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Design Input Interface for Advanced CNC Programming

A Thesis

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Abstract

The current CNC language (ISO 6983) is considered a low level language since it specifies, only, the cutter location in terms of position and feed rate. It does not define the feature of the part and it limits the portability and interoperability from system to system which remains an obstacle for cooperation among manufacturing partners. The STEP-NC, ISO 14649 and ISO 10303 AP 238, standards are being used as the basis for development of the next generation of the controller of the Computer Numerically Controlled (CNC). It gives CAM and CNC vendors the opportunity to integrate the capabilities of CAD/CAM systems through an intelligent CNC controller, which have bi-directional data flow between CNC machines.

A software to convert STEP-NC code to G&M code is needed so that old controller will be still in use. The software was written using Microsoft visual C#. The present thesis introduces this software for 3-axis CNC machining centers. The developed software has been implemented and proved successful.

Summary of the M.Sc. Thesis entitled:

“Design Input Interface for Advanced CNC Programming”

Over the last 50 years CNC machine tools were programmed using G&M code (ISO 6983). G & M code has several problems such as information loss since it delivers only limited information to the CNC excluding valuable information such as part geometry and the process plan used to generate the NC code. G&M code (ISO 6983), also, lacks the interoperability between the different controllers of CNC machines because its code schema depends on the machine tool controller. The basis for development of the next generation of CNC controllers is based on ISO 14649. This new standard is known as STEP-NC, which is being developed worldwide to replace G&M codes.

Researches in STEP-NC are categorized based on the researcher’s main focus in terms of manufacturing technology and processes such as; milling processes, turning and turn-mill processes, EDM, process plan, etc. Limited researchers studied the problems faced by the current CNC systems when STEP-NC becomes widely available. The current CNC machine tools will be widely affected because each machine tool is dependent on its own machine tool controller. The research work documented in this thesis introduces a conversion system with an aim to solve the problems faced by the current CNC systems.

The converting system takes the STEP-NC file and converts it to the required G-codes that are ready to be loaded to the targeted CNC controller. This system consists of:-

- pre-processor module which reads the STEP-NC file and extracts the required information needed for the conversion process.

- tool-path generator module which calculates the approach and machining tool paths since STEP-NC files do not contain exact tool-paths needed for the cutter location in G&M codes file.
- execution module which generate the G&M codes file according to the targeted CNC controller using the extracted and calculated information from the previous modules.

In order to apply this methodology, user interface software has been developed using Microsoft Visual C# language that enables the user to convert automatically from STEP-NC file into G&M code file which saves time and effort.

Several examples from ISO 14649-11 have been applied on the developed software as case studies. The generated G&M code file have been verified using graphical simulation software to examine the cutter movements and locations. The generated G&M code file showed correspondence between the two final shapes.

This thesis consists of five chapters and two appendices. Each includes the following.

Chapter 1: Introduction

This chapter describes the evolution of CNC machines and its programming techniques showing limitations of the currently used technique (G&M code) and the emergence of the new technique (STEP-NC) showing its advantages.

Chapter 2: Literature review

This chapter covers a brief description of the most important researches related to STEP-NC and focusing on shortcomings that is concerned in this research.

Chapter 3: Methodology of conversion

This chapter describes the conversion system showing its input and output and the components of the converting system.

Chapter 4: Case studies

This chapter includes several examples from the standard ISO 14649-11 taken as case studies.

Chapter 5: Conclusion and future work

This chapter presents conclusion about the conversion system with suggestion of possible future work.

Appendix A: Description of STEP-NC file

This appendix consists of description of the STEP-NC file according to ISO 14649-11.

Appendix B: STEP-NC Files

This appendix contains STEP-NC files which are taken as case studies.

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ABBREVIATIONS

CNC: Computer Numerical Control

APT: Automated Programming Tool

STEP: Standard for the Exchange of Product model data

CAD: Computer Aided Design

CAM: Computer Aided Manufacturing

AP: Application Protocol

SFP: Shop Floor Programming

TPG: Tool Path Generation

XML: Extensible Markup Language

NIST: National Institute of Standards and Technology

MASCAPP: Multi-Agent system for Computer Aided Process Planning

CHAPTER 1

Introduction

The representation of product data has evolved slowly over the last 200 years, **Fig. 1.1**. Before 1800, a tangible physical model of a product defined product descriptions. The invention of the engineering drawings in the early 1800s led to more precise product descriptions. This precision increased productivity six fold over using a physical model to define a product [1].

