Effect of electropulses on the plastic deformation during machining

The plastic deformation is a nuisance to study the machinability of materials in metal cutting processes. The high process efficiency can be achieved by minimizing the work done in the plastic deformation of chip. It was generally observed that in metal cutting process only 30-50% of energy spent for useful work. Therefore, reducing the energy spent in metal cutting is of high interest.

The chip compression ratio can be considered as a measure of plastic deformation which decreases with the increase in cutting speed. Due to the increase in cutting speed, the temperature rise in primary shear zone decreases the shear strength of material which ultimately reduces the cutting forces.

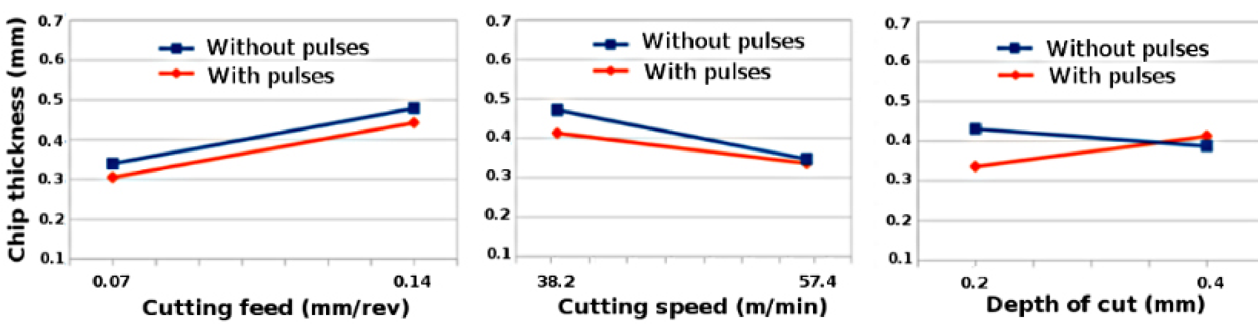

Fig. 1. Variation of chip thickness with cutting feed, cutting speed and depth of cut while turning steel S235 with and without pulses.

However, the materials with more ductility have higher degree of plastic deformation and high temperature of chip than those of less ductility during cutting. Therefore, the research is also focused on those materials in which chip compression ratio increases with the increase in cutting speed.

Commercial steel alloys (S235) and aluminium alloys (Al 6060) of 20 mm diameter were chosen as workpiece materials for test specimens. A polymeric material was used to electrically isolate the workpiece and tool holder from the lathe. The power consumed was continuously measured by a self made monophasic energy analyzer linked to the motor of the machine. A self made short duration electric pulse generator was developed to discharge multiple positive pulses.

Electropulsing is recognized as a novel technique to evaluate the machinability of materials with respect to chip compression ratio, shear plane angle and specific cutting energy (SCE) in metal cutting processes. An increase in cutting speed leads to a decrease of plastic deformation in chip formation zone. The Figure 1 shows that the chip thickness decreases as the cutting speed increases during electrically assisted turning process of steel S235. So, the region of plastic deformation becomes smaller which ultimately reduces the energy consumption. The reduction in chip thickness will result in shorter shear plane, whereas longer shear plane is associated with thicker chip thickness produced during cutting process. When chip thickness decreases, the chip compression ratio increases which shows plastic deformation of material increases.

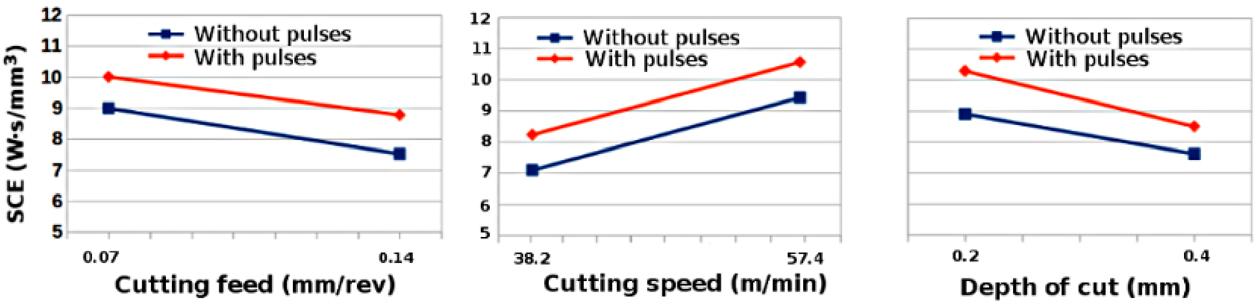

Fig. 2. Variation of SCE with cutting feed, cutting speed and depth of cut while turning aluminium 6060 with and without pulses.

However, the SCE increases with the increase in cutting speed during electrically assisted cutting of aluminium 6060 as shown in Figure 2. Since, aluminium 6060 has higher thermal conductivity and less thermal softening effect as compared to steel S235, the strain rates is the shear zone is expected to be high at higher cutting speeds. Hence, due to the increase of temperature and flow stress in the chip formation zone, the plastic deformation increases which increases the SCE of aluminium 6060.

Finally, the electrically assisted turning process reduces the machinability of aluminium 6060, which is probably due to its high ductility and higher degree of plastic deformation as compared to steel S235.

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Publication

Influence of the Regime of Electropulsing-Assisted Machining on the Plastic Deformation of the Layer Being Cut.
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