Chapter 4
Online Machining Optimization with Continuous Learning

M. Chandrasekaran
North Eastern Regional Institute of Science and Technology, India

M. Muralidhar
North Eastern Regional Institute of Science and Technology, India

C. Murali Krishna
Maulana Azad National Institute of Technology, India

U.S. Dixit
Indian Institute of Technology Guwahati, India

ABSTRACT

In offline optimization of machining process with traditional or soft computing techniques, the functional relationship between the tool life and the cutting parameters are often assumed. Application of these techniques in shop floor involves a number of constraints and has many limitations in its implementation. The complex machining process gets influenced by multiple process parameters, particularly in a finish turning operation, which often determines the final quality of the parts. In this work, an online optimization methodology with continuous learning is proposed and applied to finish turning process. Surface roughness is predicted using a virtual machine modeled with neural network and empirical equation. Minimization of machining cost is considered as an optimization objective. Optimization is carried out using simplex search or a fuzzy optimization method to determine optimum process parameters. The simulated data obtained from online machining can be stored and used for online learning of machining process. An artificial intelligence (AI) based online learning strategy proposed in this work determines the optimum cutting condition accurately without consuming significant time and resources at the shop floor. The new approach is more suitable and economical for shop floor applications.

DOI: 10.4018/978-1-4666-0128-4.ch004

1. INTRODUCTION

One of the most widely researched topics in the area of machining is the optimization of machining processes (Aggarwal & Singh, 2005; Mukherjee & Ray, 2006). Selection of right combination of cutting parameters (i.e, cutting speed, feed, and depth of cut) to satisfy one or more economic objectives such as, maximization of production rate, minimization of cost, maximization of surface finish, *etc.,* is important for metal cutting industries. From the era of conventional machine tools to the present era of CNC machine tools, a number of researchers have presented various traditional and non traditional methods for optimizing the process parameters in single and multi pass machining processes. Due to high complexity involved in machining, the prediction of surface roughness, tool life, cutting force, *etc* is a challenging task but it is necessary for proper optimization of the process. The surface roughness is often predicted through experimental based statistical or neural network models which are applicable to only for a particular work and tool combination. Most of the researchers have taken either the empirical surface roughness relation or the ideal surface roughness formula based on geometric consideration as given by

$$R_a = \frac{f^2}{32R}, \tag{1}$$

where, R_a is the Centre Line Average (CLA) surface roughness value in mm, f is the feed in mm/rev and R is the tool nose radius in mm. This assumes that only nose portion of the tool is making contact with workpiece and it is not valid when the feed is more than nose radius. For the determination of tool life most of the researchers have used extended Taylor's tool life formula,

$$vT^p f^q d^r = C \tag{2}$$

where v is the cutting speed in m/min, T is the tool life in minutes, d is the depth of cut in mm and p, q, r and C are the constants for a particular tool and work material combination. However, homogeneity of tool and work material and stability of machine tool have significant effects on tool life. Similarly, cutting force and tool wear are also predicted as functions of cutting process parameters.

Since the performance of machining process changes with time and other factors, the optimum process parameters obtained by the offline optimization based on above hypothetical consideration using empirical relations have many limitations in their implementation. To overcome these difficulties researchers employed a real time optimization using adaptive control strategy such as adaptive control optimization (ACO) and adaptive control constraints (ACC), which provides the capability to adjust operating parameters on-line, based on measurement of appropriate process characteristics. This requires costly process-sensors and acceptable interfacing circuitry in its application. Therefore there is a need for optimization method, which can cope up real time machining environment and can be implemented easily. Although the research on the optimization of machining process started since about 60 years back with the pioneering work of Gilbert (1950), there is hardly any paper that demonstrates implementation of optimization techniques in the shop floor. In the opinion of the authors, the main reasons for it are as follows:

- For solving the optimization problem offline, the functional relationship between the tool life and cutting process parameters must be known. Often this information is not available due to requirement of extensive tests.
- In the constrained optimization, dependence of process parameters on tool life, cutting force, cutting power *etc* is usually not available.

Related Content

Muscle Fatigue Analysis During Welding Tasks Using sEMG and Recurrence Quantification Analysis
Ali Keshavarz Panahi, Sohyung Choand Chris Gordon (2021). *International Journal of Applied Industrial Engineering (pp. 1-16).*
www.irma-international.org/article/muscle-fatigue-analysis-during-welding-tasks-using-semg-and-recurrence-quantification-analysis/287609

Maximizing Clicks in Email Marketing Campaigns for a Retail Company
Patrick Mackintosh, Luke Brantley, Alexander Hansen, Jacob Lindell, Jesse Pietz, Joseph H. Wilck, Taylor Leonardand Gerardo O. Gonzalez (2017). *International Journal of Applied Industrial Engineering (pp. 33-46).*
www.irma-international.org/article/maximizing-clicks-in-email-marketing-campaigns-for-a-retail-company/182722

Key Enabling Technologies
Xun Xu (2009). *Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control: Principles and Implementations (pp. 354-393).*
www.irma-international.org/chapter/key-enabling-technologies/8491

Integration of Fuzzy Logic Techniques into DSS for Profitability Quantification in a Manufacturing Environment
Irraivan Elamvazuthi, Pandian Vasantand Timothy Ganesan (2012). *Handbook of Research on Industrial Informatics and Manufacturing Intelligence: Innovations and Solutions (pp. 171-192).*
www.irma-international.org/chapter/integration-fuzzy-logic-techniques-into/64720

Group Technology
Zude Zhou, Huaiqing Wangand Ping Lou (2010). *Manufacturing Intelligence for Industrial Engineering: Methods for System Self-Organization, Learning, and Adaptation (pp. 189-213).*
www.irma-international.org/chapter/group-technology/42626