Integration models for closed loop inspection based on step-nc standard

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Abstract. Modern smart technology has the great impact of dealing with the information that meets the challenges of a new generation of industrial evolution. The main goal is to identify the nature of quality control errors that affect the final quality of the product and maintain the quality to gain better surface of final product. This paper review presents a closed-loop inspection model for implementation of an integrate CAD / CAPP / CAIP / CAM / CAI system based on STEP-NC standard. Hence, the application protocols (AP238 and AP219) are utilized to incorporate the manufacturing and inspection data. The data structure and the flow of the data that support the functional activities in the model created in IDEF0 EXPRESS language. The incorporating new functionalities associated with closed-loop inspection based on the analysis of inspection results generated by a Coordinate Measuring Machine (CMM). The review presented here highlight that STEP-NC standard with closed loop inspection shall be a good basis for future research work to incorporate and standardize material data, geometric and dynamic model, and inspection process planning.

1. Introduction

In the past two decades, the great impact of information technology on changing every aspect of our lives and culture has been evident. This impact has resulted from the tremendous diversity and rapid development of technologies and applications of technology, which has naturally been reflected in the methods of preserving and securing stored information, as well as efficient data processing methods and their delivery correctly and appropriately. Therefore, the technology of the future is a real challenge to the diligent efforts of specialists and researchers to address and keep pace with the continuous development of all the sciences related to it and how to interconnect between these sciences such as digital and multimedia and applications of artificial intelligence and integrated systems and systems of telecommunications and mobile systems and systems, cloud and intelligent web systems and many other systems which have become inherent to human life in all its fields. In the view of the Fourth Industrial Revolution (IR4.0), production processes require significant changes in data management and process the resulting information during the manufacturing process.

Programmable digital control is a mental activity and actual physical participation is between the design and documentation of the program that will be used to manufacture the part. While digital control programming that is accomplished by using a computer sometimes called computer-programming parts (CAPP Computer- Aided Part Programming) or computer aided manufacturing). The resource independent measurement specifications concept, which excludes the measurement programming tasks. In contrast, the importance of the overall measurement process integration within the digital manufacturing environment, which positively impacts manufacturing through potential cost-savings [1]. The investigate on incorporating the inspection process and manufacturing inspection to enhance the
quality of product model [2]. The development of in-line inspection of roundness error using machine vision for an automotive camshaft, to inspect the form tolerance based on image processing procedure [4]. The Quality assurance relies on continuous real-time quality feedback; hence the XML Web-based quality feedback system will help improve production [5]. Hence, the focus of this research is to build a model for defining the issues of quality controls, for provide mechanisms to generate changes in operating parameters and manage to maintain the final quality of the product. A closed-loop manufacturing aims to integrate the inspection results by [5-6].

In this context, the development of manufacturing system has been identifying the STEP standard (ISO 10303) enables the exchange of product data and attains a unified integration mechanism throughout the product life cycle. Subsequently, the various resources construct (RCs) and application protocols (APs) to cover the data exchange needs of various specific application domains [1]. ISO 14649 is a new model of data transfer between CAD/CAM systems and CNC machines, which replaces ISO 6983. In contrast, ISO 14649 provides a comprehensive model of the manufacturing process; it can also be used as the basis for a bi- and multi-directional data exchange between all other information technology systems [7]. This article presents a description of the model which proposed a solution that operates in closed-loop involving into STEP-NC standard to run the manufacturing design, planning, and inspections. In addition, the flow of information system that happens in the data loop and the functional activities which are essential for an adequate integration of the production process to gain the final quality of the product.

2. Background of studies for integration model of the CAD/CAPP/CAM/CAI

There is a lot of research worked in closed loop manufacturing knowledge on the bases of process integration. However, the most relevant issues to be resolved that concern finding the data model of quality control which meets the current demands for information exchange and the appropriate method inspection of integration into the whole CNC machine system. Table1 shows the presented summary of the literatures of the researcher in this area. Product information undergoes a series in each of CAD/CAPP/CAM/CNC systems caused by incompatibilities private sector. Thus, the change in parameters of the product made by any of CAD/CAPP/CAM/CNC systems might not be noticeable in the later process. However, the manufacturing chain may have a contrast between the product obtained and the anticipated product.

