APPLICATION NEURAL NET AT THE SIMULATION OF THE TURNING PROCESS

Josef BRYCHTA, Lenka PETRKOVSKA, Technical University of Ostrava, Faculty of Mechanical Engineering, Department of Machining and Assembly, 17. listopadu, 708 33, Ostrava Poruba, Czech Republic

Abstract: Submitted article deals the problems of measuring at cutting temperature assessment through calculation of measured or in other way stated input parameters and searching of the new acceptable operation methods of its assessment are solved through utilization of neuron network. The opinion results from long-term outcomes of temperature measuring performed with cooperation with Trinecke zelezarny, Inc. at solving of assessment of index machinability for unclassified export metallurgical materials. The latest development trends in cutting operations (high-speed and high-volume cutting) and their influence on cutting temperature are treated. Zones of temperature influence on effectiveness of the cutting process, with reference to quality of cutting material and with reference to desired properties of workpieces (heat stress, integrity of surface, roughness and so on) are observed.

Key words: Cutting Tools, Cutting temperature, Neural net, Simulation

1. INTRODUCTION

Submitted article deals with both the theoretical questions of temperature measuring at cutting and possibilities of their practical implementation partly in economic activities of our department and partly also in the frame of experimental research. The problems of temperature assessment through calculation of measured or in other way stated input parameters and searching of the new acceptable operation methods of its assessment are solved through utilization of neuron network. The opinion results from long-term outcomes of temperature measuring performed with cooperation with external company at solving of assessment of index machinability for unclassified export metallurgical materials. The latest development trends in cutting operations (high-speed and high-volume cutting) and their influence on cutting temperature are treated. Zones of temperature influence on effectiveness of the cutting process, with reference to quality of cutting material and with reference to desired properties of workpiece (heat stress, integrity of surface, roughness and so on) are observed.

With reference to application of neuron network, the theoretical outlets of their application and also description of individual phases of the process are mentioned (definition of network topology, definition of trained set, adaptation of neuron network, consultation with adapted neuron net). This is followed by, in greater detail described, inside network topology presentation which led to satisfactory results.
2. APPLICATION AREA

Measurement of machinability is difficult for several reasons. The machinability of a metal is not only a function of the metal’s own metallurgical properties, such as hardness, microstructure and chemical composition, but also a function of the type of machining process, the size and shape of cut, the cutting tool and the cutting fluid. Variation of any of these environmental conditions may affect the machinability ranking. There does not seem to be any single dependent variable in the metal cutting process that is universally acceptable as an indicator of machinability. Whatever the variable when it is measured under one set of experimental conditions, the ratings will probably differ from those obtained under a different set of conditions. Also, the rating determined by one test variable may be quite different from the rating obtained by other variables.

These difficulties notwithstanding, a variety of tests have been devised through the years to measure machining performance. These machinability tests include for example cutting temperature test.

3. SIMULATION AND TOOL LIFE

The term “cutting temperature” as used in this discussion, refers to the temperature at the tool/chip interface and is denoted by the symbol $\theta_i$. It consists of the temperature rise, $\theta_s$, in the body of the chip due to shear, the further rise, $\theta_p$, at the interface as the hot chip rubs on the tool face, and the work piece temperature, $\theta_o$.

The cutting temperature may be measured by the tool/work thermocouple method. With a given combination, such as medium-carbon steel and high-speed steel tools, the cutting temperature depends upon cutting speed, feed, depth of cut, tool geometry, and to a certain extent, the cutting fluid.

Modification of neuron characteristics is being performed according to analogous rules like in the case of synaptic weights.

---

**Figure 1** General diagram of the simulation process

The expert systems represent the area of artificial intelligence which probably gained the biggest commercial success. The idea of taking over the knowledge from experts, its coding
into a knowledge base followed by its usage during a consultation seemed to be very attractive and often also very efficient. Nevertheless, the expert systems have also another side related to a process of their creation.

