Study of Chatter Vibration Analysis in the Machining Operations and Control Methods

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Abstract— Chatter effect as a self-excited vibration in machine tools contributes to undesired surface finish of the work piece, and can deteriorate the surface quality. Machine tool chatter is one of the major constraints that limit productivity of the turning process. It is a self-excited vibration that is mainly caused by the interaction between the machine-tool/work piece structure and the cutting process dynamics. The frictional and impact chatter are mainly due to the nonlinearity of the dry friction and the intermittent contact between the cutting tool and the work piece. Chatter becomes even more critical when machining materials that are difficult to cut. The productivity of expensive machining systems is often limited by chatter. It has defined chatter as self-generative vibrations that occur when the chip width is too great versus dynamic stiffness. This phenomenon leads to a bad surface aspect and high noise level. As it reduces tool life, it increases production costs. By using various methods we can avoid the chatter vibration.

Keywords: HSS M2, vibration, Matlab, Sumulink Model, hardness

I. INTRODUCTION

From the many years there is research carried out on the chatter vibration though there is still main problem in the obtaining automation for the machining operations such as milling, drilling and turning. Chatter vibration shows some serious problems such as more noise, breaking of machine tool components, poor surface finishing, and tool life as well as productivity. In the machining processes, turning is the widely used operations to cut the metals and to produce the various types of products. The machining of metals is often accompanied by a violent relative motion between tool and workpiece which is called chatter vibration [1].

Chatter is caused by material to cut, chip proportions as affected by depth of cut, feed, tool contour, cutting speed, stiffness of work, stiffness of tool, stiffness of tool support, stiffness of work support, vibration caused and multiplied by nature and design of machine tool, such as the gear ratios and tool forms used, setting with respect to be work.

In the machining processes, there is often self-excited vibration between the cutting tool and the work piece that vibration is nothing but chatter vibration. Due to the chatter, the amplitude of the self-excited vibration gets increase to the nonlinearity limits [2]. The cutting conditions, work piece material and the cutting tool type and its material plays important role in the chatter vibration. The variation of the tool position with respect to work piece also effect on it when work piece flexibility in the considerations. In the same cutting conditions, when movement of cutting tool from the chuck to the tailstock along the work piece, chatter may occur when the tool passes a critical position. In the metal cutting field, chatter is one of the challenging research topics.

II. OBJECTIVE

The purpose of this topic is to study the chatter vibration analysis and its control methods.

By using Simulink model it can be shown that how chatter vibration affect on the machining operations such as turning, milling, grinding.

III. LITERATURE REVIEW

V.K. Murugan, P. Koshy [1] Mathewshas discussed in his paper an optimal setting of carburizing process parameters (carburizing temperature, soaking time, gas diffusion effect ,furnace air circulation) causing in optimal values of the correct depth of the case in the surface of the components. Taguchi method is a influential design of the experiment (DOE) tool for engineering optimization of a process and they concluded that The Taguchi method efficiently, obtains optimal heat treatment parameters for the plain low carbon steel, reduces the number of experiments, and analyzers the effect of each heat treatment parameter on the experiment results and the contribution of individual parameters.

S.Z. Qamar [2] has analysed results of mechanical testing performed on variously heat treated H11 steel samples, to arrive at an optimum heat treatment strategy for hot work applications. The tensile and impact test specimens were fabricated using precision milling and EDM. These samples were exposed to various heat treatment arrangements, consisting of annealing, hardening, air and oil quenching, and tempering at different temperatures. Heat treated samples then mechanically tested for hardness (Rockwell), impact toughness (Charpy), and tensile properties (yield strength, ultimate strength, ductility). The paper concludes that mechanical testing of H11 samples revealed that with increasing temper temperatures hardness first increases to a maximum and then gradually decreases; impact toughness first decreases to a minimum and then increases.

Harvinder Singh, Aneesh Goyal [3] found out that the Cryogenic treatment process uses sub-zero temperatures down to -184°C to modify the micro-structure and properties of material. This process is an extension of heat treatment which further improves the properties of material. This paper focuses on the effect of cryogenic treatment on High Speed Steel (T-15) tool material. Cryogenic treatment at -184°C is conducted in this research and its properties compared with untreated material. It has been found that as the temperature is decreased, microstructure of material is refined and more number of carbide precipitates appeared on the surface after the treatment. Interestingly to note that the retained austenite is completely converted into marten site after subjecting the T42 HSS specimen to cryogenic treatment. The micro

structural changes results in improvement of properties of HSS, (T-15) tool material.

O.O. Joseph, R.O. Leramo [4] has studied The effect of heat treatment at 850oCon the microstructure and mechanical properties of SAE 1025 carbon steel has been studied. Annealing, normalizing and age-hardening heat-treatments at 850oC were used for the experimental work. Hardness tests, tensile tests and metallography were done on the heat-treated and controlled samples. The results were additionally analysed using the one-way ANOVA test. Results obtained showed significant differences in the microstructure and mechanical properties of the different heat-treated samples. And observed that higher tensile strength was observed for the annealed samples than for the control, normalized and age-hardened samples. A microstructure of improved quality was obtained with normalizing heat treatment whereas a lesser quality was obtained by age-hardening.

IV. EFFECTS DUE TO CHATTER VIBRATION

Tool life is the major factors in the machining operations which also affect the cost as well as productivity. Chatter develops the dynamic interaction between the cutting process and the structure in the machining operations. The vibrating tool and wavy surface result in adjust chip thickness which causes regularly different cutting forces to excite work piece and machine. In the different conditions, vibrations increases continuously, resulting in uncertainty i.e. chatter vibrations.

