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Interactive Strategy of Adaptive Belt Grinding Heterogeneous Data for Aero-Engine Blade

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Abstract. In order to obtain high quality aero-engine blades, the adaptive belt grinding method including 840D CNC belt grinding machine, 828D robot, Win3Ds coordinate measuring machine and digital silo is applied to the precision grinding of blades. However, the data collected by each device cannot be uploaded and downlinked in time and effectively, resulting in a problem of poor communication between heterogeneous data information. So, this paper proposes an interactive strategy for heterogeneous data for the adaptive processing method of airborne blades. Firstly, based on the analysis of the heterogeneous data integration characteristics in the processing process, the interactive approach of XML-based integrated aero-engine data integration is studied. Secondly, an integrated model and interaction mechanism for data during the grinding process is established. Finally, the experimental verification of the interaction strategy is carried out for typical blades. The validation results show that after the heterogeneous data is realized, the data interactive transmission is accurate and the processing blade profile accuracy is within the design range.

Keywords: Aero-engine blade; heterogeneous data; data integration; XML; interchange strategy.

1. Introduction

Aero-engine is one of the key components that determine the performance of aircraft. It is a strategic cutting-edge aviation product related to national security and national economic development. As one of the core components of aero-engine blades, the quality of the machining directly affects whether the conversion between flight power and energy can be stably provided [1]. Adaptive belt grinding is the precise machining of the airborne blades under the control of the system. The seamless connection between the system and the field device is the premise of adaptive processing. The difficulty is to solve the consequences that the manufacturing data signals cannot be interacted and shared in time due to the inconsistency of communication interfaces and network protocols. Therefore, it is difficult to realize interconnection and information interaction of heterogeneous devices [2]. In order to realize the real-time nature of data integration and solve the problem of interaction and sharing between a large number of different types and format data collected by various device systems, XML is one of the integration techniques often used to solve the information island phenomenon of heterogeneous data. [3-5].

2. Interactive Basis and Strategy of Heterogeneous Data of Aero- Engine Leaves

2.1 Describe the STEP Standard and Interactive Implementation based on XML

The Extensible Markup Language (XML) is a symbol meta-language that describes performance, data format versatility, and language independence [6]. Therefore, XML is often used to describe and integrate heterogeneous data. And formulate its relevant standard specifications, and the process of general calibration specifications can be divided into the following stages: definition, description, representation, query, transmission, and processing. Finally, the adaptive sanding of the airfoil blade is determined to build a standardized data integration standard protocol based on XML.

In order to realize the mapping conversion between XML and STEP standard, it is necessary to first complete the mapping of the EXPRESS aero-engine blade manufacturing information model to the corresponding structure in XML. The core of the mapping is to convert the specific data and its

attributes and interrelationships in the EXPRESS aero-engine blade manufacturing information data model into elements and their attributes and relationships in the XML aero-engine blade processing data file. Therefore, the main body of the data information generated by the transfer and exchange of the aero-engine blade manufacturing process is the conversion rule of the mapping between the physical neutral file and the XML of the aero-engine blade data specified by STEP Part21.

2.2 Interactive Implementation of XML and Heterogeneous Data

In the process of integrated processing of aero-engine blades, the core role of XML is mainly reflected in the exchange of heterogeneous data of the aero-engine blades. In order to support the integration and interaction of the data collected by various processing and testing equipment in the adaptive belt grinding process, it is necessary to establish a mapping conversion relationship with various processing detection data of the aero-engine blade, according to the structural mapping relationship between the data pattern of the given XML document and the class object of the aero-engine blade processing data, the mapping of the data object based on the XML document to the aero-engine blade is completed[7], the schema data elements that constrained are defined by XML Schema.

The process of converting various aero-engine blade processing detection data into XML Schema can be decomposed as follows: Firstly, XML Schema is used to describe the global variables such as the namespace and target mode space of the aero-engine blade processing detection data, and the global element (root element) is defined. Then, a table element of the Complex Type needs to be created in the global element, and the table element name is the same as the table name in the database storing the aero-engine blade processing detection data.