The Neurex system should be used based on the following four stages:

1. Definition of the problem (input and output facts) including the topology of neural network. The input and output layer are defined by the specified facts.
2. Definition of the training set.
3. Learning (adaptation) of the neural network.
4. Consultation with the system.

Specific features of neural networks can be roughly expressed in the following points:

- Neural networks are inspired from biological neural networks. This feature predetermines that artificially created neural networks could be able to behave in the same or at least similar way like their biological models. It is obvious that a creation of the artificial human brain with all its abilities cannot be easily solved either from the point of view of quantity of neurons or the way of their connections, etc. Nevertheless, there is a chance to simulate at least some functions of human thinking and those to implement then.

- Neural networks use a distributed parallel processing of the information during a practicing the calculations. We can say that recording, processing and transferring the information are carried out rather by means of the whole neural network then by means of particular memory places. What means that memory and information processing within the neural network are in their natural substance rather global then local.

- Knowledge is recorded especially through strength of linkages between particular neurons. Linkages between neurons leading to "correct answer" are being strengthened and linkages leading to "wrong answer" are being weakened by means of repeated exposure of examples describing the problem area.

- Learning is a basic and essential feature of neural networks. This fact expresses the basic difference between so far common usage of computers and usage of means based on neural networks. To create a user program we had to aim all our effort at creation of algorithms which transform the input data base into the output data base. But neural networks do not need that difficult stage. The way in which the input data will be transformed into the output data is determined by the learning stage based on the above mentioned exposure of samples (examples) describing a given problem - training set. So there is no need to create an algorithm. That need is substituted by submitting a training set to the neural network and by its learning.

4. TOPOLOGY OF NEURAL NETWORKS

Topology of neural networks expresses the way in which the particular neurons are mutually connected. As well as we can find a number of neuron types there are also various types of models of their mutual connection. In the own Neurex system there is used so called topology of multi-layer neural network which is the most suitable for biological reality and the most advantageous with respect to the practical usage of neural networks. Scheme of such a multi-layer neural network is shown in Figure 2.
From the Figure 2 results the fact that the neural network is created by at least three layers of neurons - input, output and at least one inner layer.

Modification of neuron characteristics is being performed according to analogous rules like in the case of synaptic weights.

**Tab. 1 Input vectors of Neural network**

<table>
<thead>
<tr>
<th>(v_c) [m/min]</th>
<th>(VB) [0.01 mm]</th>
<th>Machinability Index [-]</th>
<th>Temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>340</td>
<td>70</td>
<td>205</td>
<td>417</td>
</tr>
<tr>
<td>340</td>
<td>50</td>
<td>205</td>
<td>407</td>
</tr>
<tr>
<td>340</td>
<td>15</td>
<td>205</td>
<td>391</td>
</tr>
<tr>
<td>260</td>
<td>72</td>
<td>205</td>
<td>396</td>
</tr>
<tr>
<td>260</td>
<td>28</td>
<td>205</td>
<td>376</td>
</tr>
<tr>
<td>260</td>
<td>15</td>
<td>205</td>
<td>370</td>
</tr>
<tr>
<td>220</td>
<td>78</td>
<td>205</td>
<td>386</td>
</tr>
<tr>
<td>220</td>
<td>47</td>
<td>205</td>
<td>372</td>
</tr>
</tbody>
</table>
All things considered, methodology of assessment of supplemental criteria for determination of machinability index utilizing the properly adapted neuron network according to temperature indication of experimental machining of testing material, are proposed.

5. REFERENCES


ADDRESS FOR CORESPONDANCE

CZECH REPUBLIC
Assoc.Prof. Josef BRYCHTA, Ph.D., MSc., Lenka PETRKOVSKÁ, MSc.
Technical University of Ostrava
Faculty of Mechanical Engineering,
Dep. of Working and Assembly
CZ – 708 33 OSTRAVA
17. listopadu 15/2172
CZECH REPUBLIC
e-mail: josef.brychta@vsb.cz