The effect of burr formation in drilling with MQL

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Abstract: Even if the manufacturing is organized in a fully automated factory many deburring operations are carried out manually or additional machining process. The cost of the manufacturing are expanded because of the deburring cost. Burr has usually adverse effects on the assembly. The reliability of workpiece with burrs in function is decreasing. During the experimental AlMgSi1 aluminum alloy was machined with different drill tools and cutting conditions to examine the effect of the tool geometry and lubrication systems. The dimension of the burr size was measured by laser scanning sytem.

Keywords: burr formation, exit angle, burr scanning, MQL

1. Introduction

After the machining process the edges of the workpiece must be burr free. Burrs developed on any surface of the product could prejudice the latter steps of manufacturing eg. measuring or assembly. Post-process deburring is feasible but only with extended expenses. A study presented by Aurich [1] shows that in automotive industry the need of human resources and manufacturing time could be raised by 15-15% due to deburring. Burrs caused a 2% increase of reject rate and a 4% increase of machine breakdown time. Averaging these datas the overall manufacturing costs were increased by 9% because of burr formation. Thus, researches on effective burr minimization have significant importance. Figure 1. shows the different levels of burr control.

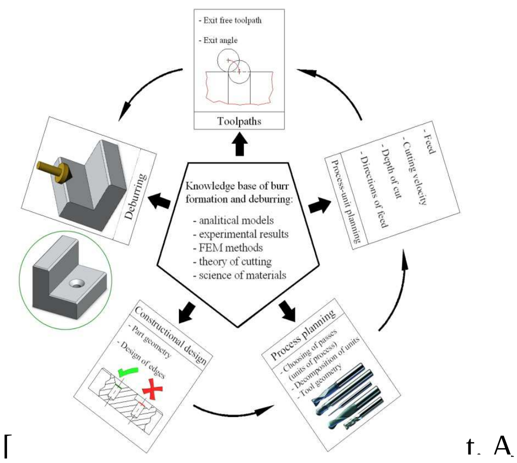

Fig. 1. Levels of burr control

2. Mechanism of burr formation

According to ISO13715 [2] an edge is considered to be burred if it has any overhang greater than zero formed by remaining material.

One of the first technical description was given by Schäfer [3]. He stated that burr is a part of the workpiece formed during manufacturing and it lies outside the ideal workpiece geometry. Based on Schäfer's work Ko [4] extended this statement and described burrs as an undesired result of plastic material flow during cutting processes. Gillepsie defined burrs as all the material which extends two theoretical (not ideal) surfaces that border the workpiece.

This paper defines burrs as a difference from the ideal workpiece edge in a certain extent, produced during cutting processes undesirably and unavoidably. The difference can be a solid body made of workpiece material (burr) or a material loss (edge breakout).

The definition describes edge breakout as a burr, because in the case of machining certain materials (eg. cast iron) burr formation can change to breaking out of exit edges depending on applied tool and cutting parameters. Numerous studies on burr formation mechanism are available. This article refers primarily to the work of Hashimura, Chang and Dornfeld [6].

