One Production Mode of Intelligent Manufacturing

Dongcai Zhao and Jiawen Qiu

***Abstract*—A new social collaborative intelligent manufacturing platform was put forward, which based on processing model, compose of users, intelligent robots, intelligent logistics and intelligent storages. Through the theoretical discussion and example proved that the collaborative platform is feasible, and found that the personalized product would be produced without increasing the cost of production, the product research and development cost would be saved, its cycle would be shortened, when the platform applied in large factory or social collaboration.**

***Index Terms*—Broadband network, Intelligent manufacturing, personalized customization, physical distribution.**

I. Introduction

Through the power of water and steam to achieve mechanized factory making Machine production replaces manual labor, and the economic society transformation from agriculture and handicrafts to economic development driven by industry and machinery manufacturing; through the electric power making parts production and product assembly successfully separated, creating a new mode of mass production; through the extensive use of electronic and information technology, manufacturing processes continue to automate, making the machine not only taken over a significant proportion of "physical labor", has also taken over some "mental labor". The moment, Europe have put forward a new industrial model, will once again lead to deep changes in manufacturing, which be introduced by some papers [1]-[4].

The concept of "Industrial 4.0" is from 2011 Hannover Industrial Fair. Its original intention is through the application of new technologies such as Internet of things to improve the level of the German manufacturing industry. "Industrial Internet" concept was first proposed by the General Electric in 2012, and the basic idea is consistent with Germany's "Industrial 4.0", the aim is to form a more efficient production system by connecting the virtual network and the entity. "China 2025" was released on May 8, 2015, which proposed "three-step" strategy, which is the major explained of future manufacturing direction, pointing out the implementation of the principles and strategic objectives, aimed at building the manufacturing power. Japan has also proposed a similar "re-Hing Strategy", are seeking to upgrade of industrial structure.

Both the "Industrial 4.0" proposed by Germany and the "Industrial Internet" proposed by the United States would realize the personalized customization of products, change the social collaboration between people, and promote the deep-seated changes in the social level.

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II. "Industrial 4.0" Points

"Industrial 4.0" is characterized by the construction an Cyber Physical System, aim to achieve vertical integration (factory), horizontal integration (between plants), and end to end (product cycle) integration by researching intelligent factory and intelligent production, and eight plans would be carried out. The eight plans are standardization, management systems, industrial broadband, security and security, Safety and security, organization and design, career development, regulatory frameworks and resource use efficiency, respectively. "Industrial 4.0" is essentially an Cyber Physical System, which based on large data to achieve the optimization of production processes, enabling customers to participate in the production process of a manufacturing, is still a continuous improvement process.

Germany's Electrical and Electronic Technology and Information Technology Standardization Committee in 2014 published the first standard roadmap edition of the German "industry 4.0", which is the Top-level design of the German Industrial Standardization 4.0, and in 2015 announced the industrial reference architecture model of industry 4.0 [5], And there are many in-depth interpretation of "Industrial 4.0" [6], [7].

This paper proposes a social collaborative intelligent manufacturing platform, based on the large data and information processing system. It can realize the horizontal integration, end-to-end integration, personalized product customization, and high efficiency research and development, respectively. The platform was introduced only from the technical level as follow.

III. Social Collaborative Intelligent Manufacturing Platforms

A. The Composition of Social Collaborative Intelligent Manufacturing Platform

Social collaborative intelligent manufacturing platform are composed of software platform, users, broadband, intelligent robots, intelligent logistics and intelligent storages components, shown in Fig. 1. Users, software platforms, intelligent robots and intelligent storages are connected by broadband, and the real-time communication would be realized without hindrance; the physical end of the broadband connection is connected through the intelligent logistics. The software platform is the core of the social collaborative

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intelligent manufacturing platform. The software platform is mainly composed of different processing models, and it also supports the functions of user interface, database, communication, coordination intelligent robot, cost accounting and payment. The user can be either a customized user or a user involved in research and development (R&D). After completion of debugging, the intelligent robot has the abilities to complete the communication, calculation, identification, processing procedure queuing, incoming material processing, spare parts assembly, and cost accounting. Intelligent storages have the abilities of communication, computing, identification, batching, and cost accounting. Intelligent logistics can complete communication, calculation, identification, change the delivery process according to the actual situation, independently.

