Advanced Materials Research Vols. 383-390 (2012) pp 2827-2831
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doi: 10.4028/www.scientific.net/AMR.383-390.2827

Review of STEP-NC Compliant System for Turn-Mill Operations

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Keywords: CNC; STEP-NC; turn/mill

Abstract. Today with the latest technology the information beyond tool movement and switching instruction such as tooling, manufacturing features and process sequences are needed to support global adaptability for manufacturing with a specific focus on CNC-based manufacture This research focuses on the use of the new standard; ISO 14649 (STEP-NC), to address the process planning and machining of discrete turn/mill components and proposes a STEP Compliant NC structure for generation of ISO 14646 code which can be used for turned component manufacture. The novel application of this work is STEP-NC compliant process control where the research will utilise and extend the standard for in process measurement at the machine and also explore the application and integration of the STEP-NC standards. The major contribution of this research is the review of a computational environment for a STEPNC compliant system for turn/mill operations.

Introduction

STEP-NC is and extension of ISO 10303 or Standard for the Exchange of Product Model Data (STEP). STEP is a fully developed ISO standard that represents all the product data through its life cycle and facilitates the integration of CAD/CAPP/CAM due to its neutral and platform independent format. Today, approximately one million CAD software (released by leading CAD vendors such as Unigraphics, CATIA, ProE) stations have an STEP translator. STEP-NC was developed to define the data required for a Computer Numerical Control (CNC) machine to produce parts. Codes for CNC have been in conventional language based on ISO 6983 or RS274D (well known as G-code) for 50 years [7].

STEP Tools Inc. has estimated, based on their Super Model Project, that STEP-NC can reduced the machine planning process by up to 75 percent. This is due to a significant reduction in drawing information usually generated for producibility. Additionally, STEP-NC can increase the task of cutter path generation up to 35 percent faster because less information has to be defined since 3D feature recognition is used. And lastly, mid-sized machining jobs can actually be completed in 50 percent less time since STEP-NC provides automation computation for feeds and speeds compensation [4].

MILLING

A milling machine is a machine tool used to machine solid materials. Milling machines exist in two basic forms: horizontal and vertical, which terms refer to the orientation of the cutting tool spindle. Unlike a drill press, in which the work piece is held stationary and the drill is moved vertically to penetrate the material, milling also involves movement of the work piece against the rotating cutter, the latter of which is able to cut on its flanks as well as its tip. Work piece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC), Data model for milling can be referring to ISO 14649 Part 11 Process Data for Milling [1].

TURNING

Turning is the process whereby a single point cutting tool is parallel to the surface. It can be done manually, in a traditional form of lathe, which frequently requires continuous supervision by the operator, or by using a computer controlled and automated lathe which does not. This type of machine tool is referred to as having computer numerical control, better known as CNC, and is commonly used with many other types of machine tool besides the lathe. Data model for milling can be referring to ISO 14649 Part 12 Process Data for Turning. The turning processes are typically carried out on a lathe, considered to be the oldest machine tools, and can be of four different types such as straight turning, taper turning, profiling or external grooving. Those types of turning processes can produce various shapes of materials such as straight, conical, curved, or grooved work piece. In general, turning uses simple single-point cutting tools. Each group of work piece materials has an optimum set of tools angles which have been developed through the years [3].

TURN-MILL

A combination between data model for milling (ISO 14649 Part 11 Process Data for Milling) and data model for turning (ISO 14649 Part 12 Process Data for Turning). A number of turning and turn–mill machining oriented papers have been published as well: Rosso investigated the use of STEP-NC in manufacturing of asymmetric rotational components. It was the researchers' conclusion that the ISO14649 part 10 milling standard milling features are capable of supporting the features that these complex components require.The necessary data models were created and tested through a prototype system. This research has now been extended by Yusof with the development of an interoperable STEP-NC compliant data model and CAM system for representing and machining of turn–mill components [6].

STANDARD

Nowadays, two versions of STEP-NC are being developed by ISO. The first is the Application Reference Model (ARM) (i.e. ISO 14649) and the other Application Interpreted Model (AIM) of ISO 14649 (i.e. ISO 10303 AP-238. The fact that both STEP-NC ARM (ISO 14649) and AIM (AP-238) co-exist and have each been implemented by different groups, presents a less than satisfactory environment for users. It is of particular importance that one understands the difference between these two "versions" of STEP-NC prior to implementation. The main difference between these two models is the degree to which they use the STEP representation methods and technical architecture. Both versions can be viewed as different implementation methods of the STEP-NC standard [2].

