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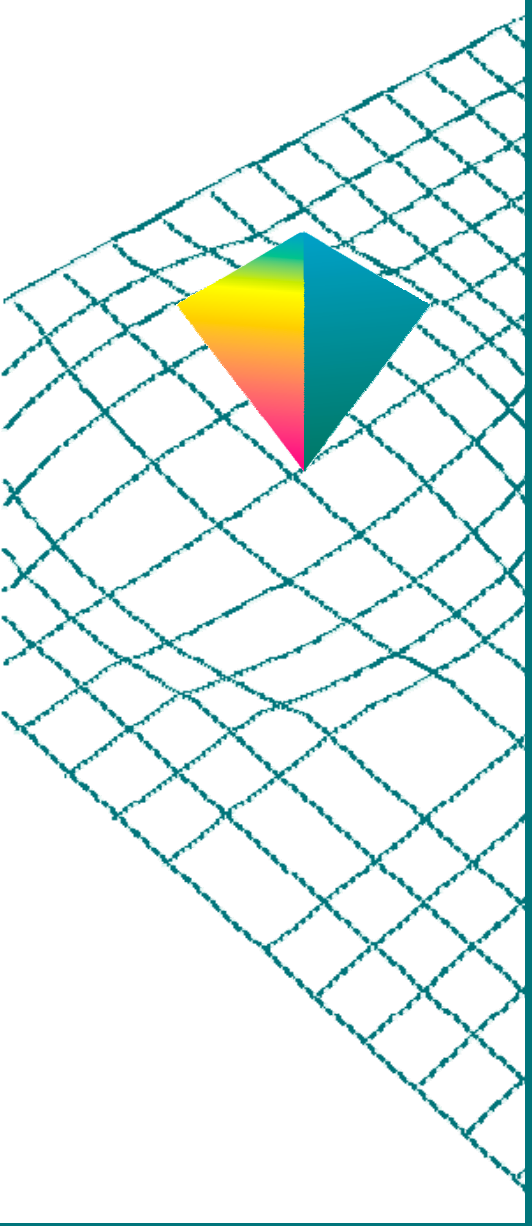

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50. Internationales Wissenschaftliches Kolloquium
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The predicted modeling of surface roughness for high speed milling of SKD61 tool steel

Abstract

This paper presents an polynomial network for predicting tool life and surface roughness in high speed milling finish operations. The polynomial network is composed of a number of functional nodes. These functional nodes are well organized to form an optimal network architecture by using a predicted squared error criterion. Once the cutting speed, feed per tooth, and axial depth of cut are given, tool life and surface roughness can be predicted based on the developed network. Experimental results have shown that the polynomial network can be used to predict surface roughness and ball nose end-mill life under varying finish cutting conditions and the prediction error is less than 10%.

Introduction

Many advantages of HSM(high speed machining) and HSC(high speed cutting) have been cited. The most common claims are high metal removal rates [1], low cutting forces and minimal workpiece distortion [2], an ability to machine thin walled sections and the use of simple fixturing [3]. The list also includes surface finishes down to 0.1 μm R_a, little or no damage to workpiece surface integrity [4], a reduction in cutting tool variety, burr free components[5] and easier chip disposal.
In practice, a desired surface roughness value is usually designated and the appropriate cutting parameters are selected to achieve the desired quality of a specified part. Hence, the predicted modeling of surface roughness is importance in the high speed milling process. The various methodologies and strategies that are adopted by researchers in order to predict surface roughness for turning and milling [6]. In this paper, a polynomial network [7] is used to construct the relationships between the cutting parameters (cutting speed, feed per tooth, axial depth of cut, radial depth of cut) and surface roughness or tool life. The polynomial network proposed by Ivakhnenko [8] is a group method of data handling (GMDH) technique [9]. In a polynomial network, complex systems are decomposed into smaller, simpler sub-systems and grouped into several layers using polynomial function nodes. The polynomial network is a self-organizing adaptive modeling tool [10] with the ability to construct the relationships between input variables and output feature spaces. Based on the developed network, surface roughness tool life under varying finish high speed milling parameters can be reasonably predicted.

Experimental design and Surface Roughness Prediction Model

To build an polynomial network for predicting surface roughness and tool life of HSM, a training database with regard to process parameters and surface roughness needs to be established. A number of milling experiments were carried out on a high speed machining

center using 4-12mm diameter ball nose end-mill with TiAlN coated for machining of SKD61 Tool Steel blocks. The cutting parameters select spindle speed, feed rate and radius. Each of these parameters was set at 3 levels, which are showed in the table 1. Then an optimal polynomial network is developed to predict ball nose end-mill life and surface roughness base on the exprementer database for the finish milling. Then, a three-layer feed-forward polynomial network is determined and synthesized to predict surface roughness and tool life in high speed milling finish operations, as shown in Fig 1. In the experimental verification, four test of high speed milling were performed and the error between the predicted and measured tool life is less than 10% (Table 2).

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cutting	level
1. spindle speed (rpm)	10000, 15000, 20000
2. f,feed rate(mm/tooth)	0.05, 0.1, 0.15
3. R,radius(mm)	2, 4.5, 6

Table 1 experimental design for HSC

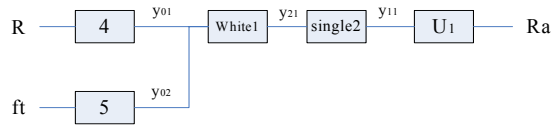

Fig.1 Structure of the polynomial network predicting HSM surface roughness

Test number		Cutting Condition R (mm)	N (rpm)	ft (mm/tooth)	Life (min)	Ra (μm)
1	predicted	3.0	13000	0.08	83.9	0.215
	measured				80.0	0.20
	error (%)				4.88	7.50
2	predicted	5.0	13000	0.12	31.6	0.201
	measured				36.2	0.22
	error (%)				12.71	8.64
3	predicted	5.0	17000	0.12	24.9	0.201
	measured				27.6	0.23
	error (%)				9.78	12.61
4	predicted	5.0	17000	0.08	76.3	0.168
	measured				80.0	0.19
	error (%)				4.625	11.58

Table 2 Verification of the polynomial network for predicting in HSC tool life and surface roughness

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