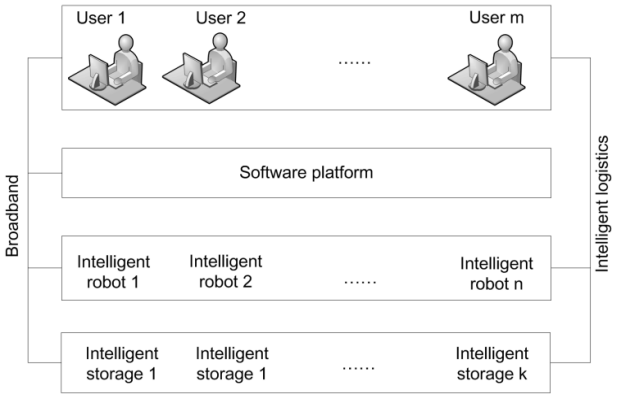

Fig. 1. The illustration of social collaborative intelligent manufacturing platform.

The processing model can automatically adapt to the individual needs of the user, and the user can also improve existing model and create new processing model through the platform, and the processing model would become more and more perfect, this will be discussed below.

Intelligent robots, intelligent storages and intelligent logistics are the important components of social collaborative intelligent manufacturing platform. If these components cannot reach the corresponding intelligent level, manpower would be involved appropriately. The cost of human participation is the decrease in the efficiency of collaboration and the uncontrollability of the period of work, but the socialization cooperation is not damaged. But with too much human involvement, the model of social collaborative would become impossible.

B. Social Collaborative Intelligent Manufacturing Platform Run Method

1) Personalized product customization

a) Personalized product customization methods

Users log in software personalized product customization platform through their own terminal, and to find their own needs product model in the processing model library. The users can make their own personal product model two types change, functional and decorative, based on model features (the expertise is not required). The size and material of component of the product model would be changed according to the individual changes depend on product model itself, so new product models formed. The new product model disassembles itself into individual components, and the single part machining scheme and assembly process plan are formed. Communicate each program of machining and assembly with the fuzzy matching intelligent robot to confirm the feasibility and form feasible product models. The all parts machining scheme and assembly process plan are communicate with the fuzzy matching intelligent robots in the vicinity of the user, and the intelligent robot chooses the machining or assembly object according to its own processing and assembling ability. Intelligent robots communicate with intelligent storages and intelligent logistics, and give the result of the ingredient. The intelligent robots determine the specific cycle of the process based on the processing cycle of the parts and the other parts that are already in line. The intelligent robots determine the price according to the processing difficulty, the processing time-consuming, each kind of loss, the ingredient price, the ingredient transportation, the intelligence logistics cost, and the profit factor. The software platform integrates the data presented by each intelligent robot, and if necessary, communicates with more many intelligent robots in the vicinity of the user. According to assembly sequence given by the model, the software platform communicate with the intelligent robot again, and re-verifies the machining cycle, assembly cycle and price elements of the parts on the basis of the large amount of machining data. According to the data of each intelligent robot, the software platform gives the product delivery cycle and quotation table according to the factors of intelligent logistics transportation, patent expenses, taxation and so on. User selects the appropriate product according to the product delivery cycle and offer form, and to complete orders and payment within a certain time frame. The software platform notifies the corresponding successful intelligent robots to start the production according to the forecast period and gives the part identification code of each part of the product. Intelligent robots, with the assistance of intelligent logistics, complete the production and assembly. In the end, mail the finished product to the user, and complete the payment of the corresponding parties, by software platform.

b) Example of personalized product customization

In the elaboration of personalized product customization method, the image is not enough. This is a simple process model to illustrate.