The ISO 14649 standard is more likely to be used in an environment in which CAM systems have exact information from the shop-floor, whereas STEP AP-238, as a part of the STEP standard, is more suitable for a complete design and manufacturing integration. The ISO 14649 standard has few mechanisms to incorporate other types of STEP data, hence making bi-directional data flow between design and manufacturing more difficult. Unlike ISO 14649, STEP AP-238 encompasses all the information from STEP AP-203 and AP- 224 plus an interpreted model mapped from ISO 14649. Hence, bi-directional data exchange is enabled. A major problem with STEP AP-238 though, is that the STEP Integrated Resources used in AP-238 are not adapted to application areas; hence the data in its files are fragmented and distributed. It only provides an information view of the data, whereas the ARM provides a functional view of the data (Xun Xu, 2006)

ARM ISO 14649

ISO14649 informally known as STEP-NC has been proposed as a high-level hierarchical manufacturing information model as a replacement for the low-level machining instructions of ISO6983 and RS274D. In the new standard, tool paths and switching commands have been replaced by a hierarchical information model that contains the feature-based geometry model of the part as well working steps required to manufacture the product. The Application Reference Model (ARM)

for STEP-NC has been formalized in ISO14649. The information entities defined within the framework of ISO14649 are capable of supporting manufacturing information and can be tailored for utilization in the adaptive manufacturing system [3].

AIM ISO 10303 AP-238

ISO 10303 is an ISO standard for the computer-interpretable representation and exchange of product manufacturing information. Its official title is "Industrial automation systems and integration - Product data representation and exchange", known as "STEP" or "Standard for the Exchange of Product model data". STEP-XML is a short term for ISO 10303-28, Industrial automation systems and integration, product data representation and exchange - Part 28: Implementation methods: XML representations of EXPRESS schema and data STEP-XML specifies the use of the Extensible Markup Language (XML) to represent EXPRESS schema (ISO 10303-11) and the data that is governed by those EXPRESS schemas. It is an alternative method to STEP-File for the exchange of data according to ISO 10303 [7].

Data storage

ISO10303-28 specifies the extensible markup language (XML) representation for EXPRESS-driven data and is officially known as STEP-XML. Similar to ISO10303-21, this implementation method specifies the representation of a valid population of STEP entities. Instead of encoding the instances in a text file, however, in part 28 the information is captured using XML. Recently, there has been a trend of using XML (or rather ISO 10303 Part 28) instead of EXPRESS language (or ISO 10303 Part 21) to represent the STEP-NC information. The reason for this is obvious, the XML processing ability can easily support the e-Manufacturing scenario. CNC machine tools can share information with other departments in and outside the company over the Internet/Intranet [1].

BACKGROUND OF RESEARCH

The changing economic climate has made global manufacturing a growing reality over the last decade, forcing companies from east and west and all over the world to collaborate beyond geographic boundaries in the design, manufacture and assemble of products. The ISO10303 and ISO14649 Standards (STEP and STEP-NC) have been developed to introduce interoperability into manufacturing enterprises so as to meet the challenge of responding to production on demand. Due to the complexity of programming there is a need to model their process capability to improve the interoperable manufacturing capability of machines such as turn/mill centres. The current ISO 6983 or current CNC regime is considered to rely on low level codes such as the description of tool movements and switching instructions.

Today with the latest technology the information beyond tool movement and switching instruction such as tooling, manufacturing features and process sequences are needed to support global adaptability for manufacturing with a specific focus on CNC-based manufacture. STEP-NC is considered to have the necessary rich information including "what to make" and "how to make". Nowadays, a new standard namely ISO 14649 known as STEP-NC is being developed by vendors, users and academic institutes world wide to provide a data model for a new intelligent CNCs. The data model represents a common standard specifically aimed at NC programming, making the goal of a standardized CNC controller and NC code generation facility a reality [2].

CRITICAL REVIEW

The review on the 31 papers about STEP-NC during a year 2000 to 2010 has been analyzed to understand the current development of this new technology all over the world. The result has been divided into 3 major items which is technology (milling, turning and turn-mill), standard (ARM ISO 14649 and AIM ISO 10303 AP-238) and data storage (STEP part 28-XML and STEP part 21-text).

