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Effect of Vibration on Surface Texture during Machining Multiphase Microalloyed Steel

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Abstract

Multiphase ferrite-bainite-martensite (FBM) microalloyed steel produced through two step cooling procedure was turned and compared with ferrite-pearlite (FP) microstructure and tempered-martensite (TM) microstructure to study the effect of vibration on surface finish. The cutting parameters like cutting speed, feed and depth of cut were varied to understand the parameter influence on surface finish due to vibration. The result shows that FBM microstructure steel gives better performance in terms of lower surface roughness and lower vibration compared to FP and TM microstructure steel.

Keywords: Multiphase microalloyed steel, surface finish, vibration

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1. Introduction

In turning process three different types of vibration like free, forced and self excited are generated. These vibrations are present due to a lack of dynamic stiffness/rigidity of the machine tool system comprising of tool, tool holder, work material and the machine. Free vibrations are generated due to shock and forced vibrations are present due to unbalance, misalignment, mechanical rigidity and gear defects in the machine tools. Frictional chatter occur when rubbing on the clearance face excites vibration in the direction of the cutting force (Fc) and limits in the thrust force (Ft) direction. Thermo-mechanical chatter occurs due to the temperature and strain rate in the plastic

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deformation zone [1]. Self excited vibrations are classified into primary and secondary chatter. Primary chatter is caused by friction between tool and workpiece, thermomechanical process or by mode coupling. Secondary chatter is caused by the regeneration of a wavy surface on the work piece. Secondary chatter or regenerative vibration is the most destructive among all vibrations [2]. Chatter vibrations occur due to instability in the dynamic cutting process. Instability occurs when the excitation frequency in cutting is equal/close to one of the natural frequencies of machine tool [3]. Modulated chip thickness that forms due to vibration increases the cutting force dynamically which in turn increases vibration amplitudes and degrade the surface quality [4]. The occurrence of chatter produces following negative effects: 1. Poor surface quality 2. Excessive noise and tool wear 3. Machine tool damage and reduced material removal rate 4. Waste of work material, energy 5. Increased cost in terms of production time, recycling of waste material [5]. Thomas et al. (1996), investigated the effect of tool vibrations on surface roughness during lathe dry turning process. It is reported that correlation between surface roughness and tool dynamic force exist only when operating in the built-up edge range. The built-up edge formation deteriorates the surface roughness and increases the dynamic forces acting on the tool. The built-up edge formation is minimized by increasing depth of cut and tool vibration [6].

Suyama et al. (2016), studied tool vibration in internal turning of hardened steel using CBN tool. Tool vibration is more critical in turning hardened steel since this operation replace grinding. The influence of cutting conditions, material of the tool bar, tool overhang (L/D ratio) in the workpiece surface roughness and tool life were studied. Radial vibration influence more on surface roughness than tangential direction. The result shows that vibration and material of the tool holder plays a secondary role in surface finish [7]. Upadhyay et al. (2013), developed artificial neural network model to correlate acceleration amplitude of vibrations in axial, radial, and tangential directions with surface roughness. The result shows that acceleration produced in radial direction is more followed by tangential and axial direction. It is also seen that for higher radial acceleration the surface roughness is higher [8]. Abouelatta and Madl (2001), also formed a regression model to predict surface roughness and tool vibration in radial and feed direction during turning free machining steel [9]. Hessainia et al. (2013), conducted turning test on 42CrMo4 steel and predicted the surface roughness and vibration in radial and tangential direction. The optimum parameters were found using response surface methodology (RSM) technique. It is reported that higher speed with lower feed and lower depth of cut gives optimum surface finish. The vibration was measured in terms of acceleration and it is seen that acceleration in the radial direction is more compared to tangential direction [10]. Dimla (2004), studied the impact of cutting conditions on cutting forces and vibration signals in turning with plane face geometry inserts. It is observed that acceleration amplitude were higher in work tool than fresh tool and this discrepancy may due to crater wear, BUE formation at lower cutting speed and alteration in the tool chip contact length. It is also seen that worn tool produces higher resonant frequency than fresh tool [11].

Bonifacio and Diniz (1994), reported that during turning AISI 4340 steel with coated carbide tool the feed rate influence only on surface roughness and did not influence much on vibration signal [12]. Chelladurai et al. (2008), reported that tool vibration increases with increase in depth of cut as well as increase in flank wear. This increase in vibration is due to an increase in cutting force which reduces stiffness of the cutting tool. The amplitude of vibration in terms of acceleration (g) increases with increase in feed rate which results in increased dynamic cutting force. The increase in dynamic cutting force is associated with reduction in the stiffness of the cutting tool. Increase in cutting speed reduces the cutting force and hence reduces the vibration [13]. In this research work the effect of axial vibration on surface roughness were studied for three different microstructure steels by varying the cutting parameters like cutting speed, feedrate and depth of cut.

2. Experimental Procedure

2.1 Material Processing

The medium carbon microalloyed steel (38MnSiVS5) was processed to produce ferrite – bainite-martensite (FBM), tempered-martensite (TM) and ferrite-pearlite (FP) microstructure steel. The processing sequence is shown in Figure 1.