Influence of Cutting Angle of Indexable Drill to Drilling Performance

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Abstract

For this research focused on the study of drilling tool steel SKD11with two types of indexable insert drills, the UP20M and VT15TF inserts, which are both from Mitsubishi Carbide. The UP20M is coated with TiN with an obstruction type chip breaker and a negative rake angle, while the VT15TF uses TiAlN with a grooved type chip breaker with a positive rake angle. The feed rate is the same across the board at 0.06 mm/rev. Three different cutting speeds were compared. Oil was used as the coolant for all processes with the insert drills. The results show that thrust force of the VT15TF certain spikes more than that of UP20M. The wear on the inserts is very prominent on the lower cutting speed settings comparing to higher cutting speed. The results of height of burr show that low cutting speed drill gives lower height of burr value than those of medium and high cutting speed respectively.

Keywords: Indexable Drill, Dynamometer, Thrust force, Wear, Burr height

1. Introduction

Drilling is quite important in machining processes since it is one of the fundamental processes in almost every manufacturing industry.[1-2] Drilling of hard-to-machinable materials such as stainless steel has been applied. Widely in a wide range of applications, such as aircraft work, automotive parts, as well as chemical related materials. The device used to drill holes must be capable of withstanding high friction resistance to prevent wear. At present, a new type of drilling equipment has been introduced that is more resistant to wear than traditional drilling equipment. Nowadays, an indexable drill has been used in order to save material, the ability to change the cutting insert after out of lifetime. The hole can be precisely produced and quick to set up. This research was conducted with vary parameters. The effects of the cutting force in z axis, tool wears and height of burr were investigated.

2. Kinetic Force in Drilling Process

By analyzing the plan of cutting forces in drilling Figure 1 it is possible to conclude that the twist drill is affected by the following loads: torque, which is the result of the two main cutting forces Fv, and thrust force as the sum of the two feed forces Fs1. The sum of penetration forces Fp is zero, only if two main cutting lips are identical and are symmetrical upon the drill axis. [9]

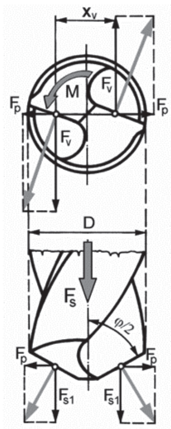


Figure 1 plan of cutting forces in drilling [10]

3. Experimental procedures

3.1 Drilling experiments

In order to run the drilling experiments, computer numerically controlled vertical machining center was carried out using 12-millimeter diameter of indexable drill. The different type of insert cutting equipment. The TiN coated UP20M insert and TiAlN coated VT15TF insert were used for comparing performance. The workpiece used in the present study is tool steel grade SKD 11. It was carried out in the strip form as workpiece material a building block with 300 mm (length) 34.5 mm (width) 10 mm (thickness) was prepared. Before the start of experiments, the SKD

11 tool steel was prepared with face mill to reduce the impact of defects on any surface of the workpiece.

3.2 Experimental setup

The experiments were performed and use wet coolant system condition by oil coolant [3]. The experimental setup of the drilling tests as shown in Figure 2. The workpiece was mounted on a specially designed fixture which connected to the top of the dynamometer. The main purpose for using the fixture is to protect the dynamometer during the drilling.

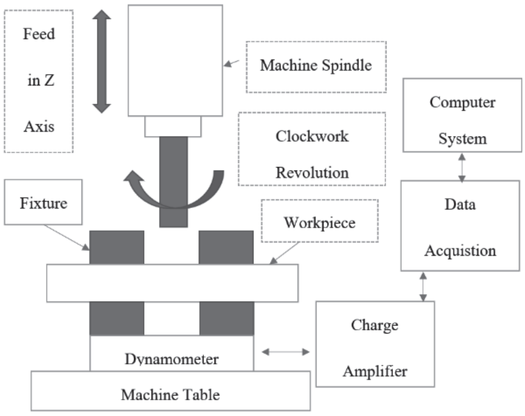
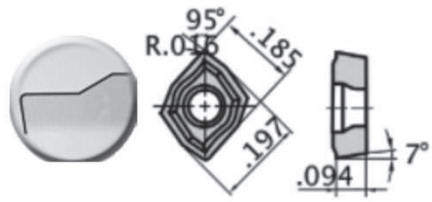


Figure 2 Schematic Diagram of Drill test set-up

In this experiment, two different types of indexable drill were used as shown in Figure 3. Both of them have the appearance of different according to the chip breaker type affects the rake angle as well. This is the angle between the tool face and the plane normal to the surface of the cut through the tool cutting edge. Generally, there are three types of rake angles: positive, negative and neutral (zero angle). A zero rake angle is the easiest to manufacture, but has a larger crater wear when compared to positive rake angle as the chip slides over the rake face. Positive rake angles make the tool more shard and pointed, which reduces the strength of the tool, as the small included angle in the tip may cause it to chip away [4]. This also helps reducing cutting force, power requirement and formation of continuous chips in ductile materials. This also can help the formation of a built up edge. Negative rake angles make the tool more blunt and increasing the strength of the cutting edge.

