ACP Approach based Intelligent Quality Management System for Manufacturing Processes

Cheng Changjian[1, 3], Wang Jie[2], Liu Xiwei[1, 3]
1. Institute of Smart Enterprise Systems
Qingdao Academy of Intelligent Industries
Qingdao, China
2. College of Electrical &Information Engineering
Changsha University of Science & Technology

Mo Hong[2], Zhu Fenghua[3], Xiong Gang[3]
Changsha, China
3. Dongguan Research Institute of CASIA Cloud Computing Center
Chinese Academy of Sciences
Dongguan, China

***Abstract*—with the rapid progress of information and electronic technology, traditional industrial processes are becoming more and more complex. It is very important for manufacturing enterprises to manage and control the product quality under the circumstance of big data. Based on artificial systems, computational experiments, and parallel execution approach, modeling methods by mechanism, data, heuristic rules, etc. are proposed to construct intelligent management and control system for complex manufacturing processes. The presented system is helpful to visualize production processes, to earlier detect potential problems, to quantitatively analyze various risks, to verify management strategies by computational experiments, to optimize decisions by parallel execution.**

Keywords—manufacturing enterprises, ACP, complex manufacturing processes, optimize decisions

I. INTRODUCTION

With the progress of industry and electric technology, traditional industrial processes are becoming more and more complex. Product quality of manufacturing enterprise involves not only engineering complexity about material, equipment, technology and so on, but also social complexity factors such as comprehensive coordination between human and machine system and personnel and organizational behavior [1]. It has been a long time for people to concentrate on researching and designing enterprise management solutions from the perspective of engineering complexity [2], and some outstanding achievements have been achieved [3]. However these researches are faced with low utilization of massively accumulated data, invariable management workflow and unpredictable development. There is urgent need to integrate a wide range of factors such as man, equipment, material, method, environment, measurement, and management.

In response to these shortcomings and deficiencies, this paper discusses the Artificial societies, Computational experiments and Parallel execution (ACP) was used in product quality for complex manufacturing system, and used to build an intelligent management and control system for complex manufacturing processes (MP) based on this method. By describing complex system with artificial system based on agent technology, taking deep computing as the main method, and combining artificial societies, computational experiments and parallel execution organically, the ACP method can be used to solve many complex problems in actual system when the situation can't be forecasted accurately, or the system is difficult to disconnect and restore, or the experiment couldn't be repeated [4-8]. In recent years, ACP method has been successfully applied in many areas such as transportation, e-commerce, emergency management, chemical engineering, social security [4-5, 6-15]. By taking ACP as the guide, complex manufacturing process as research object, this Paper try to build an outline with artificial system to integrate material flow, capital flow, information flow and staff organization. And by calculating and designing for system solutions, models and data. etc., it optimizes and dynamically forecasts the production process, realizes dynamic control of the complex manufacturing process.

This paper includes the following contents: ACP based intelligent quality management system (IQMS) framework for MP; key technology of building IQMS; IQMS architecture; innovations of IQMS; the conclusion.

II. ACP BASED IQMS FRAMEWORK FOR MP

The key contents of IQMS for complex MP based on ACP are artificial system, actual system of manufacturing process, computational experiments with artificial systems and Parallel execution which can improve artificial system and optimize actual system, as is shown in fig. 1.

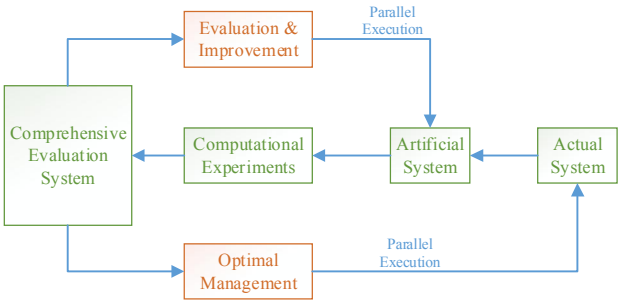

Fig. 1. IQMS framework for complex MP based on ACP

(1) Artificial systems of MP

The main function of this part is showing the personnel characteristic during design process and organization, describing the relationship between "man, machine, material, method, environment, measurement" (5M1E)of working procedure and product quality, and simulating the operation process of product-production under the restriction of management workflow/ institution and production plan. In order to build simple and consistent artificial systems, it's needed to research the following content:

- Build the relationship model between 5M1E factors of design stages, working procedures and product quality by agent-oriented modeling technology.
- Set up the management model of workshop equipment based on equipment management model and modeling technology of equipment-failure pattern.
- Establish the staff knowledge-transfer model with cognitive modeling technology.
- Build the evolution model of formation process of the components quality with process simulation technology.
- Establish a complete virtual factory based on the above model by relying on the scene management system of manufacturing workshop and using a variety of production task planning and scheduling technology.