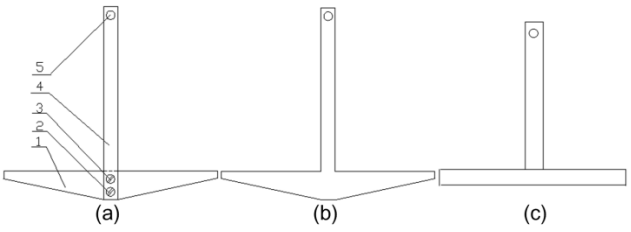

Fig. 2. Image of processing model.

User 1 needs a bracket, which have two straight shoulders for hanging heavy objects; user 1 through his terminal, landing software personalized product customization platform. User 1 finds product models he demanded in the software platform model library, under the relevant categories, such as Fig. 2. Fig. 2(a) is an assembly model, the historical processing price, provided by software platform, is lower, Fig. 2 (b) is a one-time molding model technology, and the historical processing price is higher. User 1 selected the Fig.

2(a) model, and Fig. 2(a) model provides a different material selection, the user 1 according to the reference price and his own will, select the stainless steel. Fig. 2(a) model provides a human-machine interface that requires the user to enter four parameters. The first parameter is weight ratio of weights on left and right shoulders, the second is total weight, the third is the length of the suspension bar (4), the forth is the length of balance beam(1), the user 1 input 2, 150kg, 350mm, and 200mm, respectively. In the personalized decorative step, the user 1 select two covers, (2) and (3), for protecting the two screws, supported by model(a). According to the guidance of the model, the user 1 puts forward write his name "User 1" on the suspension bar (4), and uploads his own name font under the support of the software platform, and specifies the specific location. The dimensions of the balance beam (1), the suspension bar (4), the screw (2) and (3), the through-hole (5), the relative position of the screw and the balance beam are optimized by the Fig. 2(a) model base on the above-mentioned personalized requirement. The software of structural mechanics is supplied by platform would be used in the model optimization process. In addition, a new processing model is formed by adding the user 1's other requirements, which are protective cover and the name engraving. After the new model is disassembled, the single part machining scheme and assembly process plan are formed. After the communication between the plan and the intelligent robots, the new processing plan is confirmed and submitted to the user 1. User 1 is satisfied with the appearance of his bracket and has no intention to revise it. The software platform allows the intelligent robots and the intelligent storages near the user 1 to communicate about the new model, and the intelligent robot chooses the object according to its own processing and assembling ability. Intelligent robots communicate with intelligent storages nearby, and give the conclusion of materials availability in the assistance of intelligent storage. The intelligent robot determines the specific cycle of the process based on the processing cycle of the parts and the other parts that are already in line. Intelligent robot determines the price according to the processing difficulty, the processing time-consuming, each kind of loss, the ingredient price, the ingredient transportation, the intelligence logistics cost, and the profit factor. The software platform synthesizes the data given by various intelligent robots according to assembly sequence given by the model, and after optimization, it communicates with the intelligent robots again to re-verify the processing cycle, assembly period and price elements of the parts. According to the data of each intelligent robot, the software platform choose 10 intelligent robots as potential successful bidder, and gives the product delivery cycle and quotation table base on the factors of intelligent logistics transportation, patent expenses, taxation and so on. User 1 is not urgent in time, choose the lowest quotation, and complete the payment, the corresponding only three intelligent robots successful, one of which is responsible for Fig. 2(a) balance beam (1) and suspension rod (4), one is responsible for engraving font on the hanging rod (4), one is responsible for the assembly, and the other parts are procurement. The software platform notifies the corresponding successful intelligent robots to start the production according to the forecast period and gives the part identification code of each part of the product. Intelligent robots complete the production and assembly in the intelligent logistics assistance. In the end, the finished product deliver to user 1, and the software platform to complete the payment of the corresponding parties, and the personalized product customization process is over.

Personalized product customization process is also support users to upload data directly to complete the individual products production, the process is similar to the above example, just skipping the model selection and model modification phase. Users can choose to process parts, assemble themselves, etc., can fully meet the user's personalized needs.

