Control Chart of Drilling Exit Burr in Low Carbon Steel (AISI4118)

Sangkee Min
Sponsored By: CODEF

Abstract—Experiments to investigate drilling burr formation on Low Carbon Steel (AISI4118) were carried out. The split point twist drills with different diameters were used and the ratio of the depth of hole to the drill diameter was fixed in order to ensure a steady state cutting process and prevent tool wear. A control chart for prediction of burr type and size in drilling of low carbon steel (AISI4118) by split point twist drills was developed.

Background

The formation of the drilling burr depends on many parameters such as characteristics of workpieces (material properties, geometries, surface roughness), drills (material properties, geometries, tool wear, temperature, chip formations), and process parameters (cutting speed, feed rate, usage of coolant, rigidity of machine, temperature). Even with many approximations, it is still difficult to formulate the burr formation analytically and empirically although a tool to predict a drilling burr to enhance the quality of product concerning manufacturing time and cost is of most interest of industry. An alternative way to provide a tool to predict a drilling burr is the "Drilling Burr Control Chart" (DBCC) introduced by Kim and Dornfeld [1]. They used the stainless steel because it has relatively large strain-hardening coefficient and ductility, which contribute to produce burrs of typical shapes and shows clear difference between different shapes.

Experiment

The low carbon steel alloyed with chromium and molybdenum (AISI4118) widely used in automotive industry was chosen to generate the drilling burr data and construct the DBCC. The chemical composition of the material is shown in the Table 1.

C	Mn	Si	Cr	Mo	P	S	Al
0.18 – 0.22	0.60 – 0.95	0.15 – 0.40	0.40 – 0.55	0.40 – 0.50	< 0.035	0.020 – 0.035	0.02 –0.05

Table 1. Chemical Composition of AISI4118

The split point twist drills were used and the cutting speed and feed rate were chosen over the recommended range [2]. The process parameters used for the experiments are shown in the Table 2.

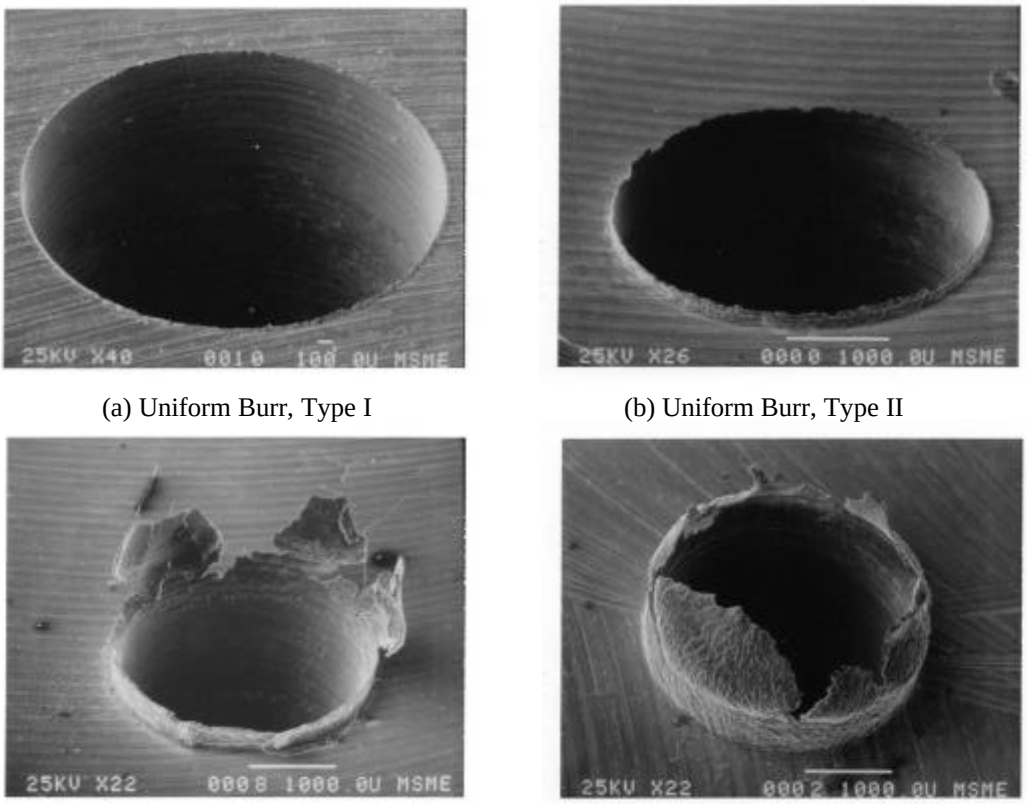
Drill Diameter (mm)	Cutting Speed Parameter (mm/min)		Dimensionless Feed Parameter	
	S_{min}	S_{max}	F_{min}	F_{max}
1.5	0.024	0.060	0.0067	0.020
2.0	0.025	0.063	0.0050	0.050
2.8	0.022	0.070	0.0054	0.036
3.0	0.024	0.075	0.0050	0.033
3.5	0.028	0.088	0.0086	0.071
4.0	0.025	0.080	0.0075	0.063
5.0	0.025	0.080	0.0060	0.050
6.0	0.024	0.075	0.0050	0.042
7.0	0.022	0.088	0.0043	0.036

