

Exploration and Analysis Based on Mass Customization Design and Production of Martial Arts Shoes

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Abstract—This paper makes in-depth study of mass customization design and production methods, analyzes materials and technology in the application of a large number of customized design and production, then analyzes the world famous shoe enterprises for a large number of customized production cases, introduces foot scanner to obtain user data, uses Rhino modeling and 3D printing technology to produce a large number of customized design and production of martial arts shoes.

Keywords—Martial arts shoes; Mass customization design production; 3D printing; Shoe design

I. CONCEPT OF MASS CUSTOMIZATION

After the Industrial Revolution, the concept of mass customization is proposed to massively produce for modern enterprises. “Mass” production means products batch, products standards and products patterns, all following the same pattern, and “customization” means unique, small production. Mass customization is a combination of two contradictory phenomena, to find the balance of contradictory things, which requires enterprises to design not only for the need of customers but also massive produce [1-3].

II. ANALYSIS ON CONSUMER DEMAND OF MASS CUSTOMIZATION

A lot of focus from consumers is brought by the customization service provided by enterprises. But usually consumers would shrink back at the sight of high price which results in the mass production in one pattern; people in the circle of subcultures would care a lot on expression and pursuit of culture on their own style, such as geek culture consumers, who go after extreme experience on technology while mass product could not satisfy their thirsty to technology, and they want to live in the world of technology when they are asked to choose shoes type. When these consumers' needs cannot be met from one brand, they will look for the next brand that can meet their needs [4-5]. At the same time, it is common to see for consumers in this situation: when he is interested in the style and color of shoes, but the function could not meet his need, so when there are enterprises can achieve the mass customization production and therefore, you will also have a lot of customers. Mass customized production could bring the maximum profit, make the products achieve single-digit differentiated production, so as to improve the product value, acquire data of consumers' need, enhance the users experience and better build the brand reputation. In America, about 25% customers shopping online

are looking for the customization shoes, and the total sales amount of all of shoes customization in America is up to about 2000 million US dollars. Together with mass application of computer design and 3D printing technology, the development of mass customization of shoes products would be boosted in the future.

III. ANALYSIS ON CASES OF MASS CUSTOMIZATION

Puma company started to try customized sport shoes – “Mongolian Shoe BBQ” in 2005. Consumers can get their shoes in the colors they matched by themselves by choosing different colors in shoe laces [6-7], upper and soles. Initial customization is merely color changing with long time spending which is far away from meeting the need of mass customization.



Fig. 1 Mongolian Shoe BBQ

“Creative Factory” was built by Puma company in 2010, where consumer can customize two classic Puma shoes by selecting materials by themselves in the store --- First Round and Basket. Compared with the “Mongolian Shoe BBQ”, the upgraded points of “Creative Factory” is that different material can be selected and all later design comments are operated online to improve the consumers experience. However, these customized shoes are too small in scope with too little choice.

Adidas Originals launched customization plan of 12 shoes styles with Japanese famous street fashion shoes store Styles in 2010. At the same time, XLarge, SILAS and MILKFED also joined the plan together. Consumers can choose different color to match and also can select different material to match, which

is able to meet the fashion and street culture consumers. But for other consumers in other subculture, extent of customization is small.

FEATURES



Fig. 2 Shoes

USA Brooks took advantage of their technology of “Run Signature” and developed 3D printing running shoes with FitStation Solution of Hewlett-Packard Company. The running shoes were based on the analysis of FitStation on users’ feet and then the injection moulding of generous parts of running shoes were produced, and that the users’ foot pressure, running posture and personal preferences were analyzed again, , lastly variable PU were adopted to injected method to customize unique middle sole and multiple adjustable areas.

Germany famous sport brand Adidas launched the first world 3d printing soles sneakers that can be massively produced. Besides customizes shoes colors and styles online, consumers can also customize soles which suit the best for themselves to go sports according to personal weight and foot steps. Domestic martial arts shoe has been always in the low-end market, and it would be a major steps for martial arts shoes devices industry if martial arts shoes are also designed and produced by customization.

