Journal of Applied Sciences

ISSN 1812-5654

science alert

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Journal of Applied Sciences 11 (7): 1171-1177, 2011
ISSN 1812-5654 / DOI: 10.3923/jas.2011.1171.1177

Design of STEP-compliant System for Turn-mill Operations using XML

[1]M. Gizaw, [1]Ahmad Majdi B A Rani and [2]Y. Yusof
[1]Department of Mechanical Engineering, Universiti Teknologi PETRONAS,
Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia
[2]Department of Mechanical Engineering, Universiti Tun Hussein Onn Malaysia,
Parit Raja, 86400, Batu Pahat, Johor, Malysia

Abstract: This study covers development contents and framework of STEP-compliant researches regarding recent advancement towards intelligent manufacturing system. ISO14649 different enumerations are means of developing a data models for CAD/CAM and CNC chain implementation on specific technology. The research trend was towards replacement of ISO6893 and enhancement of STEP (ISO1303) to incorporate CNC machine tool capability advancements. Mainly STEP-Interoperable manufacturing is to represent a common standard specifically aimed at intelligent manufacturing workstations. In this research, the system development intended to turn-mill operations, primarily in developing a data model (data structure of STEP-NC file), accompanied by a generic architecture and functionality. EXPRESS defined classes of AP224 domain are converted to an object oriented classes. They are serialized and de-serialized to and from a Part-28 file format implementation. The result is delivered limited to a generic STEP-NC data model based on manufacturing features sets of AP224.

Key words: AP224, CAPP, STEP-NC

INTRODUCTION

Recent changes of manufacturing environment orientation from mass manufacturing transfer lines to flexible manufacturing systems (FMS) and flexible manufacturing cells (FMC) relies on CNC (Computer numerical control) machine tools reconfiguration, adaptability and part programming efficiency. However; these requirements are not achieved with 60 years old operation commands of ISO6983 G and M programming. Several ongoing researches are being made on the development of new standard based on STEP known as ISO14649 (STEP-NC) to avoid the above limitations.

The new standard enables contemporary manufacturing environment to utilize new paradigm of e-manufacturing, in which the so-called DABA (Design-Anywhere-Build-Anywhere) system can be realized via the collaborated scheme of a distributed manufacturing system (Normile *et al*., 2000). It includes all information produced by the entire production process as well as operation commands of the machines.

Many researches on the software and hardware implementation of STEP concept as a data interface between CAD/CAM and CNC (Newman *et al*., 2008) has been in progress since the late 1990. A proposal of new data interface framework for milling process was suggested by OPTIMAL (ESPRIT, 1997). A subsequent effort by international community supported by ISO evolves maj or change in the concept of NC programming in extending STEP-based interface scheme to 2.5 D milling and other operations such as turning (Suh *et al*., 2006) and EDM (Newman *et al*., 2008).

Suh and Cheon (2002) proposed conceptual framework for designing and implementing an intelligent CNC system and establishment of an outlook on STEP-NC compliant manufacturing was suggested by Hardwick (2002) elaborates research development in manufacturing technology. Lee and Bang (2003) have successfully developed and built a five axis milling machine that run by STEP-NC in XML (Lee and Bang, 2003; Yusof, 2009) which utilized longevity of business data transfer in manufacturing, it has been represented using a language defined by an open standard and not exclusively dependent on a particular software vendor especially STEP, XML and Modeling Language™ UML (Mem *et al*., 2004). Newman *et al*. (2002) proposed a prototype system for STEP-compliant CAD/CAM system based on one of these frameworks using the new ISO14649 standard for milling components.

Heusinger *et al*. (2006) investigated on amalgamating turning and milling machining operation

Corresponding Author: M. Gizaw, Department of Mechanical Engineering, Universiti Teknologi PETRONAS
Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia

