STEP-NC - Hindrances and Challenges

Saima Sayeed, Salman Naqi

Abstract: In today's highly competitive designing and manufacturing industry the most important issue is to increase the profitability by increasing production. According to ISO 10303 standard STEP-NC or AP238 protocol is a new programming method which is developing as an alternative to G code for CNC Machine tools. The urge for improving quality and reliability has resulted in developing STEP-NC. This paper illustrates the methodology and working of STEP-NC and portrays the difference between the G-Code programming and new CNC programming method using STEP-NC. The obstacles in implementing the STEP-NC and future prospects are also mentioned.

Key words: CNC, CAD/CAM, G-code, ISO 6983, STEP-NC, ISO 14649

1. INTRODUCTION

:Manufacturing hascome a long way for competing the international market and meeting the insistent requirements of anextremelyfree trade area. And this fight has permitted new and competent methods for increasingefficiency and improving quality and authenticity. In last 60 years, the progression of NC machines has been done to modern multi-axis CNC machines. An international standard ISO 6983, the G code which is alsocalled the RS274D) is the basic programming language [2]. The G code which is also called the RS274D is not relevant for high level machining and complex geometries because it provides simple machine tool paths only. It does not give any information about the geometry of the machined part and the feed-back data from the shop floor to design department is not that possible that makes ISO 6983 incompetent. Figure 1. (a)Shows the currently used G codeprogramming basedmanufacturing data flow. G-code only elaborates ''HOW''to make [2]. G code programming language (ISO 6983) has few advantages but many disadvantages.

Advantages are as follows [3]:

i. Easy to learn and very simple language.
ii. It is widespread all over the world.

Disadvantages are as follows [4]

i. Lengthy programs for even simple shaped objects.
ii. It does not provide any information about the material, stock etc.
iii. Sending information back to the CAD/CAM software from the shop floor is almost impossible.
iv. Program of one CNC machine cannot be run on another CNC machine, e.g. programming codes of Fanuc is different from that of a Siemens.
v. The CAD data cannot be used directly on the machine as it requires a machine-specific post-processor and therefore simulation and authentication is difficult.
vi. ISO 6983 cannot support the spline data and thereforeis unable to control five or more axis milling.
vii. The control on program execution is limited because the program cannot be changed on the shop floor.
viii. The prime target of the language should be on the machining tasks with respect to the part instead of part programming only.

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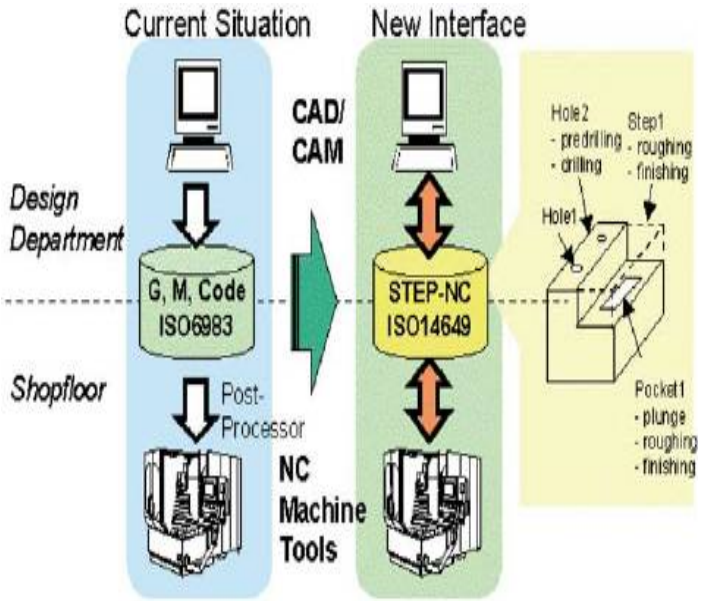

Figure1.(a) Current G/M code Programming CNC programming method using STEP-NC **Figure1. (b)New**

Figure1. (b)Illustratesthe CNC programming utilizing ISO 14649 (STEP-NC). It elaborates ''WHAT'' to make. STEP-NC is the application protocol of the STEP ("Standard for the Exchange of Product model data") ISO 10303 standard. In last few decades comprehensive work has been done all over the world for the advancement of ISO 10303 STEP – "Standard for the Exchange of Product model data" for standardizing and defining the product life cycle and as an apparatus for exchanging data between different machine systems, CADCAM systems and industries. All 2D geometric features such as holes, pockets, grooves etc and even 3Dgeometry are supported by STEP-NC. This standard allows modification and alteration of working plans by the controller so that it can be used anywhere all over the world on any CNC machine. The data can be easily spread among different manufacturing sites and thus increasing the profit [1].