In terms of the technology, from the reviewed show that around 87% cover about milling process, and in the year 2006 become the highest number of paper has been published about milling process which is from the total of 27 papers about milling. For the turning process, year 6 papers 2006 and 2008 represent with the highest number of papers which is 2 papers from the total of 6, and overall is 19%. While the turn-mill process, overall percentage only cover with 3% which is the lowest technology has been discussed through the past years.

Currently two versions of STEP-NC are being developed by ISO. The first is the Application Reference Model (ARM) (i.e. ISO 14649) and the other is Application Interpreted Model (AIM) of ISO 14649 (i.e. ISO 10303 AP-238) [8]. ARM ISO 14649 become the important standard referenced for the other authors through the reviewed with 54%, which is 17 out of 31 papers refer to this standard, while AIM ISO 10303 AP-238 show only 6 out of 31 papers which is 19%.

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Recently, there has been a trend of using XML (or rather ISO 10303 Part 28) instead of EXPRESS language (or ISO 10303 Part 21) to represent the STEP-NC information. The reason for this is obvious. The XML processing ability can easily support the e-Manufacturing scenario. CNC machine tools can share information with other departments in and outside the company over the Internet/Intranet [2]. However the result from the reviewed on the data storage, show that only 9% papers is using XML format, and for the text file format still become the important data storage which is covered by 38%.

STEP-NC Europe is responsible for milling, turning and inspection of the ISO 14649 standard. It has 15 partners, led by Siemens, with users such as Daimler Chrysler, Volvo, and the support of research institutes such as WZL RWTH-Aachen and ISW Stuttgart University. The Swiss are leading the development of the standard for wire-cut and die-sink EDM in collaboration with vendors such as Agie, Starrag and CAM manufacturer CADCAMation. The work in Korea has been carried out by both Pohang University of Science & Technology (PosTECH) and the Seoul National University in the areas of milling and turning architectures for ISO 14649 compliant controllers [5].

Other research teams working in the area include those in the UK and New Zealand. In the United Kingdom, an Agent-Based, STEP-compliant CAM (AB-CAM) system has been developed in Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University. In New Zealand, the Manufacturing Systems Laboratory at the University of Auckland has been using the AIM of STEP-NC to develop a STEP compliant CAPP system for collaborative manufacturing. The STEP-NC programmed in the USA called SuperModel led by STEP Tools Inc. and sponsored by National Institute of Standards and Technology (NIST) has made major advances to fully automate the CAD to CNC manufacturing process through the use of STEP or rather AP-238. This project involved a strong group of industrial partners including Boeing, Lockhead Martin, General Electric and General Motors, together with recognised CAM vendors such as Gibbs Associates and MasterCAM [8].

Conclusion

This review reports on publications concerning STEP-NC complaint system for turn-mill operation applications in manufacturing and business over the 10-year period 2000–2010. Although this review has not covered the whole population of relevant publications, we believe it is distinguished from previous attempts from three perspectives: wider coverage of the literature sources, broader scope of the simulation techniques, and a focus on real-world applications.

STEP-NC is the backbone of the nowadays scenario for CAD/NC process chains. Since it allows direct use of CAD data and will form the direct input format for the NC, no conversion operations are necessary. All components of the process chain are working on the same data format enabling a closed-loop process chain. The first workings on STEP-NC covered milling and drilling technology. Milling and drilling applications and machining tests already showed major benefits of STEP-NC

compared to the existing ISO 6983 standard. The development of the turning data model and applications forms the next step on STEP-NC way to a comprehensive standard data interface for manufacturing.

The author believe that the turn-mill technology will become the valuable for the future of the CNC technology, the early step taken to understand and explore this technology especially focus on the ISO 10303 part 11 and part 12, is very essentials for the Malaysia manufacturing industry. The author also suggested to making collaboration between universities and manufacturing industries in order to give benefit to our country development. Furthermore, studies of STEP-NC compliant system success and failure stories would help researchers and practitioners to conduct more efficient and successful works both in developing new techniques and applying the present techniques in new domains.

Acknowledgment

The authors would like to acknowledge the Ministry of Science, Technology & Innovation (MOSTI), Malaysia under Science fund grant (S010). Much appreciation to University Tun Hussein Onn Malaysia (UTHM) and thanks to all team members for every support provided.

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