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Chatter Suppression in turning by applying a tooling mechanism with the ability to change the tool angles

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ABSTRACT: Tool angles have a great impact on cutting mechanics and the machining parameters such as surface quality, tool life, specific cutting energy, and dynamic stability of the cutting process. One of the research topics in this field is the development of mechanisms that can be used to create more control on the machining process, such as the tool angles, simultaneously in the process. In this research, a tooling mechanism has been presented for the turning machine, which provides the ability to adjust the normal rake and clearance angles, during the turning process. This mechanism is used to develop a new active control system for chatter suppression for increasing the dynamic stability of the turning process. In this technique, the controller detects the chatter through the acceleration sensor and then reduces the clearance angle of the tool by using the mechanism, this increases the process damping and by increasing the overall damping, it suppresses the vibrations. To design the active controller, the simulation was done in the MATLAB-Simulink and then according to the simulation results, an on/off controller was designed and implemented. Then, experimental tests were performed to evaluate the performance of the chatter suppression control system. The test results showed that the proposed method can have a good effect in reducing chatter vibrations in the turning process and leads to a significant increase in the stability of the tuning process.

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1- Introduction

The tool geometry, especially the tool angles, has significant effects on the machining parameters such as surface finish, tool life, specific cutting energy, and dynamic stability of the cutting process [1]. An interesting study in this field was conducted by Mi. *et al.* [2][2], where the tooling mechanism was proposed to develop an active control technique for chatter suppression in the turning process. The main idea in their research was the interesting for chatter suppression, which has advantages in comparison to other chatter suppression/ control methods in the turning process. This technique needs no reduction in the spindle speed nor feed rate; thus, the metal removal rate is not reduced. Also, the energy consumption in this technique is very low. Therefore, according to mentioned advantages, the present study aims to extend and develop the chatter active suppression/control technique proposed by Mi *et al*. Thus, a new tooling mechanism is presented, which allows the normal/true rake and clearance angles to be adjusted Simultaneously in the turning process. Next, a chatter suppression system is proposed that is based on using the tooling mechanism, After the tooling mechanism was built, the chatter suppression system was implemented and then the experimental test was performed.

2- 2DOF tooling mechanism

In the mechanics of metal cutting, the true rake (normal rake) angle and clearance angle, are defined in the plane perpendicular to the main cutting edge [3]. Now, if we want to have a tooling mechanism that can adjust the normal rake and clearance angles in the conventional turning tools, this mechanism should rotate the tool around the main cutting edge. The proposed mechanism is a series configuration and consists of two inner and outer mechanisms; the inner mechanism is a simple two-members mechanism and adjusts the side inclination angle, whereas the outer mechanism is a four-links mechanism that rotates the inner mechanism around the instantaneous center using two circular slots. In Fig.1 the proposed tooling mechanism is shown.

3- Chatter suppression system

The implemented chatter suppression system is based on changing the tool clearance angle using the proposed tooling mechanism. So, when chatter occurs, the chatter suppression system informs the controller, and the system status is examined by measuring the amplitude of the signal via the accelerometer, when the acceleration amplitude exceeds the allowable threshold, the controller is activated and issues

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Fig. 1. The proposed tooling mechanism

