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MONITORING OF MACHINING PROCESS
MONITOROVÁNÍ OBRÁBĚCÍHO PROCESU

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Příspěvek pojednává o monitorování obráběcího procesu, zejména o monitorování opotřebení, resp. destrukce břitu řezného nástroje. Tento způsob monitorování lze realizovat dynamometry na bázi polovodičových tenzometrů ve spojení s určitou softwareovou strategií. Takto lze řešit dva klíčové problémy optimaliace a spolehlivosti obráběcího procesu.

Keywords: Monitoring, tool wear, tool breakage, machining.

1. Introduction

During the last years machining processes have made much progress. The investments associated with the use of expensive machine tools cause that for these machines it is important to select the cutting conditions much more carefully than for the use of conventional machining, otherwise machining costs will rise enormously.

Besides, there are number of different reasons which lead to the installation of monitoring and control systems in an industrial machining process: Monitoring systems improve process control by saving costs by reducing the non-productive time of machine tools, they are necessary to obtain satisfying results even under critical conditions, these systems can support an operator working with machine tools running ot high speed and using a lot of coolant (it makes human monitoring and adequate control impossible), new cutting materials have been introduced (e. g. ceramics, CBN), materials have been developed which are difficult to machine and so on.

For these reasons the predictability of cutting process has decreased. But, industrial machining needs systems which detect tool fracture, the end of tool life and the systems which realize registration of trends in running of machining process.

2. Monitoring of machining process

Monitoring and control systems are necessary to obtain satisfying results of machining process even under critical conditions.

During process planing cutting parameters are usually calculated with the aid of mathematical models. The systematic deviation which arise between the calculated and the actual values of tool life can be used to adapt the empirical coefficients used in the model. Monitoring may help in this way in collecting data for the optimization of cutting conditions.

Monitoring of the machining processes relates machine (CNC control, collision, accuracy, thermal deformation), tool (tool wear, tool breakage, tool approach, tool presence), tool conditioning (tool compensation, dressing), workpiece (raw stock dimension, workpiece material, dimension, shape, surface integrity) and process (coolant, chatter, chip building, force, torque, power).

The wear and tool breakage monitoring are the main problems of monitoring of machining process. The most important way for tool wear and breakage monitoring is based on the measurement of cutting force components. It is possible to design dynamometers using piesoelectric, resistive, capacitive, inductive and other systems. Dynamometers for cutting force measurement in laboratories are often realized with strain gauges. Semiconducting strain gauges are especially available for designing dynamometers for tool monitoring research.

In practice, force sensors with semiconducting strain gauges are realized for tool monitoring tasks. Figure 1 shows as an example a simple one-component dynamometer for tool wear monitoring in turning. It consists of four semiconducting strain gauges for measuring resultant of radial and feed force.

Dynamometers for tool monitoring may be designed as additional device for machine tools. These dynamometers is possible realize as one-component ones and for two-component measurement it is possible to place two one-component dynamometers on a machine tool.

The present developments of tool wear and tool breakage monitoring and control systems are still not fully solved. New software strategies of this kind have been designed at TU Prague.

For the tool wear monitoring when machining steel the radial or feed force (or their resultant) are usable. The bigger tool wear is, the larger force changes are obtained, as seen in Fig. 2. When machining cast iron this principle is usable too. But the ratio of radial and principle cutting force is more reliable (Fig. 3).

For the tool breakage monitoring the ratio of radial to principle cutting force is possible to use. Fog. 4 shows an example of the changes of both components when breakage of the cutting tool.

3. Conclusion

Monitoring systems may decrease machining costs and increase the reliability of machining processes. For monitoring tasks it is possible to use stress analysis of the deformation elements.

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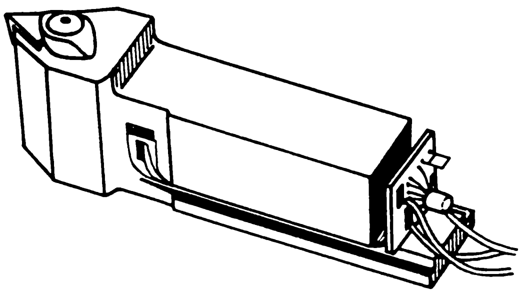
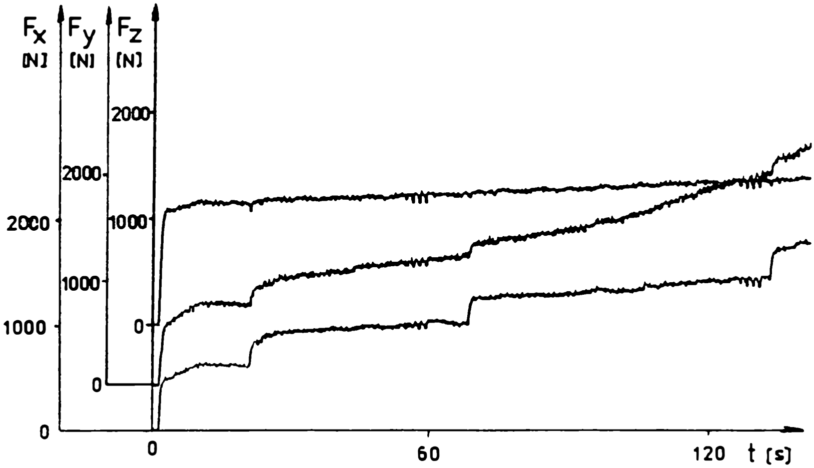
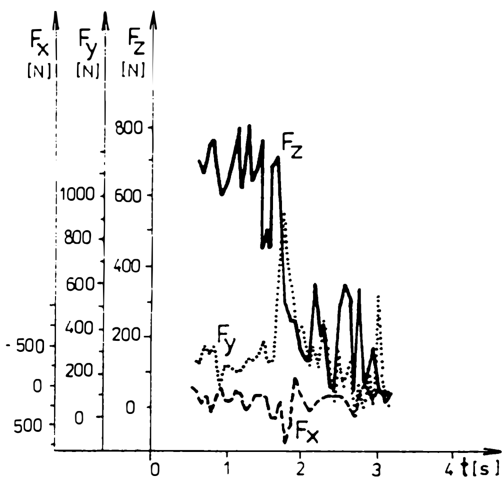


Fig. 1. One-component dynamometer with semiconducting strain gauges.

Fig. 2. Typical changes of radial F_y, feed F_y force with cutting time t (start, centre, end of tool life)



Cast iron, sintered carbide, cutting speed 169,6 m/min., feed 0,2 mm/rev., depth of cut 2 mm.
Fig. 3. Relation of principle F_z, radial F_y, feed force F_x with cutting time t.



Cast iron, sintered carbide, cutting speed 73,6 m/min., feed 0,425 mm/rev., depth of cut 1 mm.
Fig. 4. Relation of principle F_z, radial F_y, feed F_x force and cutting time t.

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