A new Construction of Garment Personalized Customization Mode combined with Garment Intelligent Production

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Abstract. Because of the changes in consumer demand and the widely application of information technology in garment field, the custom production of clothing has already made some progress. However, there are still shortcomings in customer participation and collaborative design in the design process, and the personalized needs of customers are not very satisfied. To solve this problem, we propose to combine the garment made to measure (MTM) customization system with participatory customization service, and to enhance the personalization of customized products by transforming the sales platform which connected with MTM system into a customer participation platform. Besides, the custom mode constructed in this paper can not only improve the participation of customers in the customization process, but also connect the MTM system to produce one-piece flow efficiently. Finally, based on the actual data provided by the partner, this paper conducts a simulation experiment on the production process. The experimental results show that the connection efficiency between the customized platform and the factory production is optimized under the modified production mode. In addition, the mode also improves the production management level of relevant parties.

1. Current Situation of Garment Industry Development
At present, the global manufacturing enterprises urgently need to improve the efficiency of production. German industry 4.0 aims to improve the intelligent level of the manufacturing industry, with the establishment of intelligent factories as its main development approach [1]. Smart factories can not only shorten the development cycle of products, but also improve the personalized factors of products according to the buyer's market to achieve flexible production, so that the smart factories can produce small-batch products to achieve profitability [2].

Garment manufacturing is a labor-intensive industry, due to the diversity of clothing products and the complexity of production process, a lot of manpower is needed in the process of garment design and production. Under the development of intelligent manufacturing, the clothing industry can effectively reduce the labor cost, shorten the garment production and research and development (R&D) cycle, make the clothing enterprise adapt to the diversified needs of consumers in the clothing consumption market. Therefore, the garment market can be more personalized and price sensitive to meet individual needs.
2. Research on Customization Industry

Due to the advancement of intelligent manufacturing and the utilization of various automated production equipment, the garment customization industry has developed rapidly. At present, the garment customization industry mainly develops in two directions: the first is the one-piece flow production mode realized by the MTM system, which is mainly to provide customers with fit and comfortable clothes. The second is the participating-type garment customization mode based on the online platform, which mainly takes the design elements such as color and pattern as the key reference, which emphasis on personalization and visual expression.

2.1. MTM-type service

MTM-type customized services are mainly produced and sold through the MTM system. Companies can use the MTM system to automate production according to customers' individual needs. It mainly extracts the customer's body data through 3D body scanner, and compares the data with the human body shape data in 3D human body database to select the appropriate garment prototype. Then choose the same or similar styles from the garment pattern database. Finally, the appropriate garment sample is automatically generated for production. At present, MTM system is mainly used in the mass production of clothing customization, which can provide customized services for suits and shirts [3]. However, there are still deficiencies in the participation and personalization in the customization process, so enhancing the personalization of customized products should be regarded as the key of MTM in the development trend of intelligent manufacturing in the future [4].

2.2. Participating-type garment customization service

Participating-type customization service mainly achieves the customer's participation in the design process through the customization platform, and design elements can be added within limits according to personal preference. For example, the US participatory online customization platform “CUT ON YOUR BIAS”¹, which determines design works through the interaction between designers and customers, and determines production content through voting. Compared with MTM-type garment customization service, participating-type customization doesn’t have many restrictions on style. As a result, degree of personalization of customized products can be greatly improved. However, most of products are determined by voting, and the products can’t be customized according to the customer's body size. Therefore, the products purchased by the customer still belongs to the batch products, so the personalized reflect inadequate.

2.3. Analysis of garment customization industry

Traditional MTM garment customization sells products through online platform. The front-end of the platform is mainly for the business of selling. The back-end is mainly for enterprises, which can

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¹ An online platform for consumer participation in clothing customization. 
https://mashable.com/category/cutonyourbias/
provide on-off shelf service and manage customer relationship. However, the platform corresponding to MTM-style garment customization only has the function of sales, which leads to poor user stickiness. On the contrary, the online platform of participating-type garment customization includes sales, design, interaction and other businesses, which can actively attract target customers, and the designed products with a high degree of personalization. However, the online platform does not have back-end production capacity and customized services based on the body shape of customers. From the perspective of the long-term development of consumption and production, the transformation of digital garment customization industry is no longer an optional solution, but an essential trend [5]. In this work, we will digitally upgrade the garment customization platform and garment production process to cater for the development direction of the garment customization industry.