This architecture takes difficult corrective actions in manufacturing process chain, the computer-aided inspection planning and computer inspection manufacturing has adhered. The exchange of information is still no guarantee for these advanced systems to manufacture products to their required specification the first time and the development of a machine tool process control system which would be able to provide the corrective measures in-process [9]. Several independent efforts have been made to resolve the data exchange problem based on STEP standard to be able to evolve into different alternative. The most popular formats are IGES (Initial Graphics Exchange Specification), PDES (Product Data Exchange Specification), SET (Standard Exchange Transfer) and VDA FS (Verband der Automobilindustrie – Flächen Schnittstelle). Computer-aided design (CAD), computer-aided manufacturing (CAM) and computer-aided inspection (CAI) play a vital role and these should be integrated for high-quality production with minimum lead time [10]. Some of the important features of these formats were adopted in the STEP standard. The template presented in this article is to design and provide alternative solutions that facilitate evolution the quality of the product. The main issues that run for this research:

- Define the type of quality control that provides performance in the integration with optimizing the real time based on STEP-NC (ISO 14649) of close loop inspection data models.
- Integrates of CAD/CAPP/CAIP/CAM/CAI systems. The inspections methods of geometric errors, dynamic errors and statistical process control errors
- Identify the machine error prediction database that can be included in the inspection planning for monitoring the machining accuracy and actively controlling the machine errors.
Table 1. Summaries of Consulted Literature Related to Inspection.

| Authors                | Focusing                                                                 | Finding                                                                                                                                 |
|------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Ali, L et al. [8]      | Develop an inspection framework based on STEP-compliant for discrete components | The inspection framework provides significant potential to close this inspection loop through integration of information across the CAx process chain. |
| Kumar, Sanjeev et al. [2] | Identify higher level information for process control based on STEP-compliant framework. | Presented the integration of inspection process and manufacturing inspection to enhance the quality of product model by using self-learning algorithms in accomplishing process control. |
| Zhao, Fiona, et al [6]. | Integrate programming interface for on-machine inspection.(CAIP)            | The development of STEP-NC enabled closed-loop machine. That can be consolidated by the on-machine inspection (OMI) tasks which performed the resulting measurement data. |
| Mears, Laine, et al. [11]. | Integrate CMM to the machine tool                                          | Presents the used of coordinate measuring machines in conjunction with machine. Hence, the integration has been improved the measurement system with machine tools. |
| Lungarini, Silvia, et al. [5]. | Investigate data feedback to enhance the link between machining (CNC) and process planning (CAM/CAPP) | Integrate the measuring technology into the STEP-NC based process chain. Hence, Training and maintenance costs have been reduced, while an inspection planning and programming systems were used for different CMMs. |
| Michaloski, John L. et al. [4]. | Use of MT Connect to provide Web-enabled real-time communication of (QMResult) inspection data | Proposes an Integration of real-time inspections using a common QMResults format will help eliminate inconsistencies and errors and is critical to providing accurate, measurable and actionable quality data. |
| Ayub, Muhammad Azmi et al. [3] | Develop an in-line inspection of roundness error using machine vision.    | It Presents a Non-contact in-line inspection form tolerance based on image processing procedure and the development of mathematical models for roundness evaluation of the part. |
| Majstorovic, Vidosav et al. [12]. | Develop the feature based inspection planning on CMM based on STEP standard. | Present a development of the feature based modelling to the efficient integration of CAX technologies. Hence, the CAI is integrated in the STEP-NC based manufacturing chain in the observed SME. |
Figure 1. Framework of inspection of quality control errors based on closed-loop with connection of hybrid system.

Figure 1 above presents the general scheme of an importance of resources to create a system of closed-loop manufacturing process and inspection. The system is completely integrated with multi-functional of operating systems that adhering to connect the smartphone to CNC machine.

