cut into any thickness. These features make polyurethane foam cups widely used in the molded-cup production. According to the kinds of materials of oligomer polyol, flexible polyurethane foam can be divided into two sorts, polyester-based and polyether-based. Normally, as a result of rotation of the ether group in soft segment, polyether-based polyurethane foam has a good flexibility. Since there is no ester group with favorable hydrolysis performance, the polyether-based polyurethane foam has a better hydrolysis resistance than the polyester-based. In addition, it is lower in price and richer in species. As material of molded-cup, it is necessary to test sponge's density, tensile strength, bursting strength, tear strength, and whether it is resistant to yellowing, to achieve the requirements of the standard.

2.2 The Molding Principle of Polyurethane Foam

Molding means to form a lasting, three-dimensional shape out of a two-dimensional pliable, easily shapeable material by stretching and compressing the latter through cycles of heat and pressure [4].

The required shape will be obtained according to the shape of molding mould, while the volume and appearance are gradually changed as well as a certain depth emerges. This is to say, a cup formed. However, the above plasticity is mainly decided by the molecular structure of polyurethane foam. Polyurethane foam is polyester, which is produced in the chemical reaction, between the long-chain polyol such as polyether and polyester, and isocyanate, chain extender or crosslinking. And the soft segment is generally constituted by the long chain diols, while the hard segment is mostly consitituted by the isocyanate or a chain extender. There is a physical attraction between the macromolecules which constitute the polyurethane, much weaker than chemical bonds. The physical attractive force is called as vander Waals force. The force between molecules determines the large influence caused by temperature and stress. The higher the temperature imposed in molding process of polyurethane foam lesser the gravitational force between molecules, so that molecules got close to each other, the distance between them also shortened. To the macro performance is that the volume of sponge was compressed, which resulted in lesser thickness .At the same time, based groups and links changed in regularity, high-temperature forced the group and links to rearrange so as to change its shape. If the molding temperature is too high, it would lead to the formation of a small amount of branching and cross linking of linear molecular chain. And degree of crosslinking determines the hardness and flexibility of polyurethane materials, so the increase in degree of crosslinking will increase the hardness of polyurethane foam, which is the main factor which give a hard feeling to the hand when held, caused by improper choice of temperature in the molding process. On the other hand, very high temperature also will result in continuous oxidation, which leads to change in colour (it inevitably becomes yellow).There will be a shrinkage when the molded cup is molded after a day. The shrinkage of polyurethane foam is related to the degree of crosslinking. The higher the cross linking points are, better the compressing resilience is. High-resilience polyurethane foam is the produced by adding cross-linking agent to the reactants, producing more cross-linked points in molecules. As a result, the resilience of polyurethane foam is significantly increased.