Table 2. Process Parameters

Results and Future Work

The uniform burrs are classified into the type I (burr height is less than 180 μ) and the type II, Figure 1. (a), (b). The most of the type I burrs appear at the lower feeds ($F<0.02$) regardless of the cutting speed. The crown burrs are formed at the higher feeds ($F>0.057$), Figure 1 (d). The unique difference between the stainless steel burr and the low carbon steel burr is the formation of the irregular burrs, Figure 1 (c). The irregular burrs have the transient shapes from the uniform burrs to the crown burrs. Due to the lack of ductility, the material fractures before it forms complete cap and produces irregular burrs. They appear at the specific range of the cutting speed parameter ($0.043<S<0.064$). Interestingly, the drills broke at this range with the higher feeds.

For the 2.0, 2.8, and 3.0 mm drills, the type I uniform burrs are formed up to the feed, 0.05. At this point, it is not explainable and, therefore, further experiments are needed.



(a) Uniform Burr, Type I (b) Uniform Burr, Type II

(c) Irregular Burr (d) Crown Burr

Figure 1. The Four Types of the Low Carbon Steel (AISI 4118) Burrs

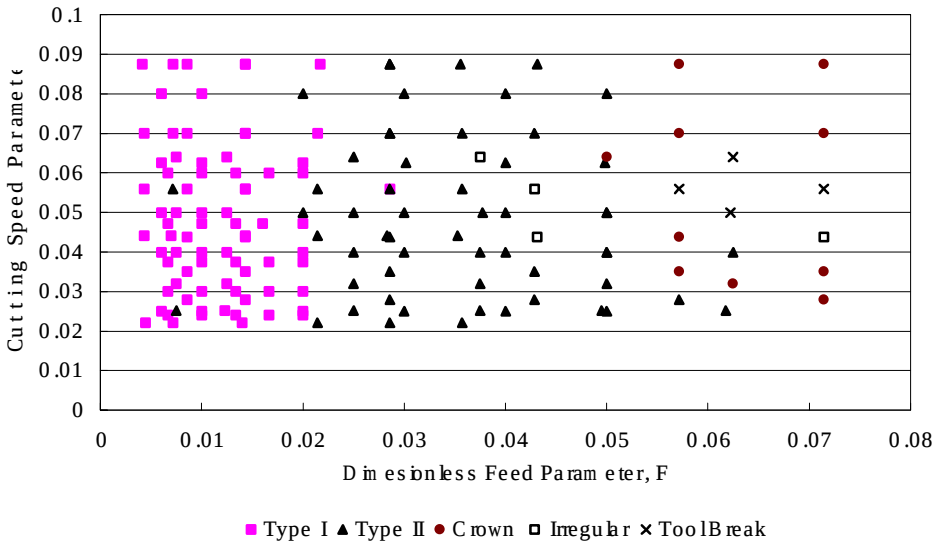


Figure 2. The Drilling Burr Control Chart (DBCC) of the Low Carbon Steel (AISI 4118)

References

[1] Kim, J., Dornfeld, D. A., “Development of a Drilling Burr Control Chart for Stainless Steel”, Submitted to NAMRC XXVIII, 1999
[2] Industrial Press Inc., “Metal Cutting Tool Handbook”, 1989