IV. PRODUCT AND USABILITY ANALYSIS OF MARTIAL ARTS SHOES

Domestic enterprises of martial arts shoes production industry have brands named Feiyue, Hongmian, etc. Martial art shoes shall meet the need that it has no influence to the movements for wearer in the exercise of martial arts and it protects wearers’ ankles, planta pedis and skin, At the same time. Design and creation shall be in light with the requirement of modern martial arts competitive sport and characteristics of martial arts, since there are a lot foot movements in martial arts with high strength. At first, the firmness of shoes should be ensured; next, cutted the weight of shoes in the maximum limit is to ensure that wearers could bring their full play in strenuous martial arts; soles of martial arts shoes shall be wear-resistant, sturdy, flexible and protective, and easy to bend without breaking; upper shall be flexible, wear-resistant and not easily broken; the heel of a shoe shall not be less than 7 cm; and with the outside of ankle lower than the inner ankle, the back quarter of shoes shall be thicken to protect; shoes crotch can not be too

big because it needs to provide enough support for wearer.(Picture 3)



Fig. 3 sketch map of current martial arts shoes

V. PROBLEMS AND SOLUTIONS OF MASS CUSTOMIZATION

So far, the problems of mass customization are: 1.limited material of mould and time. Most customization of martial arts shoes are limited to the replacement of color or material. The shape and functions of sneaker still can not be customized. 2. Customization is hard to produce massively. The traditional way to design martial arts shoes is drew up from designer and then to produce shoes, lastly test functions of the shoes before mass production. But if a pair of customized sneakers produced in accordance with the traditional design methods would cost a lot and the input of material and time would hinder the mass customization production. 3. Return problem. If mass customization product suffers from being returned, it would be difficult to sell again. Almost each customized product is unique and a large number of customized products mostly are handmade, and there would be inevitable defects. Problem of return products because of the defects is especially severe. It is difficult for consumers to accept the defected products after customization by others.

Solutions: 1.Introduce 3d scanner. Small sized foot scanner developed by Foot Technology Company in China can be installed each physical stores to scan consumers’ feet and upload foot data to database by the cloud operation, then factory produces the most suitable customized shoes for the consumer in accordance with data about the length and width, arches of the foot and dorsal foot. Base on these data, factory can establish separated information bank for each consumer to analyze future trend to recommend products. Customized shoes not only are precise on size, but also introduce concept of health to make the soles accurately correspond to the wearer's foot acupoints as massage function. The realization of massage function helps people know that customized shoes is not only shown in the surface, such as size replacement and material, but also shown in the customized function, which is more important in consumers' minds.

2.3D modelling software applications in design. Rhino 3D modeling software and TS plug-in are very suitable for the design performance of a large number of customized shoes. Rhino software has NURBS modeling function, which controls the modeling of form with the control node of the free curve (surface), and builds the model with precise and smooth precision, to be suitable for general industrial production or 3D printing production. The TS plug-in can make up for Rhino's defects caused by uneven surface undulation when using the contour line or single or double-track sweeping modeling upper. The TS insert can directly perform the functions of stretching, squeezing and dragging the shape and accurately depicting the shape of the upper. It is also very convenient for the designer to adjust the structural shape in the customization. TS can subdivide surface modeling, which can effectively reduce the number of control nodes on the surface of the model, and can be perfectly converted with Rhino's NURBS contour, avoiding problems in the modeling software due to format disagreement. After completing the modeling in the 3D modeling software, the designer can use Keyshot or V-ray rendering software for fast rendering so that the consumers can clearly see the product effect, and can also export the panoramic display animation in the software, so that consumers can observe the product's effects and deficiencies in a detailed and comprehensive manner, and improvements are proposed for the subsequent production.

VI. THE APPLICATION OF NEW 3D PRINTING TECHNOLOGY

The production process of 3D printing technology adopted by "Future Craft 4D" sneakers cooperated between Adidas and Carbon company overcomes the difficulties of low speed, high cost, and lower quality than the injection molding process and others of the original 3D printing, so that the quality of the produced sports shoes can be well matched with the produce products in the injection molding process, and the manufacturing speed and price can meet the mass production requirements. It takes only 20 minutes to make a pair of "Future Craft 4D" sports shoes. Maximilian Peter and Ingenieure GmbH, a German products development and prototyping design agency, has developed a superposition process that enables 3D printing of silicones and that would not melt and shape, like thermoplastics and metals. The system runs custom programs through robots. After each drop of the silicon catalyst doped with the platinum catalyst, the ultraviolet light beam is vulcanized in one second and then the cycle is repeated, and 100 g of silicone resin can be processed in one hour, and the system can precisely control the production with a smooth surface. The thermoplastic is better than 3D printing, and the finished product is almost the same as the injection molded product. 3DSystems company uses 3D-SLS technology to print nylon fiber materials and prints flexible thermoplastic polyurethane (TPU) fiber materials by the 3DS-Prolet printing system. Three Over Seven Companies in New Zealand has developed a fully customized production chain for consumers to use their mobile phone lens to scan the footsteps, to get a footstep model on the computer and then to print the sole and shoes upper with biodegradable synthetic polymer fiber. PVA. 3D-Grid's new printing sneaker technology utilizes raw materials such as nylon, polyester, and amides to produce exquisite mesh-like sneakers through continuous stratification and welding of materials. The Dutch company LUXcXcel uses 3D-PrintOptical technology