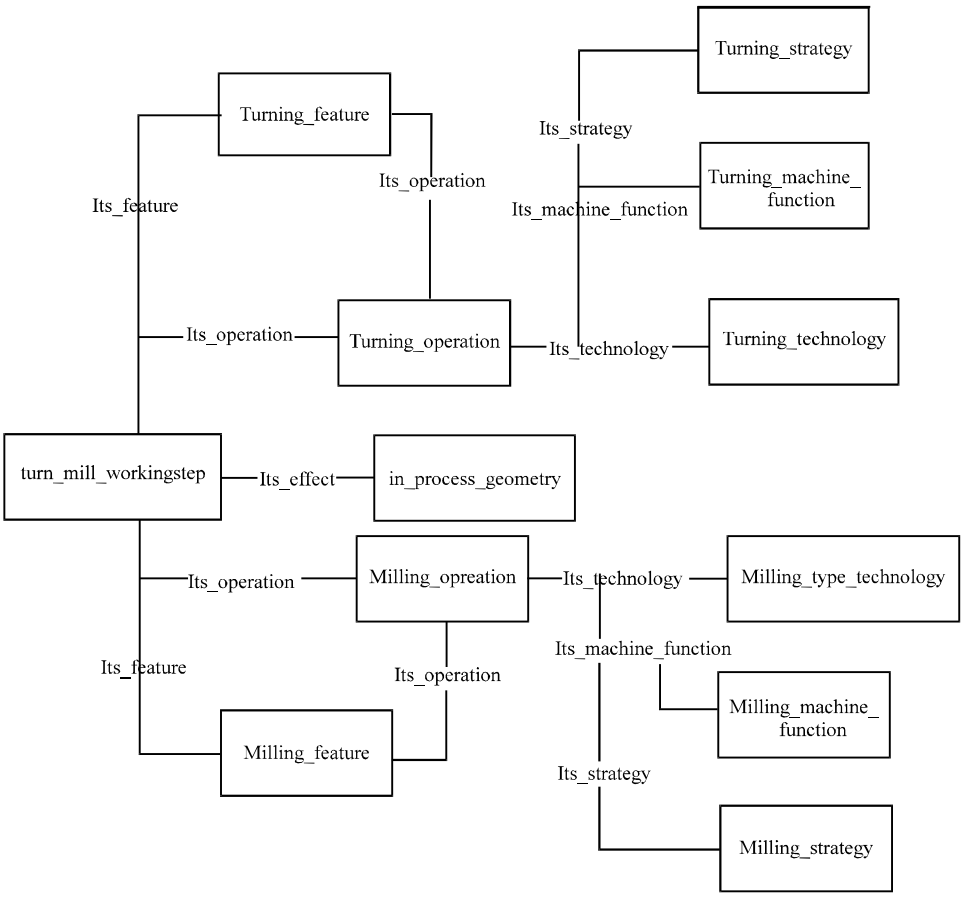

Fig. 1: Turn-mill operation based on STEP-NC adopted from ISO

and on STEP-compliant system development for turning operation (Yusof, 2007) suggested to broaden STEP-NC implementation research to turn-mill manufacturing environment.

Kumar introduced a STEP-compliant framework that makes use of self-learning algorithms that enable the manufacturing system to learn from previous data and results in error elimination and consistent quality products. It has been tested and certified for pocket and hole features for milling (Kumar *et al*., 2007). The latest achievement in 2007 is the successful development of a system called ST-FeatCAPP for prismatic parts based on ISO 14649 by Amaitik (2005) and recommends the research to extend for cylindrical parts selected as a primary target by this research. The system maps a STEP AP224 XML data file, without using a complex feature recognition process and produces the corresponding machining operations to generate the process plan and corresponding STEP-NC in XML format.

The primary task in a STEP-compliant environment system development is to outline the design and framework of STEP-NC implementation for the selected technology in this case turn-mill machining. The design of the system uses ISO 14649 Part1 (ISO 14649-1, 2002), Part 10 (ISO 14649-10, 2004), Part 11 (ISO 14649-11, 2003), Part12 (ISO 14649-12, 2003), Part 111 (ISO 14649-111, 2004) and Part 121 (ISO 14649-121, 2003). These ISO documents specify the process data needed for NC programming within all turning and milling machining technologies as a domain. The model composed of STEP-AP, i.e., application protocols in STEP describes information model of a particular engineering or technical domain.

Contrary to former researches, which use ISO14649 descriptions separately, this research basically intends to adopt the information in amalgamation for turn-mill machining operations. It provides technological shift in a workplan and an interface that can avail turn-mill machining environment as a bases for intelligent manufacturing unit.