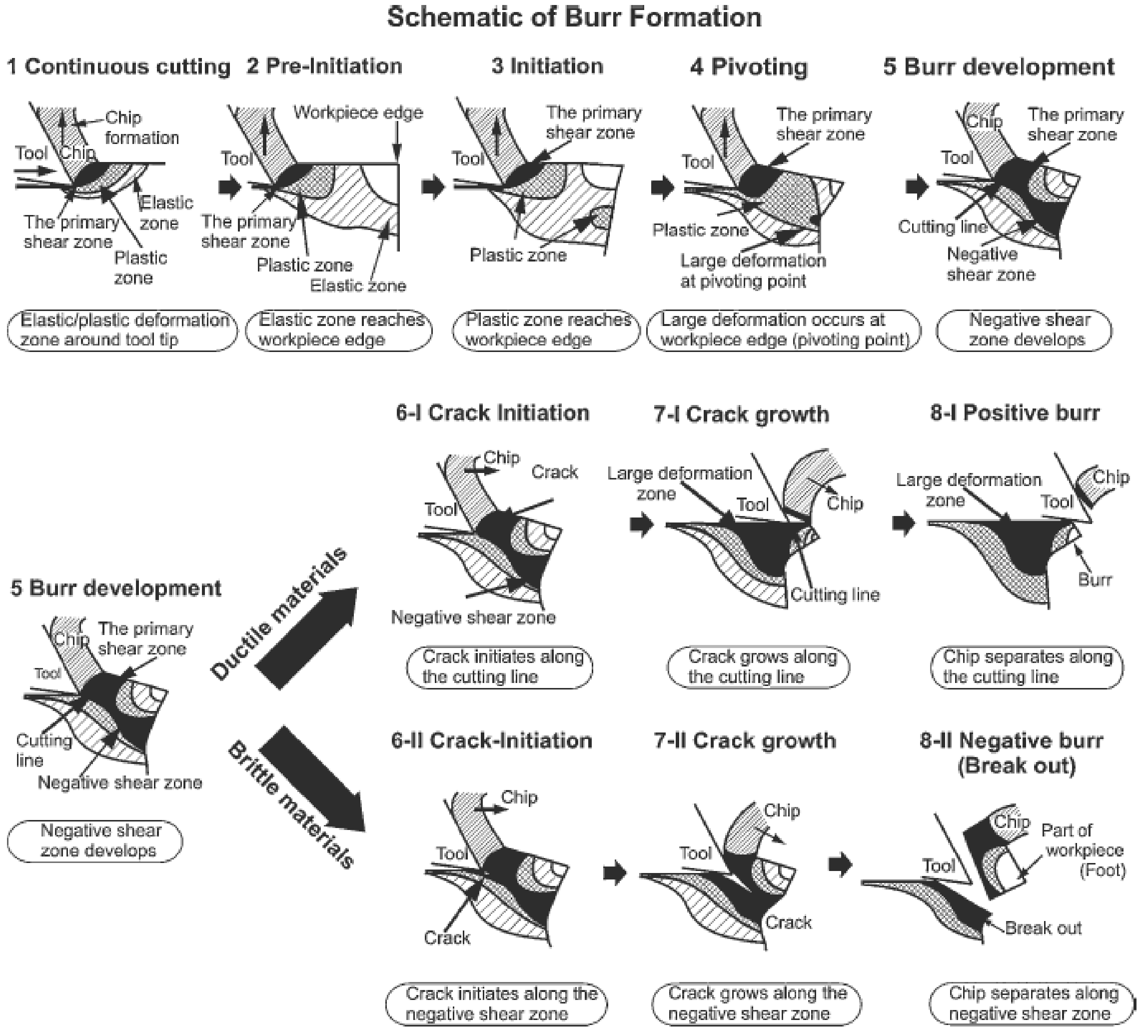

Fig. 2. Schematic of Burr Formation [6]

They differentiate 8 physical phases of burr formation, and secondary shearing have an important role in their model. (Figure 2.)

Stein checked the burr formation mechanisms at drilling operations. He showed that cutting with similar tool geometry for all machined material do have a typical substance burr height/ un-deformed chip-area ratio. This rate is valid if the tool primarily sheared material, and the rate of conversion is not significant.

It can be estimated in the light of the ratio what is available in tool geometry, where the least burr formation comes at given materials cutting. [10]

The model of Min, Dornfeld and Nakao [11] is not taken into account the exit burr surface geometry changes to determine the prospective location of the exit burr. For predicting the location of burr formation introduces relative exit angle, which is the angle between the drill tool resultant cutting velocity vector and the relative exit angle of surface vector. (Fig.4)