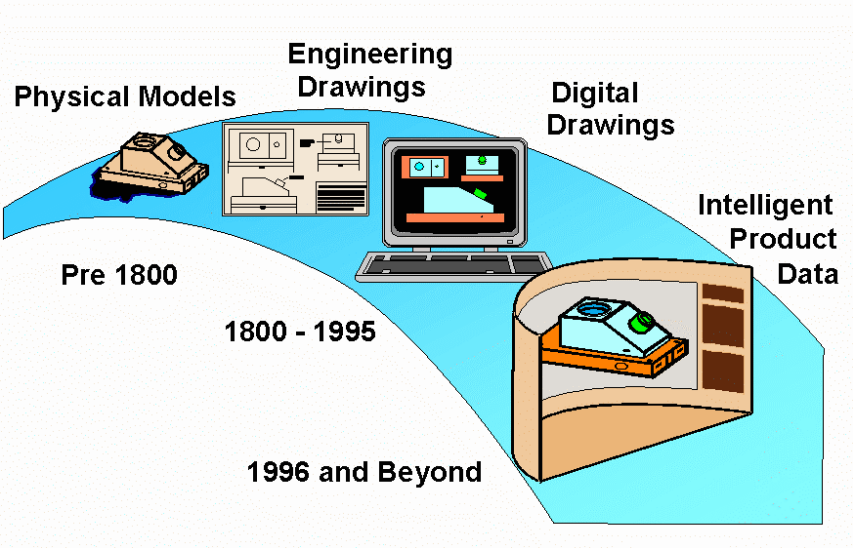

Fig. 1.1 Evolution of Product Definition Capabilities

Manufacturing technologies have advanced in a rapid pace since the first commercial CNC machine tool which was constructed in 1952. MIT developed the Automated Programming Tool (APT) to support numeric controlled manufacturing [2]. Later in 1982 [3], the APT language was adopted by ISO as international standard ISO 6983: Numerical control of machines – Program format and definition of address words. The ISO 6983 (or G-code) is a cutter location based language. The contour of a component

is machined by moving a cutter whose positions are defined in a G-code program.
Nowadays the current CNC language (ISO 6983) is considered a low level language since it specifies, only, the cutter location in terms of position and feed rate. ISO 6983 has many problems:

- it does not define the feature of the part as it only define the cutter location,
- it limits the portability and interoperability from system to system which remains an obstacle for cooperation among manufacturing partners,
- it processes in a way that information flows only from top to down so there is no information feedback mechanism to allow adaptive or preventive correction at the top level for optimizing the production line [4].

Today a new standard, informally known as STEP-NC, is being used as the basis for development of the next generation of Computer Numerically Controlled (CNC) controller. This new standard is ISO 14649 and ISO 10303 AP238. It gives CAM and CNC vendors the opportunity to integrate the capabilities of CAD/CAM systems through an intelligent CNC controller, which have bi-directional data flow between CNC machines, CAM systems or even CAD systems [5].

Unlike the G&M codes, STEP-NC associates the machining objectives (CAD design data) with solutions (CAM process data required) in an object-oriented way. It does not need to define precisely the detailed axis movement of the machine tool, although it has the mechanism to incorporate it in the STEP-NC file. The aim of an STEP-NC is to provide the CNC with a comprehensive manufacturing data model and an interface to establish an intelligent controller. Further- more, the new data interface is compliant with an STEP (ISO 10303), which is the major ISO standard for product information exchange throughout the product lifecycle. Through

incorporating STEP data, STEP-NC builds up a bi-directional information highway between the CAD/CAM and CNC systems, without using the post-processor [6] and makes interoperable process planning and manufacturing feasible and a future reality [7].

The problem arises that the existing controllers works with the G&M system and does not recognize the step system. This means that all present controllers will become unused as soon as the STEP-NC forces itself. Hence, conversion interfaces are needed to convert between the two systems.

The aim of this research is to develop a system for generating G-code from STEP-NC in which this will help in reducing time by automatic conversion and helps in using the current CNC machines when STEP-NC becomes widely available.