(2) Computational experiments of MP

On a micro level of application, computational experiments could realize quality analysis of different 5M1E such as personnel transition, equipment factors, process programming; on a macro level, the experiments can evaluate the production scheduling strategy, and search the most optimized solution to improve the quality and reduce the construction time which provides support and early warning analysis for enterprise process decision in real time. This part mainly research:

- Multi-stage experimental design and analysis. Data strategies during this time are flexible and it's needed to consider how to use the result of former stage reasonably. The next stage's design scheme can be formulated according to the result of former stage. This paper will adopt sequential branch design and sequential experimental design to improve the efficiency of experimental design.
- Meta-model establishment of the complex experimental process. To the complex experiment demand of product manufacturing, traditional linear polynomial meta-model can't describe the complex and nonlinear relationship between input factors and response variable. Therefore, some emerging statistical model and machine learning method will be applied. The key of this section is mainly selecting and building the suitable experimental meta-model. Some primary meta-modes and calculation methods includes Kriging model, Spline approach, Bayesian approach and artificial neural network.

(3) Parallel executions of product quality management

Parallel executions mean that artificial system runs in parallel with the actual system. Actual system is monitored by data center system to adopt, analyze and mine related quality data in real time. By comparison between the data information and simulation data with artificial systems, the evolving direction of quality characteristic can be monitored on-line in real time; once artificial systems operates abnormally, it will be trigged early warnings. Artificial systems could realize adjustment and improvement itself through inputting data of data center system.

III. KEY TECHNOLOGY OF IQMS

(1) Structured data from multiple sources

In order to build a data warehouse about MP of unified data source, data packets produced by kinds of information system or tools used by the enterprise, will be integrated and collected a variety of data. In addition, a data-collection system in view of MP will be designed to realize whole control of the MP. Data collected by data warehouse are not only numerical data, but also design drawing, control process, computational algorithm, video, audio and other media reports.

(2) Multi-agent system construction of MP

Traditional organizational modeling can't fully consider personnel and organization factors in the MP. This paper takes full account of these factors' initiative and randomness. Based on the principle of "simple consistency", it puts forward a bottom-up and agent-based modeling method of artificial systems from the perspective of behavior generation. Each artificial systems uses intelligent agent to describe the interaction rules between personnel, organization or equipment and other system entities. Agent-based artificial systems of MP is a large-scale and multi-agent system, and intelligent-agent behavior rules in the system are different, where their behavior are scattered and asynchronous, which needs appropriate models and methods to describe. There is computational expensiveness for computational experiments and parallel execution, and in order to improve the speed of system evolution, high-speed hardware platform and appropriate software-support environment are needed to consider.

(3) Comprehensive indexes settings and control of MP

Management system and support method toolset of production indexes are got by comprehensive indexes system mapping control system of MP to lay a foundation for visual management of MP. Product demand information is transformed into product quality, cost, schedule or other control characters by using comprehensive indexes decompose and combine the models, so that all standards of product quality can be determined. At the same time, these standards are detailed into not only the quality of product components, parts and service item, but also elemental interrelation of MP or service process, and form various

detailed indexes. Finally, key indexes are got after related indexes process.

(4) Risk management and forecast based on ACP

Key factors affecting manufacturing risk are found based on 5M1E to build parallel system about MP. Parallel system's main content include: building artificial systems related with quality, cost and schedule or other product factors based on actual data and MP; designing experiment methods and turntable mechanism affected by multiple factors; establishing multi-targets, multidimensional and dynamic evaluation scheme and control parameters indexes; setting up feedback mechanism and adaptive algorithm inside the system; building a set of system optimization mechanism according to the feedback data and quality evaluation parameters, to make artificial systems reacts operation status of artificial systems in real time and provide optimized method for improving the whole system.

(5) Control strategy's online assessment and rolling optimization technology

This technology is to establish artificial systems for MP in view of control strategies, which is designed from the perspective of control strategy's effect on quality and cost. In order to improve effectiveness of control strategy evaluation, related technologies mainly are linguistic dynamic system, cellular automation, Etc.

IV. IQMS ARCHITECTURE FOR PRODUCT QUALITY

On the basis of above technology and research method, this paper designs IQMS for complex product quality to realize real-time data collection, pre-event forecast and process control, as is shown in fig. 2. The system's main functions are

(1) Analysis of product quality data

A management visual dashboard with KPI is created by using historical data and real-time data in data center combined with user's demand. The system intensively monitors MP, analyzes production target setting and searches the formation of risk and quality defects.