2.3 Aero-engine Blade Adaptive Belt Grinding Heterogeneous Data Integration Model

In the previous content, the key interaction technologies such as the XML description of the STEP standard and the interaction path and the interaction between XML and heterogeneous data are studied, and combined with the existing XML system framework. This paper will use XML technology as the carrier for the generation, transmission and processing of aero-engine blade manufacturing data information to realize the integration of heterogeneous data of aero-engine blade abrasive belt grinding, mainly by building an integrated model of XML-based aircraft engine blade manufacturing data information. The essence of the information integration model is to unify the different types of data formats collected from the underlying processing and inspection equipment, thereby forming a set of aero-engine blade processing and manufacturing data integration standard protocol specifications, and implementing the standardized description of information by using XML Schema to realize that integration and sharing of heterogeneous data between different application systems in an aero-engine blade integrated manufacturing process. The constructed XML-based heterogeneous data integration model is shown in the Fig.1.

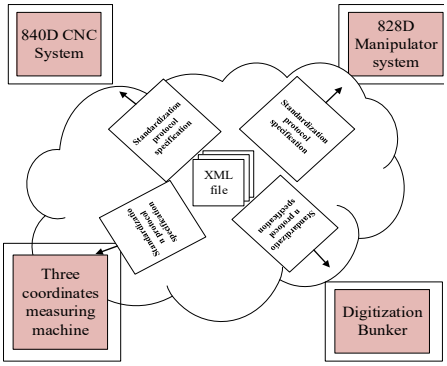

Fig. 1 XML-based heterogeneous data integration model

2.4 Interactive Strategy of Heterogeneous Data Integration for Belt Grinding of Blades

Under the premise of ensuring that the data information organization structure already possessed by the underlying processing and testing equipment data storage system is not changed, a set of XML-

based aero-engine blade data integration standard specification protocol is uniformly constructed. Thereby, a unified description of the heterogeneous data information in the processing and manufacturing process of the aero-engine blade is realized. So, the core of the XML-based manufacturing information integration model structure diagram is to define, transmit, verify, analyze, and process the aero-engine blade manufacturing data. The XML-based realization mechanism of the airborne blade abrasive belt grinding data integration is shown in Fig.2. The implementation process is as follows:

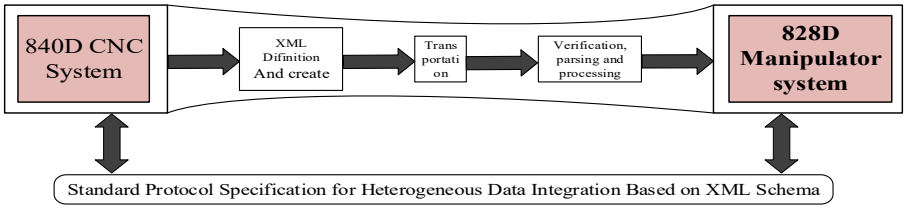

Fig. 2 XML-based aero-engine blade belt grinding data integration implementation mechanism

①An XML definition of manufacturing process information. Firstly, the aero-engine blade data and manufacturing process data and XML mapping transformation are constructed, and then the XML-based heterogeneous data integration standard protocol specification is developed to realize the unified description of manufacturing information, the XML Schema with better performance is used to define and formulate the heterogeneous data integration standard specification protocol for the aero-engine blade manufacturing process, and under the premise of using Schema as the constraint template, the XML identification and type of the aero-engine blade abrasive belt grinding heterogeneous data needs to be described. Finally, the XML document for manufacturing heterogeneous data information of the aero-engine blade is derived, or the system message in XML format is generated, so that the XML format of the heterogeneous data information of the aero-engine blade is uniformly described.

②XML manufactures the transmission of heterogeneous data information. The developed aero-engine blade adaptive belt grinding data integration system is based on Web design, so XML is used to conveniently implement Simple Object Access Protocol (SOAP) transmission. After establishing a networked unified normative description based on XML aero-engine blade abrasive belt grinding heterogeneous data information, all the heterogeneous data information described by XML can access each underlying device system through the SOPA message based on the Web service form, but the access process must be encapsulated accordingly to realize the information exchange between the various devices of the aero-engine blade integrated manufacturing.

③Inspection, analysis and processing of XML heterogeneous data information. Firstly, the definition and transmission of XML heterogeneous data information are completed, and the heterogeneous data information of the aero-engine blade is created, verified and processed. On the basis of the existing definition, the data format is verified by SAX, DOM and other technologies, and the XML data of the airborne blade is parsed into the heterogeneous data file or message, the XML aero-engine blade heterogeneous data document or message is parsed, the aero-engine blade heterogeneous data information described by XML will be read into the developed system, or XSL will be used to convert the above heterogeneous data into XML documents of other formats.