(a) VT15TF



(b) UP20M

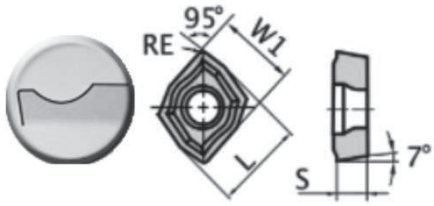


Figure 3 Indexable drill insert type:
(a) VT15TF and (b) UP20M

3.3 Measurements and analysis

Six holes were carried out to compare thrust force and tool wears, height of the burr under same machining condition. The thrust forces generated during drilling experiments were measured by a Kistler 9272 dynamometer It has the ability to measure force with Linearity less than or equal to 1% in all measuring ranges. and hysteresis is less than 1% in all measuring ranges.[5] The objective of wear inspection is to consider the efficiency of drill types due to feeding rate, and frequency of use. In order to investigate tool wear occurring on cutting tools, a microscope was used to inspect the wear of the insert drill [6-7] A dial gauge was used to measure the height of the burr of each hole. Four points of each hole were measured and averaged [8]. In the experiments, three different cutting speed (80, 120 and 160 mm/min) were used and calculated as shown in Table 1. The depth of hole was established as a fixed 13 mm in the tests.

Table 1 Variation of parameter

Experiment Drill Bits	RPM 2122 rev/min	RPM 3183 rev/min	RPM 4299 rev/min
U1 UP20M	CS1/UP	CS2/UP	CS3/UP
U1 VT15TF	CS1/VT	CS2/VT	CS3/VT

4. Experimental results and discussions

4.1 Variation of thrust force

Experimental workpiece drilling with different types of indexable inserts using different speeds, it was found that low (CS1) and middle (CS2) levels of the experiment showed no significant changes in the thrust force. When drilling with a high level (CS3) of variation of parameter, Z-axis force was measured with dynamometer. Figure 4 and Figure 5 show Z-axis force of UP20M and VT15TF. For high level (CS3), which can be visualized by the spikes. Each spike represents maximum force during each hole's drilling. In case of UP20M, spike is not clearly occurred, only at first contact between the drill and the material. The spikes for VT15TF was substantial, the first hole and the fifth hole give spikes that can reach over 20 kN. Spikes for UP20M were not occurred over than 20 kN. However, if those are disregarded, the graph still looks fairly stable, with forces averaging out at around the 15 kN. Both of Z-axis cutting forces give similar patterns, the 2nd and the 5th hole of every run seems to exert less force compared to other holes in its respective run. This may be result of cooling inconsistency, since the cooling tube is fixed into one position for the entire experiment. Judging from the graphs, the UP20M gives lower force than that of the VT15TF. It is important to note that there are some certain points where dips down to a negative value, this is probably caused by a chip that was stuck in the drilling hole or the drill was pulling on ledge during retracting.

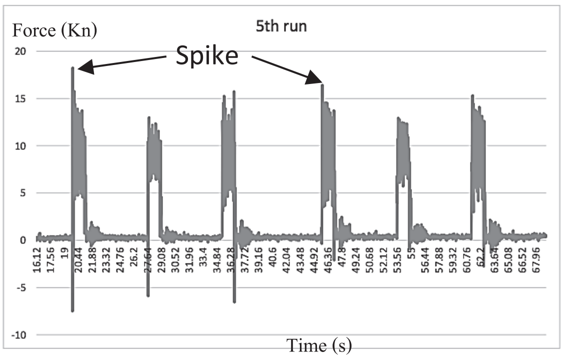


Figure 4 Z-axis force for CS3/UP

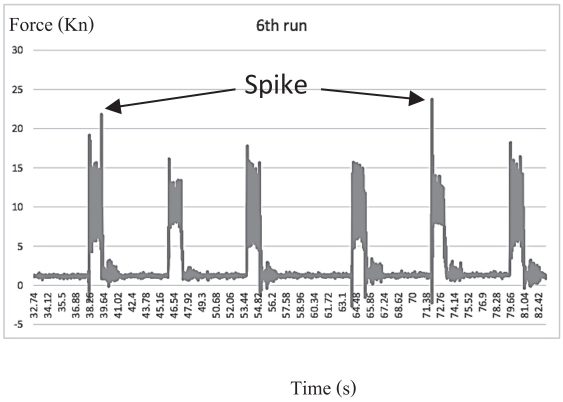
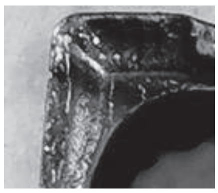


