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Tolerance Design and Adjustment of Complex Customized Product Based on Cloud Manufacturing

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Abstract

A local and temporal separated manufacturing becomes possible, which can enhance the economic efficiency of the production. Complex products such as spacecraft, large CNC Machine, large compressor face challenges in their development process. The cloud manufacturing which is based on the development of cloud computing and Internet of Things system makes the collaborative manufacturing process of complex customized product become rapid intelligent efficient and of low-energy consumption. Cloud Manufacturing is a new manufacturing pattern which organizes the manufacturing resource to provide customers with all kinds of manufacturing services as needed. Customers who have taken part in this kind of manufacturing process could integrate the resource anytime anywhere according to the product requirement. Different from the traditional manufacturing pattern, Cloud manufacturing is multi-selective dynamic and the process may be across the stage. With more resources in the manufacturing process involved, cost of the manufacturing may be increased, so the cloud manufacturing is more suitable for small batch manufacture process of large and complex manufacturing process of customized products.

In this article, we put forward a dynamic tolerance design and management framework of complex customized product based on cloud manufacturing. When the product comes into the manufacturing process, the dimension might be overflown of the acceptable zone which had been designed in the engineering phase, therefore we introduce a dynamic control that at every stage of the manufacturing we re-organize the resource based on the real-time information of the manufacturing cloud (in other word, ability of the manufacturing service) and the performance of former service. To ensure the function of the product expressed integrality and assembly process carried out smoothly, we could obtain the target optimal solution of dynamic allocation process of the tolerance on the follow-up process according to the minimum goal of the cost time and quality loss in dynamic adjustment and process stability.

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Key words: cloud manufacturing, quality loss, manufacturing cost, dynamic tolerance adjustment

1. Introduction

In the 21st century, the development of manufacturing industry had been promoted by high-technology. The concept of Cloud Manufacturing had been known by the academics in the recently years with the rising of cloud computing. The proposing of cloud manufacturing service mode [1-2] introduced the information technology into the traditional manufacturing area. Therefore, in the internet resource environment, the resource is integrated efficiently to solve the problem of new product development in manufacturing industry, to achieve the goal of appreciation and synergies. A new solution to develop

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innovation and competitiveness of manufacturing enterprise has been put forward.[3] Many studies at home and abroad have focused on the integration of cloud manufacturing and traditional manufacturing.

In the integration of cloud-computing [4] IOT [5] service-oriented-computingintelligence-science and e-manufacturing, a project of task allocation according to the workflow`s demand was proposed in the literature[6]by analysis on the characteristic and requirement of cloud manufacturing service mode, discussing the framing

and engine of workflow; literature [7] analyzed the cloud-servitization target of manufacturing resource and process requirements based on NC-processing, designed the cloud service platform which could provide the information of NC-processing products to the users with the integrated service of basic data application tools and service management; literature [8] applied the ontology to the manufacturing service systems based on the product manufacturing life cycle, describing the service and subjects which provide the service as well as the semantic attribute and data attribute of service based on the great expressing ability of ontology; literature [9] provided a optimization target system of eight target variables including time of service, quality of service, cost of service, availability, composability, reliability, maintainability and sustainability to build an optimal-target model according to the characteristic of uncertainty, coarseness, variety and dynamics in the combinations of cloud manufacturing resource based on the development of new products; literature [10] built a service-oriented cloud platform to solve the problems that the existing cloud platform provides the solution instead of supporting the combination of service; literature [11] proposed a market mechanism of configuration services based on cloud computing, but this kind of mechanism could only satisfy the demand of flow-processing users.

As the dynamics of the cloud manufacturing, it is meaningful when the manufacturing process is under the dynamic control. The dynamic control and allocation of tolerance has been discussed in the literature [12]. The actual points in feasible domain were picked to determine the dimension and tolerance of the rest processing; literature [13] proposed a concept of dynamic dimension design to solve the over proof problems in the products of small-batch according to changing the processing path or changing the dimensions for the problem that the processing dimensions were overflown of the acceptable zone; the system control was adopted to control the machining precision by allocation the tolerance after on-line monitoring of dimension in literature [14]; allocation plan and scope application were analyzed systematically in literature [15] and a new model of dynamic tolerance adjustment was proposed to solve the over-proof problems because of insufficient processing capacity.

A study on combination of cloud manufacturing and dynamic tolerance control was put forward in this paper to achieve the manufacturing principle of sensitivity,serviceability, intelligence and green manufacture by adjusting the tolerance of features which have relationship with the over-proof feature based on assembly dimension chain in the machining process of complex products.

2. Overview of Cloud Manufacturing and Complex Mechanical Product Process

Cloud manufacturing (CM) is a new service-oriented networked manufacturing mode, which combines cloud computing, IOT and other technology to virtualize the manufacturing resource. Cloud manufacturing organize the manufacturing resource according to the needs of users to supply all kinds of manufacturing services. The broad topic of cloud manufacturing runs through the product lifecycle, including the Aaas (argumentation as a service), Daas(design as a service),Faas(fabrication as a service), Eaas(experiment as a service), Simaas(simulation as a service), Maas(management as a service), Inaas(integration as a service). Users could dynamically add or delete resource whenever and wherever possible as required. Therefore the foundation of CM is manufacturing resource, the core of CM is service, the feature is dynamism and the aim is high efficiency and low consumption. CM service has the following characteristics: 1, dynamically building the resource on demand; 2, interoperability; 3, synergy; 4, heterogeneity; 5, quick responsiveness; 6, intelligent manufacturing in the whole life cycle.[16]

But the process above could not apply to all kinds of manufacturing process. When it came into the mass production, the process made no sense. Therefore the dynamics of CM works well in the manufacturing process of complex mechanical products. Complex product has the complexity in the customers` requirement, construction, technique, manufacturing process, management process, such as spacecraft, large CNC Machine, large compressor.[17] One product mentioned above consists of thousands of parts or components or subsystems, which involved in different areas. So the complex products have distinct feature in large scale, high cost, complex system, high technique, and they have long project cycle.

Comparing these two kinds of product it is more to be considered in the process of manufacturing or management and more difficult to control the process. One system has to cooperate with the others to avoid conflicts when analyze from the aspect of space, what`s more the coordinate between various resources is also