

## Standardisation of the Manufacturing Process : the IMS STEP-NC project

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### Abstract

*This paper provides an overview of a proposed new international standard for numerically controlled machine tools, ISO 14649, also known as STEP-NC. ISO 14649 would replace the current standard, ISO 6983. The paper outlines problems with ISO 6983 and benefits of ISO 14649. The projects through which STEP-NC has been developed are presented. Prototype results are described.*

### The Current Standard for NC Programming : ISO 6983

Conventional programming of Numerically Controlled (NC) machine tools is normally based on ISO 6983. This standard dates back to the time of punched cards and doesn't meet the requirements of modern NC technology. ISO 6983 uses low-level codes to describe tool movements (such as G01) and switching instructions (such as M5). ISO 6983 doesn't support complex geometries such as spline interpolation. Programming with ISO 6983 results in large programs which are difficult to handle. Last-minute changes and corrections to complex programs are difficult to manage on the shop-floor, and control of program execution at the machine is very limited. The CAD description isn't used directly on the machine, but has to go through a machine-specific post-processor (of which there are estimated to be about 5,000 in existence). Due to many different dialects and vendor-specific additions to the language, part programs aren't interchangeable between different controls and machines. ISO 6983 doesn't support needs in the areas of five axis milling and high-speed machining. The standard assumes information flow is from CAD to the shop floor, and doesn't enable feedback of experience from the shop-floor to the designer.

### The STEP-NC standard : ISO 14649

STEP-NC is a STEP-compliant data interface for Numerical Control that aims to overcome the problems of ISO 6983 and take advantage of advances in computing and controllers. The STEP-NC interface, which is based on an object-oriented data model, has been developed in several recent research projects in which many industrial companies and universities have participated. STEP-NC has been developed for the exchange of information between CAD/CAM systems and NC controls. Its object-oriented design and the use of data elements of the STEP standard (ISO 10303) support comprehensive bi-directional data exchange using common databases. Furthermore it facilitates the extension of modern NC functionality and simplifies NC programming and modification through its feature-oriented construction, the separation of operation and geometry, and the logical means for working step sequencing. The new STEP-compliant programming interface is based on an object-oriented data model to ensure that information remains in its context and is not reduced to primitive instructions such as G-Codes. The new data model is currently under final deliberation as a Draft International Standard (DIS) called ISO 14649 by ISO TC184/SC1.

## **ISO TC184/SC1**

ISO, the source of ISO 9000 and more than 13,000 International Standards for business, government and society, is a network of national standards institutes from 140 countries working in partnership with international organisations, governments, industry, business and consumer representatives. Work is carried out by Technical Committees (TC). TC 184 is the technical committee for “Industrial automation systems and integration”. Its scope is “Standardisation in the field of industrial automation and integration concerning discrete part manufacturing and encompassing the application of multiple technologies, i.e. information systems, machines and equipment, and telecommunications.”

## **Characteristics of STEP-NC**

One of the main characteristics of STEP-NC is its higher level of information. While a part program written according to ISO 6983 describes simple tool movements and switching instructions (G and M codes), the STEP-NC interface works at the level of manufacturing features (such as pockets and profiles), operations (such as drilling and roughing) and the sequence of work-steps. Through this sequence of manufacturing operations on features, all activities necessary to produce the finished part from the raw piece can be described. The new interface is fully compliant with the STEP standard for product data representation and exchange (ISO 10303).

## **Benefits of STEP-NC**

Since the STEP-NC data model describes manufacturing features and operations, the part program provides a higher quality of information to the shop-floor. As a result, modifications at the shop floor can be saved and fed back to the design and process planning departments, thus improving the communication of experience, and ensuring changes will not be lost when the part program is used again. As the geometry of the raw and finished parts is described using STEP, direct exchange of information between CAD/CAM and NC is possible.

Since the data model enables the description of manufacturing operations linked to the original CAD geometry data, the resulting part program can bring a much higher quality of information to the shop floor. By providing a complete and structured data model, no information is lost between the different stages of the process. Post-processors for machine-specific adaptations of NC programs are no longer needed. The rich information content results in higher flexibility, enabling last-minute changes or the correction of technological values within the part program, e.g. when a tool breaks and needs to be changed. In addition, the man-machine interface at the CNC controller can be more user-friendly.

Since the geometry of raw and finished parts is described using STEP, direct exchange of information between CAD, CAM and NC is possible, enabling an end-to-end CAD/CAM process chain. Geometric data can be imported directly from CAD systems. For example, when working with 2.5D geometry, manufacturing features can be imported from feature-based CAD systems. Then the technology information can be added to generate the part program. The new standard, which doesn't require machine-specific post-processors, enables Web-based Develop Anywhere, Sell Anywhere, Manufacture Anywhere, Support Anywhere (DASAMASA) strategies.

Surveys carried out during the OPTIMAL project (see below) indicated the potential benefits that could be achieved. They showed major drawbacks of NC programming using ISO 6983. While 68% of all drawings were generated using CAD systems, only 10% of these were transferred to NC programming systems as electronic data. In 90% of the cases all contours were drawn again in the NC programming system.

According to a US study [1], the benefits enabled by STEP-NC translate into savings estimated at a 35% reduction in CAM planning time, a 75% reduction in the number of drawings sent from CAD to CAM, and a 50% reduction in machining time for small to mid-sized job lots.

### **STEP-NC : Prototype Results**

The STEP-NC standard has been implemented as a prototype in some Siemens and Agie-Charmilles controllers. Initially the focus was on milling. Future activities will lead to extensions for turning, grinding, EDM, rapid prototyping, and wood and glass cutting. Practical demonstrations and prototypes of STEP-NC have proved its benefits and its potential. As a consequence, interest in STEP-NC is rising and there are activities to more strictly harmonise ISO 14649 and STEP, and even to integrate STEP-NC into STEP.

### **STEP-NC : The Previous and Present Projects**

STEP-NC has been developed as a result of several research projects carried out by European companies and university institutes. The first of these was the ESPRIT III project OPTIMAL (Optimised Preparation of Manufacturing Information with Multi-Level CAM-CNC Coupling) which ran from 1994 to 1997. Next was the European STEP-NC project (EP 29708) which started on January 1, 1999 and ran until December 31, 2001. Within the EC-funded STEP-NC project and the US Super Model Project, a large consortium validated and improved the existing data model for milling, and prepared models for additional technologies such as turning, wire-EDM, wood and glass cutting.

For further developments and exploitation of the results, a global collaborative project involving the EU, Korea, Switzerland and the USA (with links to the 1999-2002 Super Model Project) was started within the scope of the Intelligent Manufacturing Systems (IMS) Project in 2002 [2]. In addition to leading European participants such as EIG/i-tech (part of HES-SO), it includes American and Korean organisations.

### **REFERENCES**

- [1] Dr M. Hardwick, Step Tools Inc. <http://www.steptools.com/>
- [2] Mr Peter Müller, Siemens AG. <http://www.step-nc.org/>