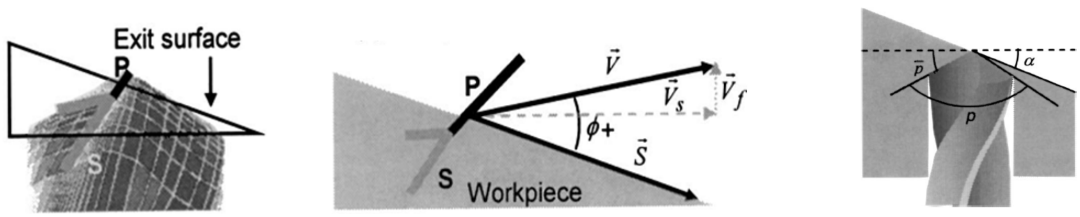

Fig.4. Definition of the interaction angle in drilling [11]

P: Primary cutting edge (angle: *p*)
S: Secondary cutting edge
Φ: Interaction angle
$\overline{S}$: Surface vector
$\overline{V}$: Velocity vector
$\overline{Vs}$: Velocity vector for speed
$\overline{Vf}$: Velocity vector for feed
α: Exit surface angle
$\overline{p}$: Slope of the primary cutting edge

According to them burr forming increases by increasing the feed rate, the speed and exit surface angle decreases it.

3. Burr control strategies in drilling

There are several reasons of burr occurring at drilling operation in the direction of tool entry: chipping, shear after wrapping, or, side way extrusion. If the drill tool is sharp at exit, then due to friction Poisson burr appears at tool edge. At normál or shabby edge the chip, that has not been fully cut-roll over („roll–over" chip), and there is underlying burr.

Kim [12] grouped the burrs at drilling operation according the formation mechanism and according to their shape,

- Even burr lid
- Even without its burr lid
- Crown or petal-shaped burr

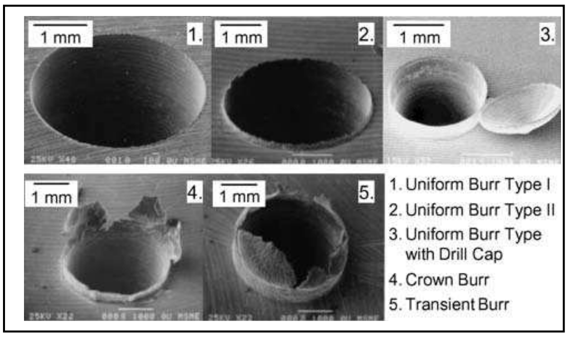

Fig.15. Typical drilling burr types [12]

We have examined how the cooling types influence on the size of burr. The following tools were been used: (all diameter is 12,5 mm)
Work piece material: AlMgSi1
Machine-tools: KONDIA B640

Table 1
Cutting tools for examination

	Two-edged drill tips DFR 125R3WD20M Ø12,5, Tip: DFR 020204 LLD KC7225
	B411 A12500 Ø12,5, four edges, straight groove twist drill, uncoa carbide, KF1 , 130°-os face angle.
	B707 A12500FBS Ø12,5, two edges, flat end twist drill, carbide without coating, KC7315
	B22512500CS5 Ø12,5, two edges, solid twist drill, TiN coated, 14 cone angle.

Cooling: 1. External cooling,
emulsion Vasco 1000
2. MQL via main shaft,
oil: TRIM® ML26

In the case of Emulsion the internal cooling is not used, because it would be difficult for MQL, coolant system exempt from coolant. The size of burr was measured by laser scanning. (Scan Tech)
During application of MQL, it was necessary to measure the quantities aerosol dispenser. This was determined by measurement for each individual tool. During the measurement of aerosols filled a sponge was introduced into a closed pan. From the substance mass of material, from the measuring duration and from the viscosity of oil minimal coolant quantity can be determined.

