Standardised Process Control System for CNC Manufacturing

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Abstract
Manufacturing firms continuously strive to improve existing methods or develop new ideas to reduce production costs and lead times in order to provide quality assured parts rapidly to customers. Maintaining control over the processes involved in manufacturing is therefore vital. The manufacturing process chain includes product design, machining and measurement processes as well as the interpretation of measurement results. However, these process chain elements are currently regarded as separate islands of information. In the large majority of current manufacturing companies the machining and inspection processes are not integrated. This limits the process control capability in terms of modifying the machining process parameters. In-process modification of machining parameters such as the work coordinate system (WCS) offsets, tool diameter and length, etc. can lead to improvements in the quality of manufactured parts and also control the rejection rates for parts produced in batches. In this chapter, literature related to statistical process control and manufacturing data analysis are presented together with a commercial process control solution, namely the Renishaw Productivity+. The authors envisage the use of STEP-NC standards as one of the ways to integrate machining and inspection processes for CNC machine tools. Based on the standards a process control information model for CNC manufacturing has been specified. The final part of the chapter describes a standardised process control system together with a computational prototype based on this system and its application with a simple piece.

11.1 Introduction
CNC machining is at the final stage of the CAx process of a highly complex chain that starts from the design of a part through to its manufacture and inspection. In recent years, CNC machines have provided greater reliability, increased capabilities coupled with more advanced attributes of servomechanism control, increased processor speeds and user-friendly programming tools. Today the measurement accuracy using either On Machine Measurement (OMM) or Coordinate Measuring Machines (CMMs) has reached an acceptable limit in real-time production environments [11.1]. However, until now CNC machine tools have had limited...
process control capability. The majority of the current state-of-the-art CNC production systems use statistically process control techniques for the manual modifications of process plans at manufacturing shop-floor. In the current manufacturing setup, skilled engineers are required in addition to the machine operators for interpreting the inspection results obtained from either OMM or CMMs. The conventional method is to plot the control charts for the measurement results and investigate whether the process is under control or not, with subsequent corrective measures being taken for adjusting the process deviations [11.2]. However, this involves a large amount of scrap, especially if the process is out of control after the measurement of a machined batch of parts.

One of the primary reasons for the lack of process control systems is the use of independent machining programs and inspection programs for components on the machine tool. The need for integrating the machining programs along with inspection programs to achieve process control has been realised in industry [11.3] as well as by academic researchers [11.4]. Using this concept of integration for machining and measurement programs, two types of process control systems have recently been developed. A prototype process control system based on STEP-NC standards has been realised at the University of Bath [11.5]. This system enables the automatic modifications of the process parameters for feature placement locations for prismatic components. One industrial solution from Renishaw, a leading manufacturing company of precision measurement products, is a process control system which enables machine tool users to integrate measurement cycles into the machining part program. This system automatically provides compensation for tool offsets, fixturing error, tool wear, etc. into the CNC machine registry settings.

This chapter describes process control in CNC manufacturing and presents the advantages of such systems for CNC machining, with an example of the Renishaw process control system. A brief review of contemporary Statistical Process Control (SPC) techniques and manufacturing data analysis is also provided. The main goal of the chapter is to present a standardised approach for achieving process control in CNC manufacturing. A framework for standardised process control is presented together with information models which underpin this system. The final part of the chapter provides a general discussion of the use of process control systems and how they provide benefits through increasing the productivity of manufacturing systems.

11.2 Process Control

Process control has evolved as a term from a number of different industries such as the chemical process industries, semiconductor manufacturing industries, machining industries, etc. The function of a process control system in any industry is to monitor the behaviour of the process and provide appropriate feedback to adjust for undesired deviations. In this regard, the authors envisage a generic architecture for a process control system as presented in Figure 11.1. A similar architecture for process control has also been presented by Siu [11.6].