2.5 Consistency Verification of Blade Belt Grinding Heterogeneous Data Integration

The heterogeneous data interaction strategy proposed above is applied to the data integration module of the main module of the airborne blade adaptive abrasive belt grinding heterogeneous data integration system.The data module function realizes the step of data conversion: firstly mapping the data read by the system into an XML aero-engine blade manufacturing data document, and then mapping the document into the required target format data. Through the integrated system, the X, Y, Z three-axis position coordinate data of the 840D machine tool is obtained, and the theoretical value of the position coordinate data is compared with the collected detection value for statistical analysis.

It is calculated that the root mean square value between the measured data and the theoretical data collected by the Z-axis is 3.46×10^{-3} mm, and the value is within a reasonable error range. This verifies the correctness of the data after the integration of the data collection.

2.6 Accuracy Analysis of Grinding Profile of Aero-engine Blade Belt

In this test, the three-coordinate measuring instrument is used to detect the precision of the blade and the contour of the geometric blade. The following Fig.3 shows the section of the blade profile accuracy, the blade line error is within the tolerance zone. From the analysis of the experimental results, it is known that the integration of the heterogeneous data of the aero-engine blade meets the design requirements in the processing accuracy and surface quality of the blade, which also proves that the interaction strategy proposed in the paper is effective.

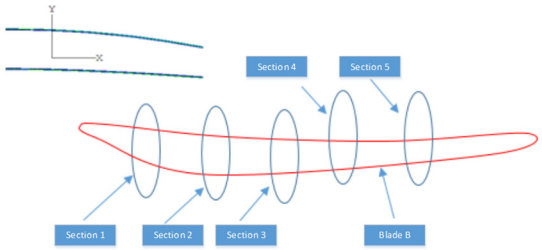

Fig. 3 Aero-engine blade profile error after grinding

3. Summary

For the problem of heterogeneous data integration in the process of integrated processing of aero-engine blades, the research work and research results of this paper are as follows:

①Through the technical system, the mechanism of information integration and sharing of the aero-engine blade manufacturing information is realized. The specific implementation process of the realization mechanism is: XML definition of manufacturing process information, transmission of heterogeneous data information by XML manufacturing, verification, analysis and processing of XML heterogeneous data information.

②The test proves the coincidence degree of the data collected by the Z axis of the 840D machine tool before and after integration, the root mean square value of the Z-axis acquisition data and the theoretical data is calculated to be 3.46×10^{-3} mm, thus the result verifies correctness of the data acquisition. At the same time, the accuracy of the processed blade profile after the test is between -0.03 and +0.05 mm. The reliability and effectiveness of the data integration module of the airborne blade adaptive belt grinding heterogeneous data integration system are verified.

References

[1]. DAVIS W, WALLANDER A, YONEKAW-A I. Current status of ITER I&C system as integration begins [J]. Fusion Engineering & Design, 2016, 112:788-795.

[2]. DING QC. Research on integrated scheme of airborne blade adaptive belt grinding system and its shutdown technology [D]. Chongqing University Master thesis, 2017.

[3]. AMIHAI M, PHILIPP A. Fusionplex: Resolution of Data Inconsistencies in the Integration of Heterogeneous Data Sources [J]. Information Fusion, 2006, 7(2): 176-196.

[4]. Wang X, Huang LP, Y Zhang, et al. A Solution of Data Inconsistencies in Data Integration Designed for Pervasive Computing Environment [J]. Journal of Computer Science and Technology, 2010, 25(3): 499508.

[5]. HUANG JD, TU QQ, YANG HC. Re-search on Product Information Sharing Technology of Agile Supply Chain Based on XML Yin. China Manufacturing Informatization, 2006, 35(17): 1821.

[6]. NURMILAAKSO J M, KOTINURMI P, LAESVUORI H. XML-based e-business frameworks and standardization [J]. Computer Standards and Interfaces, 2006, 28(S): 585-599.

[7]. FU XJ. Research on Data Exchange Force Method Based on STEP/XML [D]. Harbin: Master's Degree Thesis of Harbin Engineering University, 2009.