Table 2

Carburettor/injection pressures (bar)	2/4,5	2/3,5	2/2,5
Tools	q [ml/h]	q [ml/h]	q [ml/h]
DFR 125R3WD20M	45,9	34,1	31,1
B411 A12500	34,5	29,5	27,6
B707 A12500FBS	50,5	43,7	38,6
B22512500CS5	56,7	45,4	38,4

4. Burr measurement

By the help of a laser scanner placed into the main spindle of the machine-tool, surface placed on the points (X, Y, Z co-ordinates) of burr shape received at the exit of the drilled hole. The hole base plane was considered as the reference plane. The burr is positive, if greater than the size of the Z plane and negative if smaller. This is the break out. The layout of the measurement is shown in Fig. 16. The shape of hole burr after determining the burr could be seen in Fig. 17.

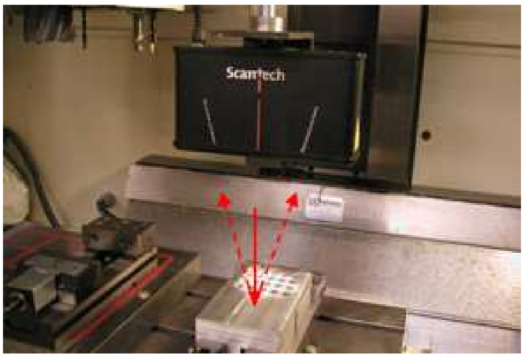

Fig.16**.** Non-contact measurement of burr with a Scan tech laser system

A total of 96 holes were been made in the course of the experiment, with 4 cutting tools, with emulsion cooling minimal lubrication (MQL). The size of burr was taken at each 60^0 .of periphery. The results obtained by the similar technology holes are averaged.

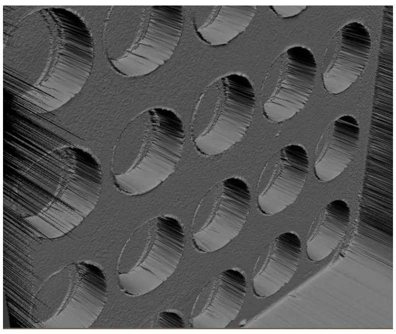

Fig.17. Exit burrs from the leaser measured burr points

5. Results of experiments

For reasons of space few charts are presented in the same the diagram.

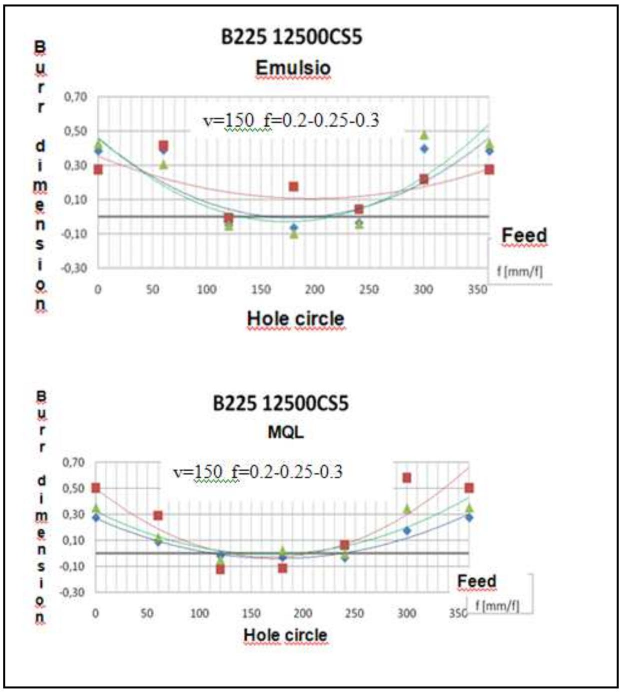

Fig.18. Result of experiments

6. Conclusion

To minimize the burr formation the first powerful tool is the design. At same time the operation sequence planning can also help to minimize the burr. At drilling operation, it is shown the influence of the cooling mode on the resulting size of burr. With minimal quantity lubrocation (MQL), the negative burr can be reduced (break out), and burr size could be kept in to a narrow zone.

7. Acknowledgement

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[2] International Standard ISO 13715:2000, Technical drawings - Edges of undefined shape Vocabulary and indications

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