A New Mode of Forging by Using Intelligent Manufacturing

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Abstract. With the development of the Internet of Things and the Internet, the advanced sensing technology, information technology and intelligent technology can be utilized to transform and upgrade the traditional manufacturing industries and to prompt the deep fusion of industrialization and informatization. Consequently, the production and management modes of the enterprises will be changed, the production and operation efficiency will be significantly improved and the production cost and energy consumption will be reduced, which therefore turns to be very significant. This paper puts forward some new modes for intelligent forging under the trend of Cyber-Physical System to solve the difficulties of the forging industry, which are often characterized as complex machining process, low production efficiency and quality stability, high production uncertainty, difficult equipment maintenance and low degree of production traceability. In these modes for intelligent forging, during the production process, the information sensing, network interconnection and artificial intelligence technology are utilized to establish a forging production intelligent platform, so as to realize the efficient collaborative working of the procedures and the global optimization operation of the whole forging process; a forging cloud data center is established for the forging equipment maintenance, so as to realize the efficient operation and maintenance of the forging production line; and on the forging upstream and downstream supply chain, the cloud data platform and the data collecting and integrating technologies as RFID, QR code and EDI are utilized to realize the traceability of the whole forged product through upstream and downstream process. The above new methods can significantly improve the production efficiency of the forging enterprises, reduce the production and operation & maintenance cost and improve the market competitiveness through the deep application of the new methods in the forging enterprises.

Guidelines

In recent ten years, the Internet of Things and the Internet have attracted wide attention and achieved significant developments. According to the related data statistics [1], the terminals connected to the Internet in the whole world exceeded 6 billion in 2014; and the market scale of the Chinese Internet of Things will exceed 750 billion Yuan in 2015. Moreover, this trend will continue. Under this background, in the field of industrial manufacturing, the advanced sensing technology, information technology and intelligent technology are utilized to transform and upgrade the traditional manufacturing industry, and to prompt the deep fusion of industrialization and informatization, which will lead to the innovation of the enterprise production and management mode, the significant improvement of the enterprise production and operation efficiency, the decrease of production cost and energy consumption, as well as the initiation of the industry transformation of profound influence and the formation of new industrial forms and economic growth points, and therefore have significant meaning and functions [2].

To follow this trend, the main manufacturing countries in the world have put forward their own development strategies for manufacturing industry one by one. Germany has put forward the Industry 4.0 Strategy at first, the USA has put forward the Industrial Internet Plan and China has also developed the Made in China 2025 Planning, with the common purposes of advancing the deep application of informatization, networking and intelligent technology in the manufacturing industry,
realizing the deep integration of cyber world and physical world (namely establishing an Cyber-
Physical System CPS), innovating the production mode and industry chain division, and finally
establishing an efficient and flexible individual and digital production and service mode, so as to
achieve the competitive advantages in the global manufacturing industry. For example, Germany’s
“Industry 4.0” Planning has displayed a brand-new industry blueprint [3]; and in an “Intelligent and
Networked World”, the Internet of Things and the Internet will permeate all the key fields, the
process for creating new value will be changed gradually, the industry chain division will be
reorganized, the traditional industry boundaries will disappear, and all sorts of new activity fields
and business cooperation forms will be created.

As the basis of other manufacturing industries, The forging industry has a long history of
development and a considerable scale in China. According to statistics, China has totally about
10,000 forging enterprises at present, of which there are more than 7,000 enterprises above the
designated size (the data is quoted from the website of Confederation of Chinese Metalforming
Industry). The forging industry as the typical traditional manufacturing industry also faces
difficulties as redundant production capacity, serious homogeneous competition, low automation
and intelligentization degree, and urgent need for product transformation and upgrading. Under this
background, in regard to the urgent needs of the forging enterprises in improving production
efficiency and product quality, reducing energy consumption and production cost and improving
market competitiveness, this paper focuses on the analysis of the characteristics and difficulties of
the forging enterprises in production and management at first, and analyzes and discusses the new
production and operation modes of the forging industry, and the significant effect and the
corresponding implementation difficulties and strategies brought by the application of these modes
to the forging enterprises by combining with the new idea of intelligent manufacturing and the
 technological features of the Cyber-Physical System on this basis.

**Characteristics of Forging Industry**

The forging production process has the following significant characteristics:

- **Complex Processing Technology**
- **Difficult Equipment Maintenance**
- **Difficulty in Tracing Material**

It’s well known that forging enterprises mainly provide components and parts for the downstream
complete machine enterprises (automobile, engineering machinery and household appliances). As
the downstream users have paid more and more attention to the safety and customer satisfaction, the
production tracing precision and range have become more and more important. However, as
multiple production procedures during the forging process need to be manually completed and the
forge pieces are not easy to be added with marks (e.g., bar code or RFID), the raw material
management is rather extensive, and the multiple basic information required for material tracing
can’t be effectively recorded. Even some forging enterprises manually collect the material tracing
information, however the manual recording is easily subject to error and the material, the order
form and the equipment machining parameters are not relevant enough, consequently resulting in
the poor effect of material tracing.

On the other hand, most of the forging enterprises have paid more and more attention to the
informatization and automation during the production process, and new forging production lines are
usually equipped with multiple production information sensors, PLC and configuration software to
monitor and control the forging production process in real time. Moreover, some enterprises have
implemented the manufacturing execution system, and have a good informatization and automation
basis as well as the hardware conditions for carrying out intelligent forging.
Intelligent Forging: New Modes

Overall Framework

This paper puts forward some new modes for intelligent forging by combining multiple new ideas, methods and technologies, so as to meet the urgent needs of improving production efficiency and production quality while reducing energy consumption and production cost of the above forging enterprises. The schematic diagram is shown in Figure 1.