and uses the one step of Ulmoker2 3D printer – from CAD drawings to printing finished products. The company's products are made from UV-curable fiber polymer materials.

The application of manipulators. American famous shoes factory Keen works with Automation Solutions Company House of Design to create the world's smallest shoe factory, constituted by two robotic arms. After users choose color and size, the two robotic arms will start working together under the guidance of an intelligent program. It only takes six minutes to finish a pair of customized sandals. (Picture 4)



Fig. 4 Uneekbot Factory Store

Intelligent technological process appeared after the introduction of manipulator production. Robot would not make mistakes like traditional handmade production, and the defect free rate will be improved and the return situation will be decreased.

VII. CASES ABOUT MASS CUSTOMIZATION OF MARTIAL ARTS SHOES DESIGN

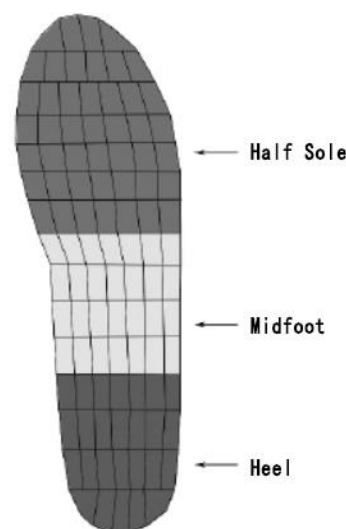


Fig. 5 Sketch map of users' foot stress areas

In the martial arts movement, the flight part and jumping action all uses the forefoot to touch the ground and exert force. According to research from Tang Yunqi, Lu Meilian, Qin Lei, and Zou Limin (China Leather 2018) will partition the user's foot force (Picture 5).



Fig. 6 Sketch map of martial arts power points

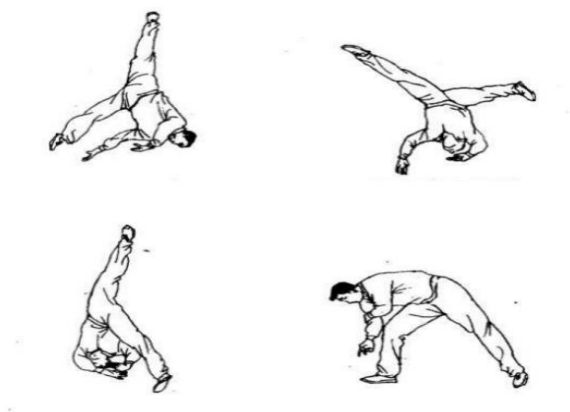


Fig. 7 Sketch map of power points of martial arts flight part



Fig. 8 Forefeet soles flowers picture

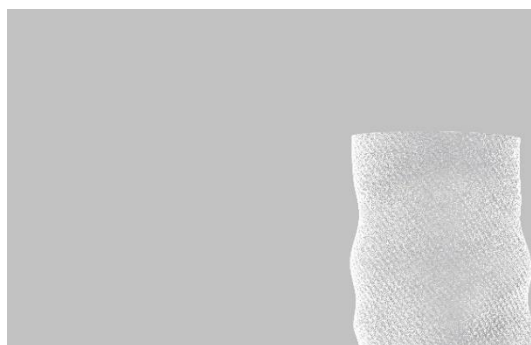


Fig. 9 Overlength ankle protection

Users of martial arts shoes usually exercise with the power focused in forefeet, so special design should be made for the anti-skid, wear-resisting and shock absorption of the user's forefeet.