Development and major activities: The system aims to generate ISO1469 code of feature-based process plans for turning and milling operations on the basis of

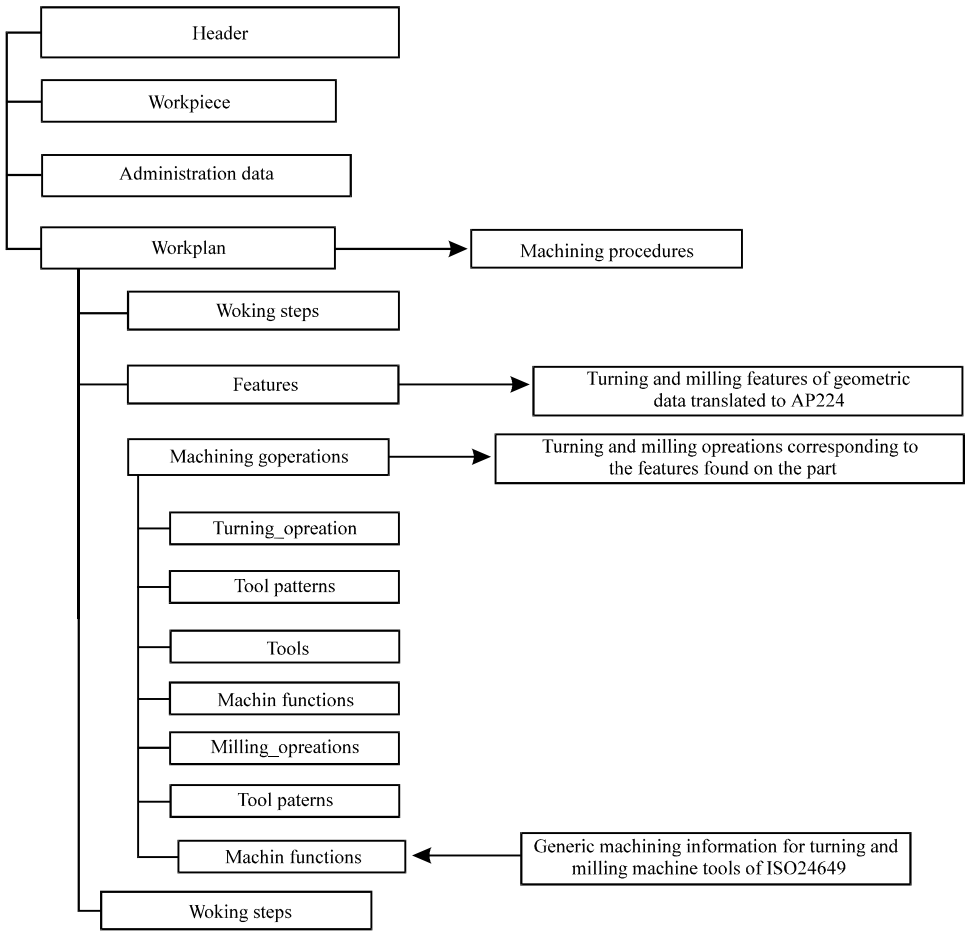

Fig. 2: STEP-NC, ISO 12649-11 and 12 XML structure

STEP-compliant environment. It consists of STEP-AP 224 elements that define turning, milling and drilling or all Tow 5D-manufacturing-features. This system implements feature-based design approach and begins with selection of workpiece followed by choice of Tow 5D manufacturing-feature, machining-operation, machining-strategy and finally the choice of the tools. The output of the system is a physical file complying with ISO Part 28 file.

The research is to address the process planning and machining of turn-mill components and to propose a STEP complainant NC structure for generation of ISO14649 code which can be used for turn-mill manufacturing having interoperability as a main significant issue.

The data model for manufacturing of turn-mill manufacturing is based on ISO14649 standard. In turn-mill operation a workplan consists of a series of machining_workingsteps of type turning and milling, to carry out turn-mill operations on a two 5D_manufacturing features. The turn-mill operation is supplemented by turning and milling technology. It is also supported by machining function and strategy as shown in Fig. 1.

The system is developed on Visual Basic dot NET and SQL server database. It generates STEP-NC entities that defines or translate workpiece and workplan data in to an XML file form of Part-28 having a skeleton as Fig. 2.