Figure 1 shows the characteristics of the two customization modes in terms of customization platform and production, and the part selected by frame is the advantage function of each customization mode. Through comparison, it can be found that the platform function of participating-type customization service and the production function of MTM-type customization service can be effectively connected to form the personalized customization mode shown in Figure 1. In the next section, we will reconstruct the platform and production structure of garment customization system.

3. The Construction of Garment Personalized Customization Mode
The garment customization mode constructed in this paper is to take the participating-type customization service platform as the front-end, which displays the characteristics of MTM production end. Two modes are integrated effectively so as to make it have the production capacity of MTM customization service and complete industrial mode. Therefore, in order to improve the degree of product personalization and fit the new customization mode of the service platform, we made the following improvements:

Improvement 1: The new customization service platform mainly transforms the overall customization of garment into module customization, which makes the customized products more personalized.

Improvement 2: The customized production mode of MTM is improved to fit the new custom service platform.

3.1. Construction of personalized customization platform
As a complete garment customization industry, the customization platform does not only need to provide participating-type services, but also needs to coordinate the production management of orders. Therefore, we propose to transform the sales platform into a personalized customization platform with customer participation functions as shown in Figure 2. The platform includes functions such as independent design, information interaction, customer management and information feedback.

Figure 2. The operation mode of personalized garment customization platform
A. User self-design: the platform includes a design and drawing interface, through that users can design any style or directly select the finished works to publish in the social space of the platform.

B. Platform information interaction: the platform provides information interaction between users and the opinion interaction between designers and customers. The main interaction methods are comments, concerns, redesign, etc.

C. Platform management strategy: the platform ranks all published designs. The ranking method can be comprehensively given by combining voting with the interaction times of the works in the platform. Giving the top works more discount to obtain the copyright.

D. Feedback platform for designs: the selected design works will be decomposed into garment modules (garment modules refer to collar, sleeve, pocket, pattern, etc.), and then the overall garment works and design modules will be put into the customization platform as customization options.

3.2. Construction of production data in MTM system

Customers can choose different clothing modules for customization through the platform, or choose ready-to-wear customization. Moreover, they can combine the two for customization. It can give customers more options. In this mode, the platform attracts people with personalized demands, and the released custom products have consumption potentiality in the platform. It has all the ingredients of a participating-type platform. Finally, in order to integrate the platform with MTM system, we need to digitize the garment module. As shown in Figure 3, digital content includes four aspects A, B, C and D as follows:

A. Module pattern data: the pattern data of garment module will be input into the pattern database of MTM system and the corresponding component style database.

B. Module production data: the module production process and technological process will be refined and put into the technology database, and combined with the production floating rate to calculate the processing time of garment module.

C. Module bill of materials (BOM): fabric and lining are checked by module template. Other accessories materials are checked one by one.

D. Module cost data: calculating material cost by material usage and calculating the labor cost by the processing time of the workers. Other costs can be fixed according to the actual situation of the enterprise. In this way, the approximate cost of module production can be obtained.

The BOM and cost data is put into MTM system, so that the system can give the basis of pricing when customers select garment module customization, it also can build a more complete production process.
4. Garment Production Mode Based on Participating-type Platform

RFID cooperating with MTM system is the main production mode of customized products [6]. The order information is identified by RFID, and then the corresponding production information is retrieved from the database of MTM system for production [7]. For example, the process information can be read through scanning during sewing, and the remaining work tasks and processing time can be known through the data feedback by RFID [8]. Therefore, we take advantage of this feature of RFID to reconstruct the customized production mode proposed to this paper. Users can make two kinds of customization through the platform: the overall garment customization or customized by several personalized modules.

When the users choose the overall garment customization, it only needs to modify the pattern according to the customer's body size. The remaining production data directly uses the data recorded in MTM database in advance. When the custom platform receives the orders generated by garment modules, it needs to arrange the pattern of each module, automatically summarize its BOM and process information on all modules. For any type of order, we need to input the order information on the RFID tag, and retrieve the production information from the MTM database by identifying different transponders in different workshops. The production process is shown in Figure 3.

