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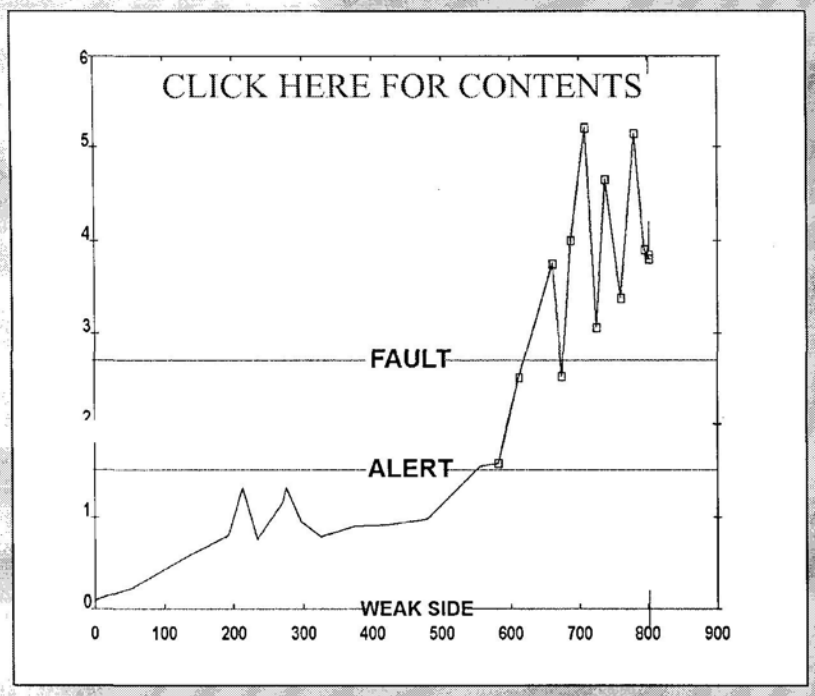
Kings College, Cambridge, UK
18th - 21st July 2005



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THE INTELLIGENT SYSTEM FOR QUALITY RATING OF MACHINING MATERIAL PROCESSING

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1. INTRODUCTION

The quality rating of technological processes of the machining material processing at conditions automatic production the performance of CNC-equipment and intensification of machine-tool industry is conditioned.
Quality surveillance of the technological processes of material processing in requirements of industrial automation is stipulated by the development of the flexible production, automatic systems in the manufacture enterprises, intensification of the production. Quality management of the technological processes provides diagnostic of instability and the formation of correcting actions. For machining processing of materials diagnostic of a technological processes monitoring of the limiting conditions are included: the critical wear of a cutting edge of the tool, the breakage of the tool, the fixing down action of the tool in a body of a workpiece, crashes of a production equipment when the normal action of the machining process is upset. In this case quality of made products is aggravated, that is the discordance of parameters to prescribed values is observed: parameters of the details formation, the surface roughnesses of the details are not ensured.
It is possible to avoid, for example, a critical or limiting wear of an edge tool, using performances of a workability of an edge cutting tool and workpiece, by replacement of the cutting tool before the termination of the durability period.
However in this case the crashes interfering quality of a technological processes are possible. Therefore the solution of this problem can be achieved only with application of computerized means of a flow control.
Increase of the nomenclature of worked materials, appearance of new marks of metals, including the composites, increasing tolerance requirements of the details manufacture determine an urgency of system engineering of quality surveillance of machining process. The concept of accuracy implies correspondence of parameters of a work piece to the given in the designer and the fabrication documentation. Accuracy check by the quantitative monitoring of this parameters of process or concrete products is determined.
Functions of an engineering control are determined by two stages: obtaining of a source information about an actual condition of inspected object, about parameters of its properties and performances; and then comparison of a source information to the preset requirements, tests, obtaining of the information on divergences of actual and required data, or discovery of their discordance.
Quality surveillance of a machining process actuates the diagnostics of the emergences at cutting. Diagnosing of quality includes monitoring the quantitative values or quality indications of the technological process. The most sensing to instability of the technological processes are the physical phenomena naturally originating at cutting of materials (acoustic emission, an EMF of cutting). Changes of parameters of the signals identifying these phenomena, characterize the full the changes happening in a cutting zone, a condition of a production equipment, a cutting edge of the tool, the formation surface roughnesses of a workpiece. Therefore the engineering control of parameters of these signals will match to functional check of a technological processes. Functional check of process by ability of correct fulfilment of this functions is determined.

2. MODELLING OF THE TOOL WEAR IDENTIFICATION

The integration of the defects of the cutting tool edge at the wearing process result in the initiation of the normal processing process failure. For the metal processing intelligent equipment the information need about the identification of the cutting tool edge defects is evidented. The receipt of such information for the several study of the cutting tool states at its shakedown period the checking feature and identification of the failure pattern of the dynamic system of the cutting tool. Thus the processing equipment maybe to control at the "cutting tool study" and to forecast of the cutting tool remaining life. The transacted investigations of the different means application for the diagnostic of current cutting tool states the statistical methods preferences are showed. The diagnostic indicators normalized geometrical parameters contour of the cutting edge wear and its defects are offered.
As the prospective study for this problem solution and automatic identification of the cutting tool fault by Wavelet-analysis is offered. The investigated signal $f(x)$ at the sensor, which proceed into processing system, the assembly wave packets on some basic function are notated. This assembly is different at different part of the time space at the signal identification and by coefficients is corrected. It the local signal distinctions at the time and frequency space is allowed. Then it is possible effective data compression for the productivity analysis of the current dynamic of the cutting process states.