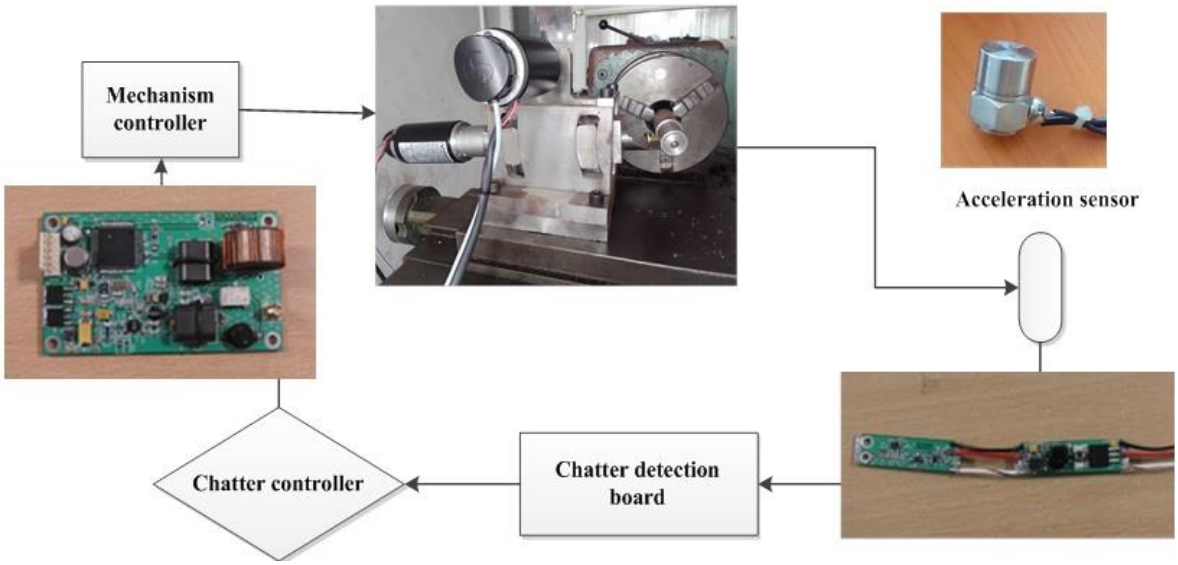

Fig. 2. The implemented chatter suppression system

the angle alteration command to the tooling mechanism. Therefore, the higher the acceleration amplitude relative to the allowable value, the more extreme command is issued for the control operator. In Fig.2 the implemented chatter suppression system is shown.

4- Results

Experimental tests were conducted for the evaluation of the proposed chatter suppression system. In Fig.3 the results of the experimental test are shown in the form of the depth of cutt graphs.

5- Conclusion

The experimental test results show that the proposed technique can be effective in increasing the dynamic stability of the turning process and can easily be implemented on the turning machine with only a change in the tooling mechanism.

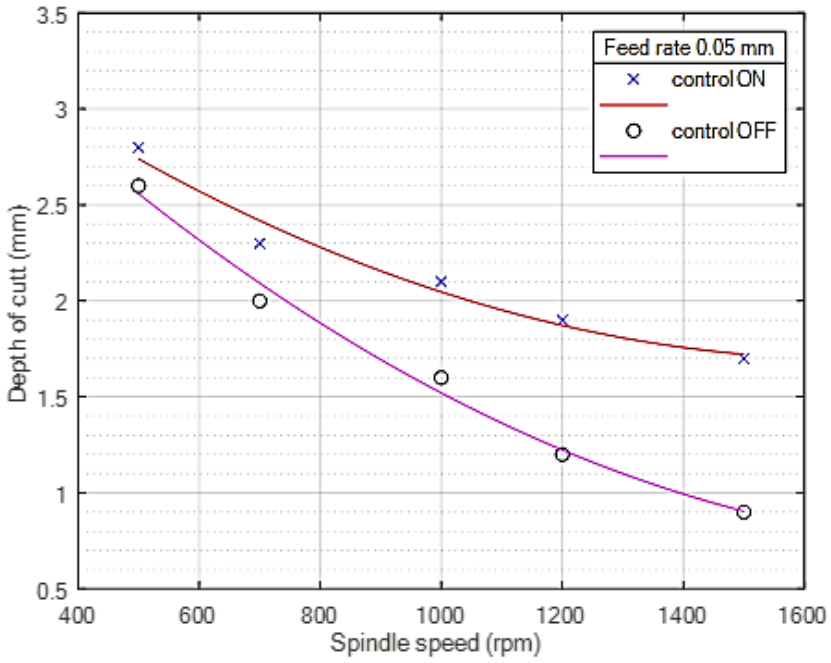

Fig. 3. The depth of the cut graph in two conditions: with and without of chatter suppression system

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