3. Implementation the methods of closed-loop based on step-nc standard

In the implementation of models, methods and protocols in the EXPRESS language which utilize to observe the data flow. However, the language EXPRESS (ISO 10303-11 1994) was designed for use in the information modeling, technology, allowing the data representation, constrains and procedures [6]. With integration model represented in this article that can be passed to the implementation functions associated with CAIP and CAI within the closed loop system. Hence, the model allows the issues to be solving the data structure that meets the requirements of industrial 4.0 with manufacturing assessments. The next phase consists of building the reference model (ARM) and implementing of each the activities functions.

The description of the quality control technique is influenced by three factors: ease of use of the technique; ability to measure product specification fulfillment; and ability to improve critical quality and productivity problem. The integration of measurement system with machine tools has been improved [14]. Whereas the advantage of more powerful processing capabilities, measurement technologies are become more efficiently and accurately [11]. The significance of self-learning algorithms in accomplishing process control is recognized. Hence, the integration of the inspection process and manufacturing inspection to enhance the quality of product model [2]. An integrated CAD/CAM/CAPP innovation and improvement of products’ rapid design, manufacturing ability, shorter producing cycle, that can be an essential to tool industry with the full use of advanced design and manufacturing measures [13]. By identifying the STEP- complaint, knowledge-based, generic algorithm, feature-based, neural network and internet-based methods have been used in the majority of CAPP works as compared to fuzzy set theory/logic, peter nets, and agent-based methods. However, the functional block method is still new as compared to other works and considered to be a new direction for CAPP with the STEP-compliant method [15].
3.1 The AAM and ARM models specification

The AAM model intends to characterize the functional activities based on closed loop inspection planning and inspection manufacturing. Hence, the Development of AAM Model creates the IDEF0 feature that provides tools to describe the data flow and the hierarchy of activities used in the model. The integration models of CAD/ CAPP /CAIP /CAM/CAI are presented in the figure 2 below.

**Figure 2.** The integration of CAD/ CAPP /CAIP /CAM/CAI with AAM model.

Figure 2 describe the sequence of CAIP/CAI systems within the closed-loop manufacturing which defined in functional activity. The main objectives of the proposed measured model are to study the nature of errors in geometric inspection and dynamic inspection of CNC machine that affect the performance of quality control which intends to gain the better surface quality of the product. The AAM was obtained utilizing the integrated resources of ISO14649 applied specifically in manufacturing and inspection depending on application protocols AP224 and AP238.

4. Discussion

The AAM models presented in this article has been developed to integrate a path to guide the computational implementation of each functional ages required to integrate the inspection results in a closed loop. The model illustrates the degree of complexity of these activities, and the solution approach development. The reference models (ARM) contains the settings information and integration methods which provided by protocols the AP219 and AP238 applications. The main contribution of this research to make issues of interoperability and create an integration alternative comply with current manufacturing requirements which gain the quality of the product. Regardless of the technology used model details are necessary to structure the data that allows the implementation of closed loop inspection based on STEP-NC standard.
5. Conclusions
In this review article discusses the methodology to implement geometric and dynamic model of prismatic part, the coordinate measuring machine (CMM) analysis the results with manufacturing closed-loop. However, the integration model and the exchange of data between CAD / CAPP / CAIP / CAI CAM systems were defined into manufacturing feature and inspection feature based on the relationship of AAM and ARM models. The feedback of the manufacturing process based on the closed-loop inspection with ISO 14649 standards. In contrast, the main contribution of this research is possibility of feedback the information obtained in the CAIP and CAI system, developing a closed-loop with the manufacturing process that enables the correction of errors occurred during the manufacture process which leading to better quality in the manufacturing part. Moreover, the inspection system is works to eliminate the barrier in interoperability which is important to conceive a STEP-NC that contains a standardized data structure for manufacturing process. Proper handling of perm will improve production, promote continuous improvement at all levels and save time on production issues. The design of architecture with information structure provides the means necessary for development of future methods of solutions.

6. References
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