Development and Optimization of Men’s Underwear Design Based on 3D Technology

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Abstract. The purpose of this study is to solve the design process of men’s underwear by using the present 3D technology. And to test the theoretical feasibility of the new patterns of men’s underwear according to the “body-underwear” system. Based on the simulation effects to do the preliminary modification and adjust patterns. In order to achieve our desired goal, after getting feasible and good results, we can go directly to the next step of production inspection in the factory, to reduce repeated human body try on and manufacture.

Introduction

At present, three-dimensional simulation technology is developing rapidly, and gradually applied to other fields. The application of 3D technology in garment design and product development has developed rapidly in recent ten years and provided great convenience [1]. However, there are few researches on tights, male virtual body and knitted underwear. Most of the researches focus on the design of two-dimensional pattern or the testing of fabrics. The study of men’s knitted underwear is more deficiency [2, 3].

After nearly 1000 questionnaires, men’s underwear also needs to be customized [4]. Especially for young men, due to different needs, comfort satisfaction and shape characteristics. To this end, we measured a large number of young men in the early days and classified them [5]. We also compared different underwear with corresponding bodies to verify the new sizes classification of body.

The aim of this paper is to complete the design process of men’s underwear by using the present 3D technology (all the basic data have been studied [6, 7]) based on the “body-underwear” system.

Methods and Steps

This study includes 3D body scanning measurements, 2D&3D underwear structure design, virtual fabrics analysis, pattern, pressure evaluation etc.

- We used VITUS Smart 3D body scanner measure 115 Chinese (18…28 age young males) and use KES test 14 kinds of knitted fabrics.
- Next, we used new method to draw 2D underwear (for basic and functional types) by software Richpeace CAD and CLO 4.1.
- We checked the parameters of virtual fabrics, then, modified and applied them to the 3D underwear models. We measured the virtual knitted fabrics pressure values accuracy and reliability with software CLO 4.1.
- We built the virtual underwear in 12 different sizes of virtual bodies from small S– to larger L++. In our test, the index of S, M, L are the sizes to describe the hip girth, “+” and “–” are different sizes of waist girth, large and small).
Results and Analysis

Reconstruction of Human Models

Fig. 2(a) shows three male profiles. We can see that the shapes of the profile are very different, even at the same size M. Then, we establish S, M, L sizes virtual male bodies (see Fig. 2b) in the same height and thigh girth. It can be clearly seen from the profiles that different waist sizes have different shapes on the part of abdomen and the back of the waist, when the hip girth is the same.

Next, the “obj” model file is imported into the CLO software for subsequent simulation works. We try-on a variety of virtual bodies to test the patterns of underwear designed for more detailed body shape.

Pattern Adjustment and Simulation Test

CLO software often used to simulate some loose, non-elastic clothing (coat, dress etc.) and commonly used fabrics (cotton, silk etc.). But our design is mainly for tight underwear, its size will be smaller than the human body (smaller than the coverage area). Therefore, we need to consider the performance details of the elastic fabric. We selected 14 knitted fabrics from Chinese company and extracted their parameters of physical properties into the CLO “Fabrics” option for simulation. After several times parameters adjustment, and pairing the actual and virtual fabric pressure values on the human body to determine the simulate effect of the fabric.

Form the simulations of virtual knitted fabrics, we adjust the parameters and put the KES results into CLO. Such as the option “Detail”, the best way is take the fabric parameters G (shear stiffness), thickness and density into these 4 options of “stretch”, “shear”, “thickness” and “density”. After adjusting the properties of virtual knitted fabrics, virtual pressure test was carried out. And compared with the actual knitted fabrics pressure data we tested before, more than 3900 pressure data. The simulated virtual pressure is 0.14…2.13 kPa (the real pressure on human body is 0.05…2.31 kPa) with knitted fabrics elongated from -20.0…-5.0% in warp (virtual is 0.00…2.82 kPa, real is 0.13…2.02 kPa in weft). We find that the elongation value (-15.0 to -10.0%) of virtual knitted fabrics.
has the largest pressure difference from -0.26...0.24 kPa. There is ± 0.19 kPa difference between real and virtual pressure. Then, we dressing the designed basic pattern on the virtual body.

Fig.3(a) shows the basic type virtual underwear try-on in front view. We clearly see that there is an excessive pressure (red color) at the crotch part and front belt in modified pattern. Fig.3(a) right shows the modified front crotch part and belt length of the pattern, after this, we measured the pressure is lower than before, and the fabric deformation/elongation at crotch part is changed to 32.8...41.2%.

Fig.3(d) shows the back view. 2D pattern and 3D simulation are also shown. The crotch part of back pattern has also been modified.

Fig.3(c) shows functional/push-up type, the pattern designed with fabric’s different directions. Average deformation can reach 32.5%. Combine with the basic underwear, we can see independent crotch piece makes the fabrics stretching at crotch part get a very good solution, outer thigh bottom very good fit, the design of the structure back line has a good support for the buttock lower.

Next, we graded the pressure distribution of underwear. It is calculated by measuring the different positions of underwear. As for this, five grades are applicable to evaluate the compression underwear from low pressure to high. The range includes five grades: 1 (very low pressure/loose/not fit at some part), 2 (low pressure/fit/a few loose), 3 (comfort pressure/close-fitting/tight), 4 (high pressure/tight), 5 (very high pressure/very tight) to evaluate the final score which was equal to the average grades measured in six parts per underwear.

As shown in Fig.4(a, b), we can see from the evaluation charts that in these two groups (four samples in each group), when the evaluation value is less than “2”, the underwear wearing experience will be loose at the upper hip line. For example, as shown in Fig.4(a), the S++ size of the designed product is not suitable for the human body S, but in the other three groups on the right side, when the S body wears the S or S–, the evaluation values are during “2-4”, the pressure and fit degree are relatively good. This has preliminarily achieved the purpose of tight design of our underwear. But, as shown in Fig.4(b), the underwear S size dressing on the virtual bodise with the same hip girth and different waist girth has a similar evaluation values about “2-4”.

Therefore, the virtual underwear style and size we designed can match the bodies well, we have verified our underwear design methods and knitted fabric simulation can achieve good virtual finished products.
Different sizes underwear on S body
Same sizes S underwear on different bodies

Figure 4. Virtual evaluation of pressure distribution: (a) – different sizes underwear on S body; (b) – same sizes S underwear on different bodies.

Conclusion
By adjusting the virtual body sizes to fit the scanning human bodies, we build a variety of virtual human models with different sizes. After our correction, the CLO software can simulate well. Then we test the virtual pressure and evaluation. We use 2D pattern drawing and 3D simulation technology to test our new patterns on virtual bodies. The simulation experiment demonstrates the rationality of our design method and classifications. The body wears matching underwear size performed the best fitting and reasonable pressure distribution. Next, we will apply these results to the underwear factory for the verification of real products.

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