Figure 5 Z-axis force for CS3/VT

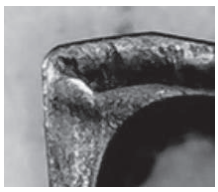
4.2 Tool wear

Figure 6 show tools wear for variant conditions with both inserts. In case of the lowest setting (Cs = 80m/min) of cutting speed, the inserts suffered from an unexpected huge amount of wear as shown in Figure 6(a). This may be due to the extended drill time. In the case of medium setting (Cs = 120m/min) as shown in Figure 6(b) and high cutting speed (Cs = 180m/min) as shown in Figure 6(c) both inserts look similar wear equally. The reason may be explained with its positive rake angle (first contact has lower surface area). At medium speeds the inserts still were affected from wear, but certainly less than the previous setting at the highest speed, astonishingly minimal wear made way onto the inserts. This is by far the best setting to use wear the inserts has to suffer

(a) CS1/UP20M



(b) CS2/UP20M



(c) CS3/ UP20M

Figure 6 Wears for varient conditions

4.3 Heights of burr

Heights of burr were investigated for each indexable insert. Figure 7 shows comparison for heights of burr for UP20M and VT15TF when using low speed test. The result shows that the VT15TF insert produces less burr's height than that compared to the UP20M. The comparison of the height burr using medium cutting speed test are shown in Figure 8. The results still show the same pattern as using low cutting speed, the VT15TF makes less burr's height than that of UP20M. From Figure 7 and Figure 8 it can be seen that the low cutting speed gives lower burr's height than that of medium cutting speed. The height of burrs for the 3rd and the 6th hole using VT15TF are less than other runs which could be probably caused by chips being stuck while drilling, which would make the cap be pushed out with uneven force on

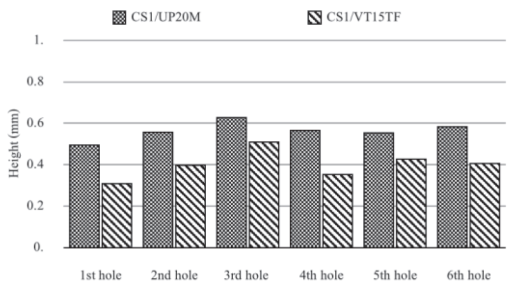


Figure 7 Burr height for CS1

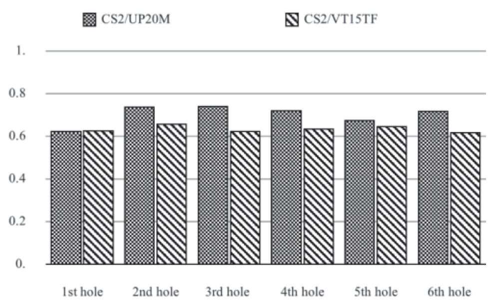


Figure 8 Burr height for CS2

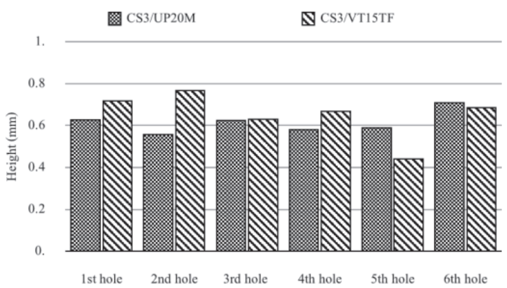


Figure 9 Burr height for CS3

Figure 9 shows that for drilling holes using the two type of indexable inserts that use high cutting speed for setting parameter, the burr heights for each hole are similar. Unlike the use of low and medium setting parameters, the UP20M indexable insert gives a burr height greater than that of the VT15TF indexable insert. However, the use of high cutting speed gives the burr height higher than that of the low and medium cutting speed.

With the high cutting speed test as shows in Figure 8, it is noted that the UP20M does not give the height of burr obviously more than that of VT15TF compared with low and medium cutting speed in Figure 7 and Figure 8 It may be explained that both inserts performed very well at high of this set up.

The reason for the higher burrs in the lower speeds in case of the UP20M due to its chip breaker, which is an obstruction type with a negative rake angle, so it performs like a pushing hole surface rather than a cutting edge. However, in case of using higher cutting speeds, the rake angle seemed not matter both types perform almost equally. However, the speed is too high, a positive rake angle with a grooved chip breaker could suffer due to its smaller contact area [8].

5. Conclusions

The performance of two insert drills was compared and can be concluded. It reveals that the indexable insert with a negative rake angle produces less thrust force than that of the indexable insert with a positive rake angle. The burrs height for the high setting (Cs = 160 m/min) were have the effect of increasing burrs height. The wear on both inserts were very prominent on the lower cutting speed settings (Cs = 80 m/min) compared to higher cutting speed (Cs = 120m/min and Cs = 160m/min).

6. Acknowledgements

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7. References

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