(2) Online assessment of quality defect

Potential defects difficult to identify during the MP may not be found until after continuing several business process which leads to waste of waste product and use risk. Traditional method can't solve pre-event research and product defect estimation while this system can solve these problems based on statistical data, experience and dynamic evolution before these problems come out.

(3) Pre-event node control of quality sensitivity analysis

According to the pareto principle, 80% of the energy is used to deal with key nodes. Process simulation based on artificial systems provide abundant data and intensify corresponding resource allocation through finding key manufacturing link by computational experiments.

(4) Product quality effected by work atmosphere & fatigue

Work atmosphere, fatigue, task allocation of the workshop are human factors that influence management, while these factors have important influence and spatial improvement during the quality management. In order to avoid too nervous work atmosphere, too much burden, high fatigue and unbalanced task assignment, enhance the level of humanized management and promote quality improvement, this system could analyze kinds of behavior features, find abnormal condition and caution managers to adjust task allocation or product schedule based on human behavioral sample database through the technology of artificial systems forecast and video analysis.

(5) Analysis of 5M1E influence on product quality

5M1E influence on product quality is analyzed by artificial systems to provide quantitative decision support for resource configuration of MP.

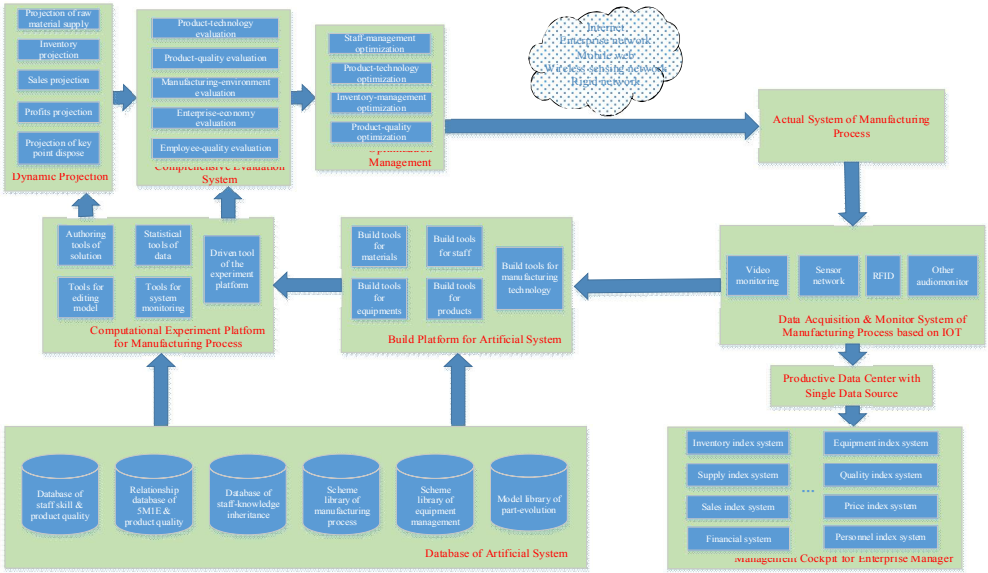

Fig. 2. IMCS architecture based on ACP

V. INNOVATIONS OF IQMS

(1) Visual control of wholly real-time status during MP

Quality management of electronic products is of complexity. By establishing visual control system about the wholly real-time status driven by big data and models, this paper can realizes global, dynamically interactive, visual control of product life-cycle.

(2) Loop-locked process of order dispatch and feedback for dangerous problems.

If the technology and quality problems can't be handled well, it would result in some risks such as a longer cycle, poor reliability. Effective solution depends on not only timely control of information, but also the real-time feedback channel for solving problems. Therefore, the paper establishes loop-locked processes of order dispatch and feedback for dangerous problems avoids risk and reduces cost effectively by organizing information orderly produced by each process by artificial systems.

(3) Improving forecast capacity of product quality, cost, schedule and other factors

This paper builds artificial systems of risk control based on ACP, and realizes foreseeability and traceability of process control.

VI. CONCLUSION

The paper adopts ACP method to build IQMS. By artificial systems, kinds of factors related with organization and personnel such as infrastructure, capital flow, management system are modelled; computerization artificial systems is built by multi-agent technology, and function and influence of various decisions are analyzed by CE to make PE of artificial systems and AS; and then, synergy evolution and interaction of AS and artificial systems are done by PE; finally, management and control of complex management system are made come true. This system combines personnel, organization and other factors, takes full consideration of employee knowledge, skill, performance, logistical support and so on, inspires stuff initiative effectively, helps the enterprise shapes characteristic culture, and promotes harmonious development of the enterprise.

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