The system has major activities:

- Translating turning features shown on Fig. 3 and milling features
- Turning and milling feature library in Visual Basic dot NET class defined on the bases of ISO14649
- Specifications of base shape, i.e., shape and dimension of the initial part shown on Fig. 4
- ISO 14640 process plan generation Fig. 5 shows a machining strategy portion of it
- Machining operation planning
- Tool database

Fig. 3: Manufacturing features and turning features (Suh and Cheon, 2002)

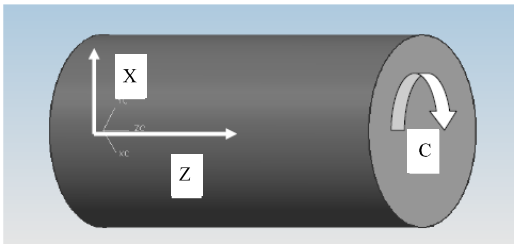

Fig. 4: Cylindrical base part

Implementation of the system: EXPRESS is a modeling language based on relationships between entities and attributes to describe the contents of STEP-NC (e.g., task, geometry, technology and tool descriptions). The relationships of the entity set and entities converted in to object-oriented visual basic dot Net class.

The algorithm is aimed at on the basis of developing STEP-NC process plan data structure shown on Fig. 2, STEP-NC data structure.

The architect or flowchart of implementation shown on Fig. 6 used to develop the system starting on user defined information for different phases.

In comparison to the required data model of STEP-NC process data file, the system initially started on summiting part and Administration data with work piece definition incorporating turning and milling manufacturing features parameter with corresponding machining strategy shown on Fig. 5.

```
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- <Darlling_type_strategy>
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<reduced_feed_at_start>5</reduced_feed_at_start>
<depth_of_start>25</depth_of_start>
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</its_maching_strategy>
- <its_tools>
- <its_tool_body>
- <dimension>
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</dimension>
</its_tool_body>
</its_tools>
</its_operation>
</machining_workingstep>
</Main_workplan>
```

Fig. 5: Part-28XML file for tool data schema

A business-object or business-logic considering different level process planning phases represented as defined in ISO14649. It is used to develop generic process planning for the system. These programming logics are accompanied by STEP-NC interfaces which present the business object and allow the user to interact with the system or manufacturing information as object-oriented