2) New product developments

a) New product development method

User A through his own terminal, landing software development platform, and describes the product requirements in detail, such as positioning, development cycle and R&D advance payment, respectively. The software platform uses a set of evaluation system to require user A to pay a certain margin (if user A specifies R&D users, the prepayment is not need). If the product is a very complex system, then user A needs to divide it into subsystem, and build a system model so that it can be implemented smoothly. Software platform released the R&D program under the related categories, the similar models are provided as reference for developers by fuzzy computing, and the integrated database and manufacturing software modules will be opened to the developers in a suitable way. Users, who are interested in participating R&D, login software development platform, looking for suitable R&D projects. Under the demand traction of user A's R&D project, part of the R&D users have selected part or the entire user A's project to design and development, according to their own condition. R&D users will submit their own design to the software platform (R&D users communicate with intelligent robots on the issues of parts processing, assembly, and other problems at any time in the development process). The software platform will consult the intelligent robots on issue of the operations of the design submitted by the R&D users, if the design is not operable, only feedback to the R&D personnel, if the design is operational, after confirmed by the R&D user, it would be submitted to the user A. User A, collects all solutions submitted by R&D users in a limited time frame, virtual assembly in the software platform, and views the function. User A submits the assembly model to the software platform, and the platform communicates with the intelligent robots to annotate the unreachable processing items and feedback to the user A. User A would amend his original decomposition of the system and other items, and release R&D tasks again, the original design of the users involved in the sub-system or component design again, until the user A's needs reached, or a standard set by software platform reached, the R&D task is completed. In the end, the software platform should to complete the payment of the corresponding R&D parties. If the user A wants to produce the product, repeat the personalized product customization methods to complete the production. If user A wants to add the R&D model to the software platform model database, he should submit the

application to the software platform. Software platform through a set of assessment methods, gives the audit conclusions within a limited time frame. If the user A's model of the product through the software platform audit, the reliability of the product should to verified in accordance with industry standards and related rules, if necessary, manual intervention. If the reliabilities are confirmed, the platform and user A signed the relevant transfer agreement through negotiation, and the model would add to software platform-related categories.

From the R&D method can be seen that the R&D method is especially for the development of complex product by team. In the beginning of R&D, make participants. In the design process, some or all intelligent robot can specify, and the feasibility and cost of product could be understood in real-time. When the product model is finalized, its processing cycle and cost are determined.

The R&D method presented by this paper has obvious advantages relative to the traditional R&D method.

b) Example of new product development method

In the elaboration of new product development method, the image is not enough. This is a simple process model to illustrate.

User 1 needs a bracket, which have two straight shoulders for hanging heavy objects. User 1 through his own terminal, landing software development platform, described his needs in detail, gives a functional diagram shown in Fig. 2(c), gives the limitations of the design cycle for one week, the reward for 1,000 yuan, and paid 1,000 yuan as a deposit. Software platform release the R&D program under relevant categories, and the integrated database and manufacturing software modules are provided as reference for R&D users in an appropriate way. The R&D users login software development platform, look for R&D projects. In the user 1's R&D project traction, the R&D user 2 gives his design as shown in Fig. 2 (a), he gives the dimensional change relationship of the balance beam (1) and the suspension bar (4), the selection relationship of screw (2) and (3), the relationship between the size and position of the through hole (5), the relative position relationships of balance beam (1), screw (2) and (3). The all features as shown above indicate that the model has the abilities of personalized customization, and in the end, user 2 submits his design to the software platform. In the user 1's R&D project traction, the R&D user 3 gives his direct molding design as shown in Fig. 2(b), she gives the dimensional change relationship of all parts, which indicate that the model has the abilities of personalized customization, user 3 submits the design to the software platform in the end. The manufacturing software modules provided by software platform are used in the design process by user 2 and user 3. The software platform will consult the intelligent robots on issue of the feasibility of designs (as show in Fig. 2(a) and Fig. 2(b)), and get a conclusion that their design is feasible, and then the designs are submitted to user 1. The designs were presented to the user 1 in the order of their submission. User 1 chooses the direct molding design. The software platform finishes the payment to R&D user 3, and transfers all data of the direct molding design to user 1. In the input of personality parameter step, user 1 chooses titanium alloy in the material selection, making the weight of the left and right suspension is the same, the total weight is 1000kg, and the space of the hanging rod is 500mm. The model shown in Fig. 2(b) is optimized according to the individual needs of user 1, and a new model formed. The production process of the product is completed as personalized product customization method, which was discussed in detail in the above article. User 1 submits the application to the software platform, hoping that the model shown in Fig. 2(b) will be added to the model library of the software platform. Software platform through a set of assessment methods, gives an adoption conclusion within 1 week, organizes the relevant industry parties to carry on the appraisal to the model shown in Fig. 2(b), and it is concluded that it do not need to carry out the relevant reliability verification and pass it directly. Software platform and user 1 through consultation, signed an intellectual property transfer agreement, model shown in Fig. 2(b) join the relevant categories under software platform. Software platform determines the charging methods, which is publicly available to all users, based on estimates of expenses and profits. User 2 submits the application to the software platform, hoping that the model shown in Fig. 2(a) will be added to the model library, after a relevant procedure, the model has also been added to the relevant categories under software platform. The product R&D is ended.