For the sake of ankle safety, this martial arts shoes have been designed with extra long ankle protection (shown as picture 9).

In order to enhance its fashionable sense, the toes of this martial arts shoes is made of transparent PVC material. (shown as picture 10)

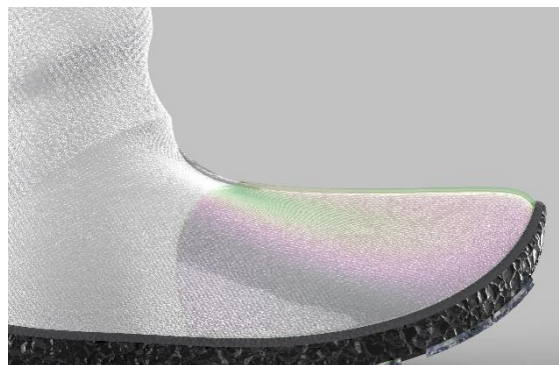


Fig. 10 Transparent PVC Materials in toe of shoes



Fig. 11 3D Printing shoes bottom

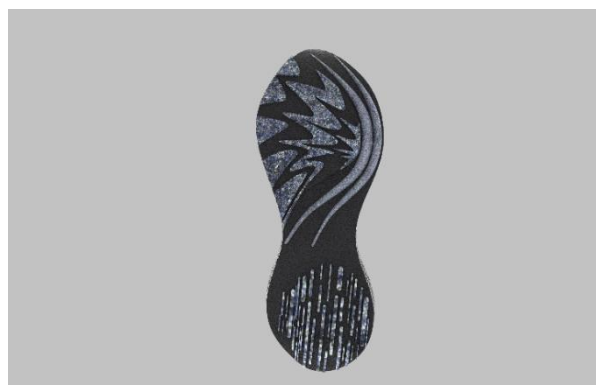


Fig. 12 Personalize flowers in the sole



Fig. 13 Final effect picture

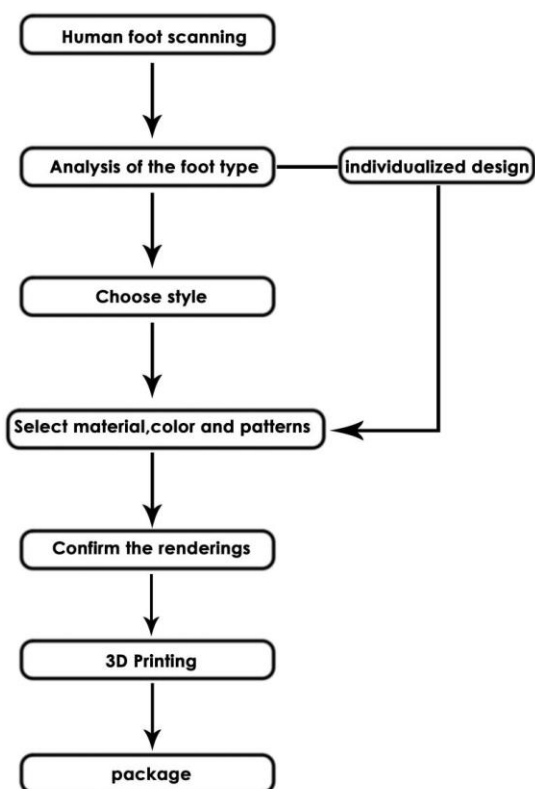


Fig. 14 Flowchart of mass customization production

According to the user preferences of the customized flower color in the soles, only with the fully participation of the users in the process of design and new technology and material can finish the massive customized design production of the martial arts shoes. The future design of the footwear can be more comprehensive to meet the needs of consumers.

VIII. CONCLUSION

The number of martial arts in the world continues to increase, and only the number of exercisers for Tai Chi (a kind of traditional Chinese shadow boxing) in the world is nearly 300 million. According to statistics of nunchakus Alliance in high school (from new semester in 2017 to 2010), the number of exercisers for nunchakus has reached about 8000. Culture of action movies, Extreme Martial Art, parkour and sneaker gets more and more popular with the society. The demand of the professional martial arts shoe from martial arts enthusiast is getting bigger and bigger; 3d foot scanning pattern uploaded from users can produce massively and also meet the need of customized martial arts shoes which will be welcomed by the vast number of martial arts practitioners and for sports shoes enterprises to provide a way as reference.

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