Therein, by establishing the Cyber-Physical Network in the forging enterprises and complying with the corresponding security protocol and the domain application standards, the real-time connection, precise recognition and effective interaction of the related equipment, resource, material, client and producer during the forging production process are realized. On the basis of the Cyber-Physical Network, during the forging production process, the information perception, network interconnection and artificial intelligence technology are utilized to establish the whole forging process production intelligent platform, and the platform realizes the efficient man-machine interaction and the overall collaborative optimization operation during the whole forging process by providing the related intelligent control, intelligent decision support and visualization tool on the basis that the platform collects the large amount of real-time data produced by equipment, order form, material and energy to establish the forging process data center; in regard to forging equipment maintenance, the forging equipment remote operation & maintenance platform is established to bring technological advantages of the forging equipment supplier into full play and realize the efficient operation & maintenance of the forging production line; and in regard to production tracing, a plant data model covering the whole production process is established at first and the mobile data collecting technologies as RFID and bar code are adopted, so as to realize the automatic collecting and active collecting during the whole material flow process, effectively avoid the defect of manual entry and realize the traceability of the forging product upstream and downstream whole process. One point needs to explain that the above new mode can coexist with the existing information systems (e.g. SCADA and MES) of the enterprises, for example the forging production intelligent platform can adopt the SCADA system as the carrier.

New Intelligent Production and Manufacturing Mode

The operation optimization during the manufacturing process is being transformed from the local optimization of single equipment during the operation process to the global optimization of the production system. For the forging enterprises, key production equipment is usually equipped with a rather independent production operation control system, and is capable of accomplishing the optimization and control of the equipment during the production process, therefore for the next step,
it becomes quite necessary to realize the global optimization operation by utilizing the technologies as intelligent sensing, intelligent analysis and intelligent analysis. Figure 2 shows the schematic diagram of the new intelligent production and manufacturing mode.

![Figure 2. Intelligent Optimization Platform of Forging Production System.](image)

During the forging production process operated with global optimization, the interconnection and interworking between the intelligent sensor and the unit information systems is increased at first, so as to establish the network environment of the Cyber-Physical System, collect and integrate the production information of the key procedures (heating, forging and pressing and annealing) required for the global optimization of the forging process as well as the information concerning material, product and energy and store in the form of the enterprise production real-time data platform, and therefore form the intelligent plant environment; on this basis, by taking the objectives of reducing the overall energy consumption and production cost of the system and improving the production quality and efficiency, the intelligent optimization platform of forging production system is established. The platform can be closely combined with the production characteristics and needs of the enterprises, through the large amount of accumulated historical data, the combination of physical and chemical reaction mechanism, data and knowledge and the utilization of feature extraction and data mining methods, on the basis of real-time working condition identification, by taking the objective of realizing the global optimization during the forging process. A relational model between the above key technological parameters of the procedures (as intermediate frequency furnace motor gear, duration of heat and impact force set value), the equipment characteristic parameters and the above operating indexes is established based on the platform. The model should be continuously updated along with the generation of the production data, so as to improve the accuracy of prediction. The model is mainly used for the prediction of the comprehensive energy consumption and the final product quality index of the whole forging process under the condition that the given parameters are predicted in real time. On the basis that the prediction model of equipment key operating indexes is established, by utilizing the production process real-time data and taking the objectives of reducing energy consumption and stabilizing production quality, the knowledge base with the self-learning feature is established, and through the intelligent optimization algorithm based on the collaborative optimization between the procedures, the above key procedure parameter set values of the procedures of the heating furnace, the forging press and the annealing furnace are given. Through the reasonable technological parameter setting, the heating furnace and the forging press are ensured to adjust in a self-adaptive way according to the blank condition and the equipment working condition and always produce under the excellent working condition, and the energy consumption lowest “borderline” control is
realized under the condition of meeting the quality requirement, so as to realize the global optimization of the procedures during the forging production process.

**New Production Tracing Mode**

Under the new production tracing mode, from the raw material entering the factory to the completion of product delivery, the material lot, the production equipment of each procedure, the production and machining parameters, the quality and energy consumption indexes, the person in charge of production and the storage location of each lot of products during the whole forging production process should be collected and integrated totally. The present mainstream forging production equipment all provides a digital program interface for collecting the machining parameters and the corresponding production performance index information, and can adopt the collecting technologies as RFID, QR code and bar code to automatically collect the information as raw material lots and storage locations. On the basis that the above whole process is digitalized, the whole process production data can be effectively organized according to the plant data model, so as to realize the one-key tracing of the final products, semi-finished products even the raw material needed to be traced, therefore the defects as low production tracing efficiency and poor effect caused by the problems as incomplete production information record and information islands can be greatly improved.

After the establishment of the digital and intelligent plant, the forging enterprises have got the flexible organization capability, greatly improve the transparency of production process and minimize the contradiction between the individualized client order and the lot size equipment production demands. The clients can know the production schedule and the quality condition of the order at any time through the convenient production tracing, and the decision maker of the enterprise can also have the knowledge of the production situation at any time, so as to make the production decisions as optimal order receiving and material management.

**Conclusion**

The rise and development of the Internet of Things and the Internet have brought new opportunities for the industry transition and upgrading of the traditional manufacturing industry as the forging industry. This paper analyzes the major difficulties faced by the forging enterprises at present, including complex machining technology, low production efficiency and quality stability, high production uncertainty, difficult equipment maintenance and difficult production tracing and put forward the intelligent forging new mode for solving the above difficulties by combining with the idea and technology of intelligent manufacturing. The new forging production mode can significantly improve the production efficiency of the forging enterprises, reduce the production and operation & maintenance cost and improve the market competitiveness through the deep application of the new forging production mode in the forging enterprises.

**References**