Advantages of this new CNC programming are as follows:

i. It supports interchangeability i.e. the geometrical and technological data can be interchanged among CAD, CAM and CNC machine.
ii. It enables bi-directional data flow i.e. amendment at the shop-floor can be sent back to the CAD/CAM department
iii. It provides high level information. The CAD information such as tolerances to be considered, size and types of tool, etc are utilized directly on the CNC machine.
iv. The postprocessors will be eliminated i.e. the same program can be run on any type of controlor any type machine [5].
v. It is more adaptable as it is independent from the machine tool vendor i.e. the companies can use their current CAD, CAPP and CAM software.
vi. The fixtures position could be defined in advance as a part of setup and therefore the total safety checking is feasible.
vii. Large reduction in paper documents.
viii. A single file is required for storing of all the data needed for producing a machine part.
ix. The information could be transferred utilizingXML files and thus enabling e- manufacturing.

The aim of this paper is to clarify the capability of ISO 14649 in a global manufacturing industry and to counterbalance and upgrade the shortcomings of the still predominating ISO 6983.The challenges and difficulties faced by the manufactures and industrialist in adapting this new programming skills are also reviewed.

2. STEP-NC PROTOCOL - OUTLINE

STEP-NC has been developing all over the world by various industries, academic institutes and research projects.The first publications for ISO 14649 are: (i) ISO 14649-1:2003 Overview and fundamental principles; (ii) ISO 14649-10:2003 General process data, (iii) ISO 14649-11:2003 Process data for milling. IMS (Intelligent Manufacturing System) project is the main coordinator for all global research going on in the areas of STEP-NC.USA, EU, Korea and Switzerland are the partners in this project. They covered the manufacturers, the users and academic institutions. STEP Tools (USA), Siemens (EU), CADCAMation (Switzerland), and ERC-ACI (Korea) are the regional coordinators. ISO TC 184/SC1 and ISO TC 184/SC4 are two ISO subcommittees that are working on the STEP-NC standard. ISO TC 184/SC1 is working on the ISO 14649 (ARM model) whereas ISO TC 184/SC4 is working on theSTEP AP-238 (AIM model). ISO 14649 and ISO 10303-238 can be observed as two different implementation methods of the STEP-NC standard. The ISO 14649 standard can be utilized when CAM systems have exact information from the shop floor whereas STEP AP-238 is applicable for a complete integration of design and manufacturing. The storage area required in ISO 14649 (ARM model) is nearly 10 times less than ISO 10303 -238 (AIM) model. The programming used in AIM is more complex than ARM model. ARM Model is partly alterable and the AIM model is fully alterable. The original design information in case of ISO 14649 is discarded whereas it is preserved in AIM Model. The human readability is difficult in ISO 14649 whereas it is almost impossible in case of AIM model.

STEP NC Data configuration

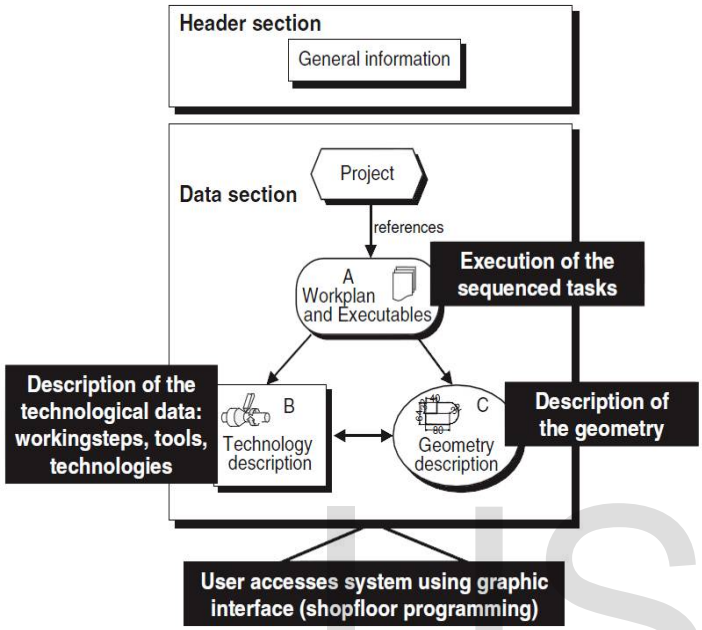

Figure (2). STEP NC Data configuration

The formal language used by STEP and STEP-NC is the EXPRESS language (10303-11: 1994). It assures uniformity, authenticity and permits smooth data exchange between CAD, CAPP and CAM. The conventional internal structure of STEP-NC data is shown in figure (2).The top most section of the program file is named as "HEADER". This section contains the general comments and information about the part program such as organization, author, filename and date. The second section of the program file is marked by the keyword "DATA". It is the main section and known as the data section containing all information regarding part geometries and manufacturing tasks. The content of the data sectionis further divided into following three major parts:

I. **Executables and Workplan**:According to the mainWorkplan succession tasks are executed. All information about the work-piece to be machined is included in it. The commands for manufacturing sequences are contained in the Executables. The three types of executables are working-step, program structure and NC function.

II. **Technological description**:It includes elaborative description of technological data,different tools required, working steps to be performed and other technologies involved for a particular job such as cutting width, spindle speed, feed, finish allowance etc.. STEP-NC provides tooling information such as types of tools needed for a particular job, expected tool life and tool geometry.

III. **Geometry Description:**It includes information regarding shape size, relative position etc. In STEP-NC, ISO 10303 parts 21, 42/43, 511, 514 are fordescribing all details required for a particular workpiece. It also illustrates the set-ups and manufacturing features. The CNC machine directly uses this data which results in improving accuracy.

Thus, rich information is provided to CNC machines for manufacturing of part. The information such as tool operation and Working steps to axis motion are also translated by the CNC machine tools.

3 Hindrances in Execution of STEP-NC

The target of any company is to assure profitability but the execution of STEP-NC is not developed adequately enough to ensure it. It is not easy to replace an existing profitable system without evaluating the benefits provided by the changes of a new STEP-NC system that no doubt could boost up the machining process. The benefits provided by the STEP-NC covers from the design stage up to the inspection of the final product i.e. the whole life cycle of a product. And when the product is discarded then in the same manner the disassembling can be managed. An extra capital investment is required for altering and upgrading the present NC machining equipments for STEP-NC [1].

There are many risks involved with STEP-NC such as the design data and other information can be shared among different companies. So advanced security methods are to be employed for sharing files between the different department viz. design, manufacturing, clients, consultants etc [2]. Some STEP-NC standards and protocols do not provide consistent and complete information.

4. CHALLENGES FOR STEP-NC

STEP-NC is emanating and getting more and more attentiveness from researchers but still there are somechallenges that needs to be overcome for its implementation all over the world

- The STEP-NC controllers are much more complicated and needs more knowledgeable machine operators because of the shifting of certain capabilities of CAM systems to CNC controllers on adopting STEPNC.

- The redesign of strategies and structures of new STEP-NC compliant controllers for CNC machines needs to be developed so that STEP-NC can be practically utilized for manufacturing.
- There is a need for development and standardization of databases for other STEP-NC supported processes also such as milling, turning, EDM etc.
- For enablinge-manufacturing, security issues have to be sufficiently addressed while transmitting STEP-NC through LAN or internet.
- The ISO 6983 has been deeply rooted in our minds so resistance can be expected from the manufacturing industry.

4. CONCLUSION

This paper mainly presents the merits and demerits of current NC programming, which is based on ISO 6983, called G-code. In spite of the fact that G/M codes are well accepted world-wide, they are now becoming a bottleneck for the manufacturing industry. It mainly specifies the cutter motion in terms of position and feed rates. Any last minute changes in programming or correction at the shop floor is almost impossible. Porting of programs between different vendor's machines is not possible as part programmes cannot be interchanged among different controllers. The verification and simulation is very tough as the CAD data needs to be processed by a machine specific post-processor. That means CAD data cannot be used directly on the machine.

On the other hand, the STEP-NC grants the detailed description that includes not only the information about the part program but also about the manufacturing process such as stock available, cutting parameters, complete information about the tool required for a particular job. It can easily translate the working steps into tool operation and axis motion. The STEP-NC is a complete library of specific machining operation that can be performed at any CNC machines. Part information between the CAD/CAM and shop floor can be exchanged smoothly and seamlessly through STEP-NC and thus providing the facility of program porting among different vendor's machine. It helps in maintaining reliability and repeatability of standard and quality because of providing the object oriented manufacturing methods by targeting the different machine operations performed on the part instead of focusing the machine tool axis movement. [6]. Some disadvantages associated with STEP-NC such as the need of advanced security methods for transferring information through LAN or internet and the requirement of highly skilled machine operators. In a very short period of time it will become the main standard for NC machining.

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