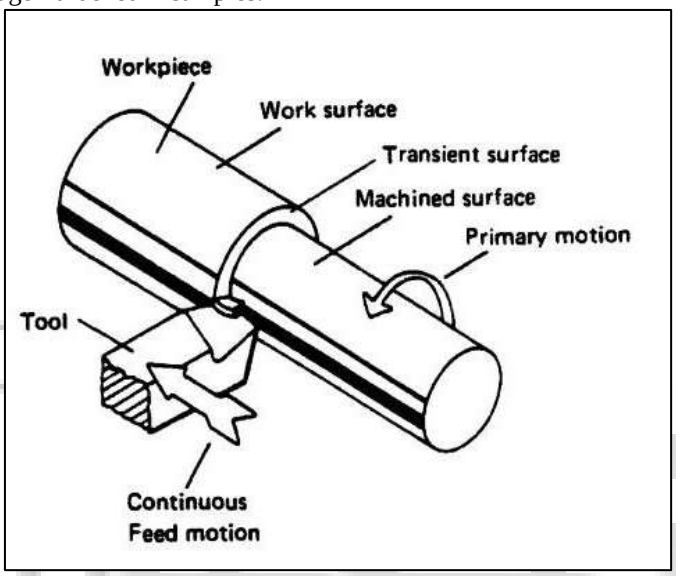

Fig. 1: Cylindrical Turning on a Lathe

A. Effects on the Productivity

With today's increasing requirements for high quality and high productivity in manufacturing operations, the stability analysis for non-uniform work piece becomes especially important.To avoid chatter vibrations the removal rate of material can be reduced which decreases productivity. There is a need to develop best techniques to avoid the chatter vibration and control methods because of there are also pressure on manufacturing industries for higher productivity. The major obstacles in achieving desired productivity is chatter vibration among all the cutting operations. Because of chatter vibrations there is also effect on the tool life and due to this productivity also get lower down.

B. Simulink Model

Simulink is done by using the matlab which is developed by Math Works, which is used for mathematical modeling, simulating, and analyzing dynamic systems. By using Simulink library we can make the block diagram. It offers tight integration with the rest of the MATLAB environment and can either drive MATLAB or be scripted from it. For the simulation and design Simulink is used in the digital signal processing and control theory. Model is created to generate chatter signals at various conditions such as speed, depth of cut, and feed in the noisy environment. By using the numerical simulation of the turning process of a cylindrical work piece the effectiveness of the chaos spindle speed, feed and depth of cut variation technique is tested. With the help of matlab tool we can solve both the linear and nonlinear problems. The Simulink model is as shown in the figure 5. The simulation parameters used are as follows: m =100 kg, c=5321 Ns/m, k=4×107 N/m, k_c=2000 N/mm^2, S_0=1200 rpm, f_0=1 mm/ rev, b=2 mm, and the input gain k_p=1000.

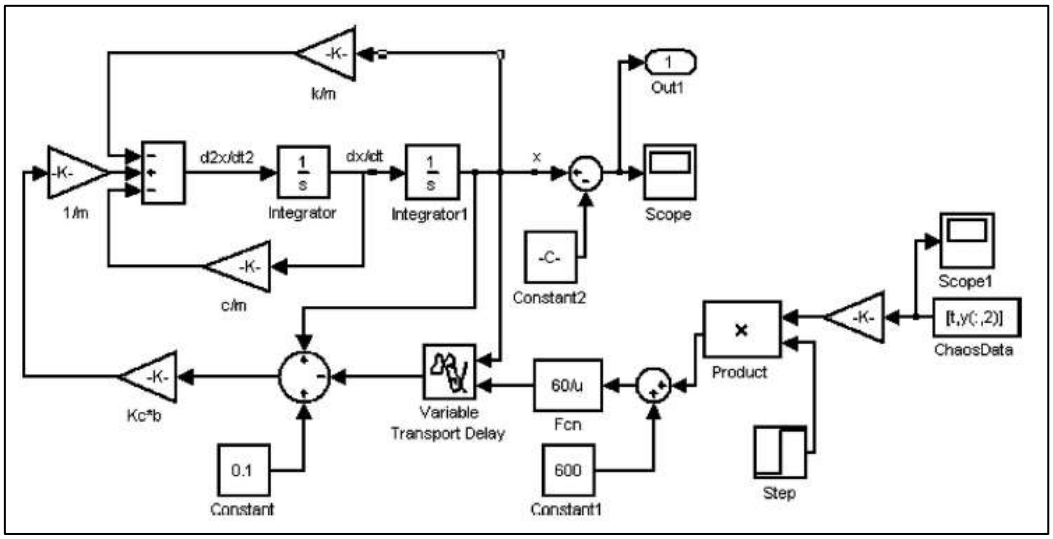

Fig. 5: Simulink Model

V. Result & Discussion

By using Simulink model it can be shown that how chatter vibration affect on the machining operations such as turning, milling, grinding. It is always better to avoid chatter vibration before it appears. Chatter vibration shows some serious problems such as more noise, breaking of machine tool components, poor surface finishing, and tool life as well as productivity. Due to the chatter, the amplitude of the self-excited vibration gets increase to the nonlinearity limits. Tool life is the major factors in the machining operations which also affect the cost as well as productivity.

Chatter vibration effect on the tool life, tool wear, productivity and due to vibration it also decrease the production rate. There are various methods also mentioned in the control method section of the report. In the case study section force vibration measurement also carried out. By using the equations of motions of the chatter vibration Simulink model is created. With the help of mathematical equations and some standard data Simulink model gives the various results. This simulation result demonstrated the capacity of the system to enlarge stability.

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