C. Characteristics of Socialized Collaborative Intelligent Manufacturing Platform

1) The access to the software platform is a single intelligent robot, which can be composed of multiple robots and other large robots, so the social collaboration degree is improved for low access threshold.

2) The user, without industry knowledge, can raise his personalized needs according to the user interface in the process of personalized product customization.

3) In the process of personalized product customization, whether the processing model is feasible will be known in a very short time later through the Internet of things system, only costs a little communication. In the subsequent processing, is fully automated operation, and the efficiency is similar to batch production. The efficiency of capital use is improved for no stock, and the inventory risk reduced too.

4) The R&D personnel spent a lot time on materials, parts and producer selection in the current product development process, but in the social collaborative intelligent manufacturing platform, all this can be completed anytime in a few minutes bidding, and the optimization results would be provided. It is obvious that the efficiency is improved.

5) All designs are conservative in the current R&D conditions, for the bold ideas, because of cost and time factors, cannot be tried. In the social collaborative intelligent manufacturing platform, it can make a virtual attempt at a micro cost, and can make the product experiment at lower cost, which is beneficial to the innovation driven.

6) The whole process can be traced back.

IV. Prospects of Socialized Collaborative Intelligent Manufacturing Platform

The realization of the social collaborative intelligent

manufacturing platform relies on the intelligent degree of the processing model, the intelligent robot, the intelligent storages and the intelligent logistics, and the higher intelligent degree, the higher operation efficiency. The design of the platform is self-perfect and has strong compatibility.

In the processing of model, the adaptive modifications include decoration and function. The evolution of the model can be modified gradually from decorative to functional personalized modification. Taking the vehicle as an example, the initial stage of the model is mainly based on the body color, security configuration and technology configuration customization. Gradually, transition to the dynamic system and body appearance personalized customization. And then transition to the chassis expansion, drive form and other personalized customization.

In the initial stage of development of intelligent manufacture platform, if the intelligent degree of logistics and warehousing can't support the smart manufacturing, a little manpower would be involved at the cost of efficiency. And develop gradually to the direction of intelligent robots, intelligent logistics, and intelligent storage support.

The technology of the intelligent robot developed freely except the interface technology, which require the robots have the abilities to read individual parts processing and product assembly. The manufacturing industry is made of several similar social collaborative intelligent manufacturing platforms, and the same intelligent robot can access different social collaborative intelligent manufacturing platform, full freedom of competition can achieved, and is conducive to the rapid development of manufacturing.

It can be seen that the socialized collaborative intelligent manufacturing platform can be applied to various fields of the manufacturing industry, which will meet the needs of individual customization and improve the efficiency of R&D. The threshold of entrepreneurship is reduced; the development of small companies is facilitated; the efficiency of social idle assets is improved and the resources are saved.

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