As is well known Wavelet transformation of the function $f(x)$ by the direct and inverse transform is united, that is investigated signal f(x) at the assembly coefficients $W_\psi(a, b)f$ is converted. Thus

$$W_\psi(a,b)f = \frac{1}{\sqrt{C_\psi}} \int \frac{1}{\sqrt{|a|}} \psi\left(\frac{x-b}{a}\right) f(x)dx, \tag{1}$$

a, b – parameters - designator of scale and displacement of the function ψ - $\psi\left(\frac{x-b}{a}\right)$ (Wavelet analysing);

C_ψ – normalizing coefficient:

$$C_\psi = \int_{-\infty}^{\infty} \frac{|\tilde{\psi}(\omega)|^2}{|\omega|} d\omega = 2\int_0^{\infty} \frac{|\tilde{\psi}(\omega)|^2}{\omega} d\omega < \infty, \tag{2}$$

$\tilde{\psi}(\omega)$ – Fourier image of the Wavelet $\psi(x)$: $\tilde{\psi}(\omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \psi(x) e^{-i\omega x} d\,x$.

Thus it is possible to get our function of the investigated signal $f(x)$ from our sensor, if the assembly coefficients $W_\psi(a, b)f$ we are known:

$$f(x) = \frac{1}{\sqrt{C_\psi}} \iint \frac{1}{\sqrt{|a|}} \psi\left(\frac{x-b}{a}\right) \left[W_\psi(a,b)f\right] \frac{da\,db}{a^2}. \tag{3}$$

Thus Wavelet transformation of the univariate signal from the our sensor to compose 3D matrix by amplitude, frequency and time signal is allowed with full information $W_\psi(a, b)$ about investigated current signal.

3. ACTION OF SYSTEM

Application of an engineering control of a condition of a production equipment by a functionality of the details' processing that determines also requirements to quality of technological processes is stipulated. Decreasing the values of tolerances on the formation, a surface roughness, etc. accordingly changes the quality of operation of a production equipment. The most important link in this circuits becomes the devices which allow to execute the problems of control and diagnostic of the technological parameters of machining. Reaching productivity, stable quality of a machining is possible only by the development of the touchsensitive subsystems of diagnostic and the process control, which have a hair accuracy, the response, including interface units with means of the computer facilities and the control systems of a production equipment. Performances of such systems, the operation algorithms of the devices and monitoring systems should answer requirements of the modern computerized production. Known systems of the limiting regulation intended for the lot production and mass production and do not ensure an adaptive control with the process of the individual production. Therefore the problem of development of the evaluator of a condition of a machining process for flexible automated production is actual.

Our flexible hybrid system with polyvalent sensors allow to execute polyvalent monitoring of performances of the electrical signals in real time, identifying to a time history of operation of process of a materials machining.

By the development of the monitoring modules the problem of security of reliability of these devices activity is actual. Reliability can be determined properly to save in time in the installed limits of value of the parameters describing ability to design required functions in the this conditions and conditions of usage, that is property to save the functionability in the period of time. Functionability is meant as such condition of the device at which its performance meets' the requirements of the engineering specifications.

The data, which we can recover from our sensor, it is necessary at dynamics retain at the outward keeper. The scheme at basic on retain at tabular form of the database. For our problem any executive systems of database (ESDB) one can used. However since our problem not mean by specific requirement for the database administration and simple easy access, and just basic procedure with data, we decided in favour of simple and accessible ESDB, for example, FireBird, MySQL. Positive factor of this application are the fact that this ESDB are freeware.

The tabular form structure intuitively conform to the structure of data, which we can recover from our data processing system from sensor's signal $f(x)$, that is:

- Amplitude of signal $f(x)$ under consideration,
- signal $f(x)$ relative frequency,
- current time,
- identifying number of registration.

For the formalization of the cutting tool state we are assigned dynamic 3D matrix array the amplitude, frequency of signal $f(x)$ and cutting current time from pitch Δn_j of the discretization. It is necessary be observed, provided we given amplitude of signal $f(x)$ from sensor, current time from beeper, this frequency we are calculated.

Thus the analysis of this current matrix the complete information image of the signal and current cutting process with the consideration of the concrete type cutting power is given. *A priori* data as tabular form with the consideration of the concrete type of the produced detail at our developed database are formed. This values with current values of signal are compared. The pitch Δn_j of discretization due to with the consideration of the concrete type of process conditions the reiteration of the detail parameter rating is identified. This form database it is necessary for following correction of estimation with respective coefficients are used. Registration and reading of the data by method of the standard queries at SQL92 language.

The date-line as result of comparison to go into database for the further processing and data set archive for the knowledge base are allowed.

4. CONCLUSION

The findings are enabled the application of the formalized technological procedures with application variation of technological equipment, tools, cutting conditions etc.

This approach is supported the effective productivity nondestructive control of the cutting edge from the current rating of the accuracy production of precision detail at CNC-systems.

As a result of with use the given working information system of technological processes manufactured efficiency is increased.

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