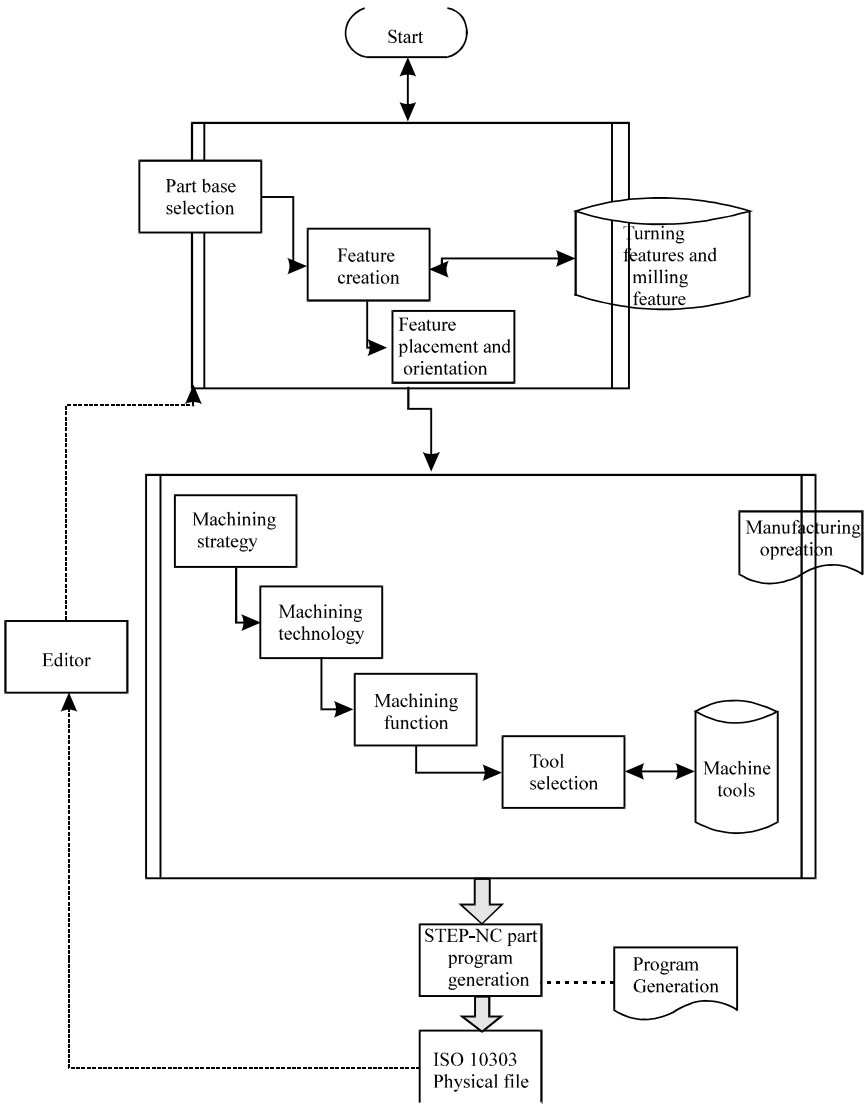

Fig. 6: Architecture of STEP-NC process data file

data. The STEP-NC interface presentation relies on the bases of design, manufacturing and shop floor constraint and information requirements.

In this system, EXPREES data model of AP-224 is converted to visual basic dot net classes. These classes are serialized (i.e., the process of converting an object into a linear sequence of bytes called a "byte stream.") (Reynolds *et al*., 2003; Mem *et al*., 2004) to develop Part-28 file format. The system also can de-serialize a similar file format to an instant object data of the above classes which can help the user to edit the process plan at any phase.

System.xml.Serialzation.xmlSerializer class to save entire objects to disk (serialization) is the methodology used in the system. The same object was used to load from disk (de-serialization). It uses concept of XML (Extensible Markup Language) for software integration.

The data model developed in accordance to the structure given on Fig. 2, on a Part-28 or an XML file format implementation. The system uses Round hole feature as a representative machining feature the data file as shown on Fig. 7. This system provides us entirely object-oriented encapsulation of ISO-14649 information, allowing the user application efficiently to manipulate

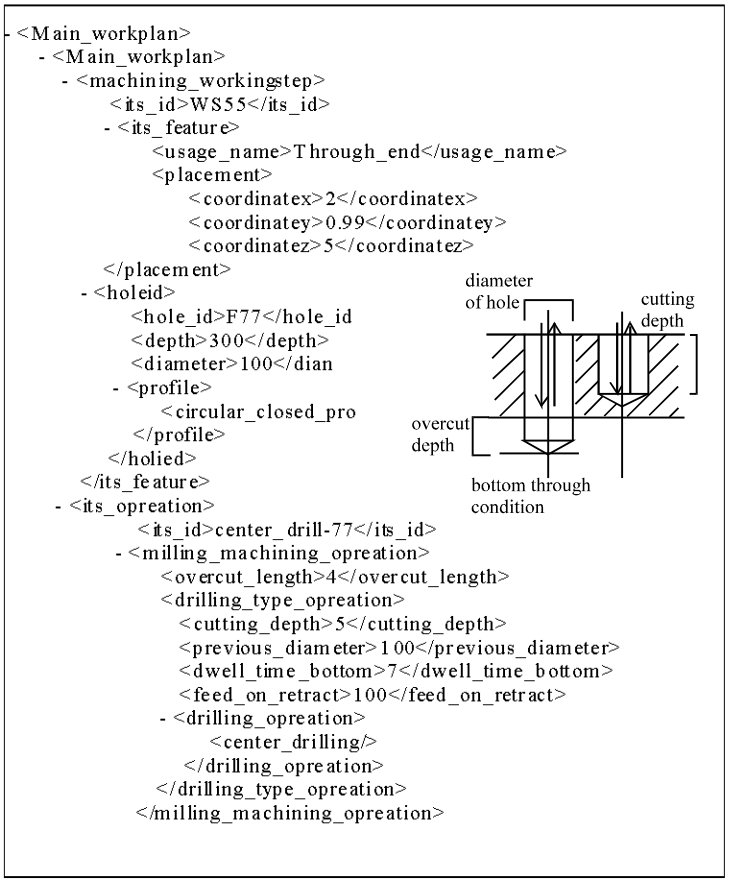

Fig. 7: Part-28XML file for main workplan data schema

extensibility and flexibility over former Part-21 file format implementation. This XML file flexibility enables the system to incorporate a workplan for the various configurations and technology shift (turning to milling) at a time.

The system established on a generic process plan perspective so that it can be mapped to a native process plan related to specific resource. That enables the system to incorporate different configurations and capacity of turn-mill machines on the basis of the software integration.

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