Worker obtains the final material information of the order by scanning the RFID in the warehouse, and then take the materials. The fabrics are delivered to the cutting workshop for RFID scanning and automatic cutting. Different fabrics have to be cut several times. The pieces and other materials are delivered to sewing workers through the garment hanging system for production. The production process information is obtained by scanning RFID. Then they go through the inspection workshop and the finishing workshop. Finally transport them to the warehouse for delivery.

So far, we have constructed the entire clothing custom production mode from consumer into production. In this mode, the data of the order can be sent to the workshop, and the workshop can generate RFID tags for production. In this way, the platform and the production ends can be connected directly, which reduces the time from the issue of the order to the start of the production. In addition, the production of modules is estimated in advance so that the system can control the production process more accurately. In terms of the production efficiency and the production management of garment in this mode, the simulation tests are conducted as follows.

5. Production Experiment

S is a garment enterprise which applies MTM system for customized production. The main products are suits and shirts. We take 12 shirts produced by S company in a day as the research object, and test the actual optimization effect and production planning accuracy of our proposed strategy. The test contents are as follows.

Efficiency optimization experiment: We started experimenting with the first 6 shirts, testing the time from the platform to the sewing workshop, which is the time spent in the warehouse and cutting workshop, and then we used the optimized production mode to test the same working time for the next 6 shirts. The optimization efficiency \( \eta \) is calculated by equation 1.

Results of efficiency optimization experiment: Table 1 shows that the average production preparation time of the last six shirts is 7.95% less than their consumption time.

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\eta = \frac{t - t_0}{t} \times 100\%
\]

Table 1. Efficiency optimization experiment.
Normal production time $t_0$ 1169s 1198s 1119s 1224s 1249s 1177s $\bar{t}_0=1189.3s$

Optimized time $T$ 1083s 1099s 1034s 1132s 1156s 1090s $\bar{T}=1099.0s$

Optimization efficiency $\eta$ 7.95%

Production planning experiment: we divide these 12 shirts into multiple garment modules for production, and the time for this experimental test is from the beginning of garment sewing to the finished product entering the warehouse. The remaining time of subsequent processing can be predicted by randomly selecting a time point in the process, then compare it with the actual time to calculate the production plan’ accuracy. In this experiment, we test each time point three times and we test four time points in total. Calculate the actual prediction accuracy $\varepsilon$ of each test point by equation 2, and then obtain the average prediction accuracy $\bar{\varepsilon}$ by equation 3.

Experimental results of production planning: Table 2 shows that the accuracy have some deviation according to the change of time points, but the average accuracy is 92.52%.

$$\varepsilon = \left( 1 - \frac{|t_0 - t_1|}{t_0} \right) \times 100\% \tag{2}$$

$$\bar{\varepsilon} = \frac{\sum_{k=1}^{12} \varepsilon_k}{12} \tag{3}$$

Table 2. Production planning experiment.

| Time node number | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Estimated time $t_0$ | 732s| 732s| 732s| 565s| 565s| 565s| 480s| 480s| 480s| 332s| 332s| 332s|
| Actual time $t_1$ | 798s| 793s| 796s| 603s| 595s| 597s| 513s| 509s| 517s| 358s| 360s| 362s|
| Actual accuracy $\varepsilon$ | 90.89%| 91.66%| 91.25%| 93.27%| 94.69%| 94.33%| 93.13%| 93.95%| 92.29%| 92.16%| 91.56%| 90.96%|
| Average accuracy $\bar{\varepsilon}$ | 92.52% |

6. Conclusion

This paper analyzes the characteristics of the current garment customization market, and proposes a customization mode that combines participating-type garment customization with the MTM customization production mode. This customized mode solves the following problems: (1) Insufficient customer participation and personalized choices in the garment customization process. (2) The problem of insufficient production capacity for garment participating-type customization services. (3) The problem of insufficient functionality of traditional MTM customized sales platform. In addition, we rebuilt the production structure of a new customized mode, and we tested the estimated production mode through S company. The results showed that: compared with the traditional MTM production mode, the improved production structure can respond to the order production information more quickly and manage the production plan more accurately. Finally, the personalized customization mode constructed in this article meets the development needs of the garment customization industry, and it also proposes specific implementation steps and reference modes for the future personalized customization production mode.

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