Abstract

Machining is a widely used manufacturing process. This work explores the simultaneous machining by two single point cutting tools to enhance the productivity of the turning process. In order to perform a double tool turning process a conventional lathe was modified. A tool holding fixture was developed and mounted at the rear side of the lathe carriage. In double tool turning process the various process parameters are cutting speed, feed, depth of cut and distance between the two cutting tools. Experimental investigation was carried out to determine the influence of cutting parameters on cutting forces, cutting temperature, cutting tool vibration, diametral error, tool wear and surface roughness. The chip morphology was also studied.

In the present work, it was observed experimentally that the rear cutting tool experienced lesser cutting force than front cutting tool at certain cutting condition, while turning grey cast iron. This is attributed to the reduction in coefficient of friction of the rear cutting tool, caused by the cleansing effect of the front cutting tool. At other cutting conditions, there is no significant difference in cutting forces between the front and rear cutting tool. It was found that the temperature rise in the workpiece caused due to the front and rear cutting tool remained uninfluenced by the distances between the cutting tools. An analytical model was developed for single tool turning process based on ductile fracture mechanics approach and experiments were also performed on mild steel work material. The analytically predicted cutting force and cutting temperature was correlated with the experimental results. For the selected cutting conditions it was observed that with the increase in cutting speed the cutting tool vibration of both the tools reduced. The rear cutting tool vibration was lesser than the front cutting tool. One obvious reason is that the rear cutting tool is mounted over the fixture made of cast iron while the front cutting tool fixture is made of steel.

In double tool turning process the deflection of the workpiece due to front cutting tool is resisted by the rear cutting tool, as the cutting forces of the tools acts opposite to each other. Moreover the rear cutting tool acts as a follower rest apart from removing material from the workpiece. It was realized that the diametral error got reduced by 80% while turning grey cast iron at a cutting speed of 116 m/min, 0.24 mm/rev feed, 1 mm depth of cut and 10 mm distance between the cutting tools. The diametral error was found to be higher at the tailstock end due its lesser rigidity and lesser at the headstock end due to its higher rigidity. In comparison with single tool turning for depths of cut of 1.5 mm and 2 mm, a significant reduction in diametral error was observed for double tool turning process. At higher depths of cut, the resistance offered by the rear cutting tool against the workpiece deflection was more than at lower depth of cut. The radial deflection of the workpiece was calculated theoretically based on simple strength of materials approach. The experimental results were in agreement with the theoretical results. The front cutting tool machined the material as well as heated the workpiece slightly. The effective coefficient of friction of the rear tool was lesser than the front cutting tool. However, the average surface temperature of the workpiece near the rear cutting tool was higher than that near the front cutting tool and this may be due to strain hardening. The rear cutting tool experienced lesser wear compared to front cutting tool. The chips generated during double tool turning process were examined using a scanning electron microscope. Morphology of the chip produced by the front cutting tool exhibited cracks and streaks with fracture as the dominant failure. The rear cutting tool generated chip with cracks, streaks and micro pores along with fracture.

In this thesis, experimental investigation was also conducted to determine the influence of machining parameters on the average surface roughness of AISI 1050 steel and grey cast iron work surfaces. It was observed that the average surface roughness decreases with the increase in cutting speed. On increasing the feed for AISI 1050 steel, initially the average surface roughness decreased up to 0.12 mm/rev feed and thereafter it increased. For grey cast iron the average surface roughness increased with feed for all cutting conditions. A similar behaviour was observed for depth of cut except for low feeds. The average surface roughness was not affected by tool separation distance. An approximate cost analysis was carried out for single tool and double tool turning process. Double tool turning process produced a good surface finish and less diametral error. It was cost effective compared to conventional turning process.

Keywords: Cutting forces, cutting temperature, cutting speed, diametral error, tool wear, tool vibration and surface roughness, turning, multi-tool machining