Burr formation and prediction in slot milling of titanium alloy

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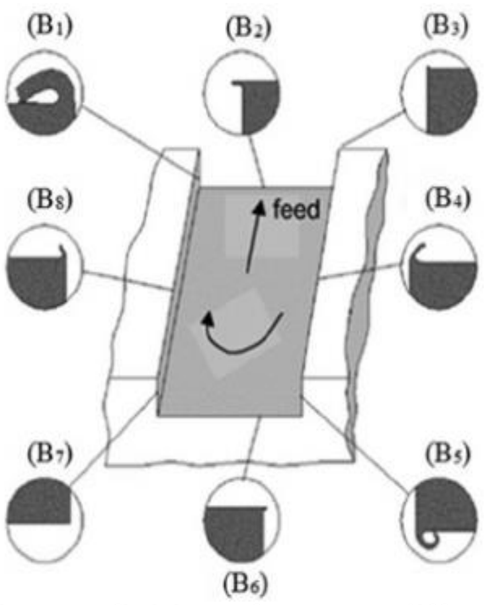
Background & Aim

The existence of burrs may deteriorate the dimensional accuracy and surface finish, decrease the fit, and pose a challenge to the subsequent assembly during automatic production. For machining of titanium alloys, burrs have profound influence on the final performance and safety life of end products. Four different types of burrs (including Poisson, rollover, tear and cut-off burrs) had proposed in terms of their formation mechanism[1]. Tear burrs are also described as top side burrs in the micro milling process and its existence will cause poor machined quality. Many researchers have investigated the burr formation mechanisms and the influence of micro milling parameters on burrs. However, there is not many studies investigating the effect of up-milling and the down-milling, which simultaneously happen in a slot milling process and generate different heights/volumes of burrs on the 2 top side of the milled walls.

In this research, the top side burrs' formations at the milled walls (B4 & B8 in Fig.1) during slot milling of titanium alloys are investigated. The geometrical configurations of burrs are obtained by using white light interferometer. The machined-induced burr's geometry are analysed and compared considering that both walls actually experienced different milling processes: down-milling and up-milling.



B1: Exit up milling side burrs
B2: Exit bottom side burrs
B3: Exit down milling side burrs
B4: Top down milling side burrs
B5: Entrance down milling side burrs
B6: Entrance bottom side burrs
B7: Entrance up milling side burrs
B8: Top up milling side burrs

Fig.1 Definition of Burrs at different location of slot milling[2]

Approach & Results

To investigate and compare the effect of different up-milling and down-milling processes on top side burr formation and burr geometry during slot milling, corresponding cutting experiment are carried out. The cutting parameters, workpiece material and tool geometry are listed in Table 1. The milling setup is shown as Fig.2. The titanium alloy, Ti-6Al-4V, is used for the machining experiment and numerical simulation. The J-C material model is used for the cutting simulation and the parameters adopted is in Table 2. The cutter is a 2 flutes milling cutter with a diameter of D=0.5mm.

Table 1 Cutting experiment parameters

Parameters	Value	Parameters	Value
ap (mm)	0.01; 0.05; 0.1	**WP Material**	Ti-6AL-4V
vf(mm/min)	400	**Tool**	2 flutes
n(rpm)	30000	**D (mm)**	0.5

Table 2 Cutting simulation related material parameters (J-C model)

Parameters	Value	Parmaters	Value
A (MPa)	782.7	**d1**	-0.09
B(MPa)	498.4	**d2**	0.25
n	0.28	**d3**	-0.5
m	1	**d4**	0.014
ε	10E-5	**d5**	3.87
C	0.028		

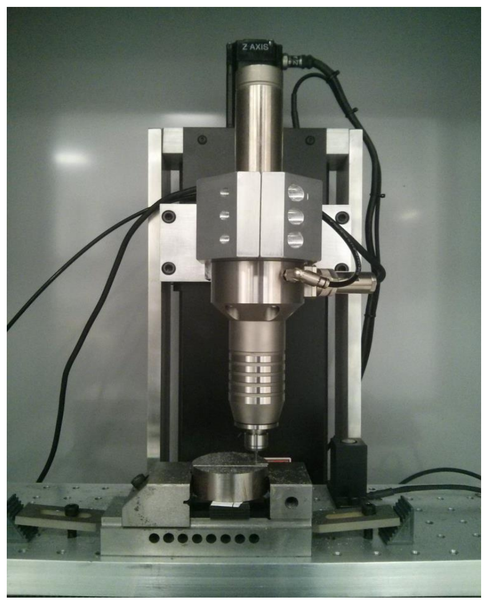


Fig.2 Micro slot milling experiment

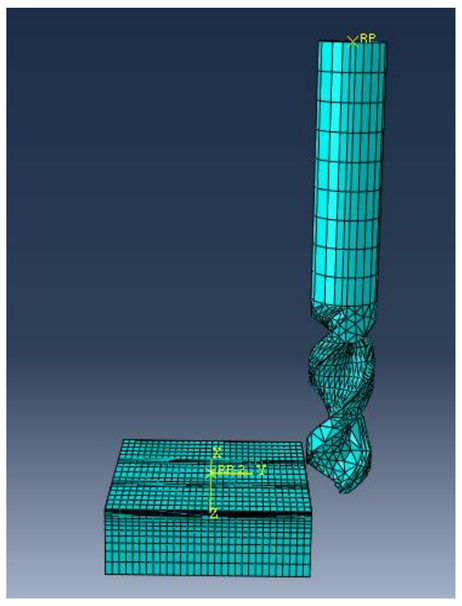
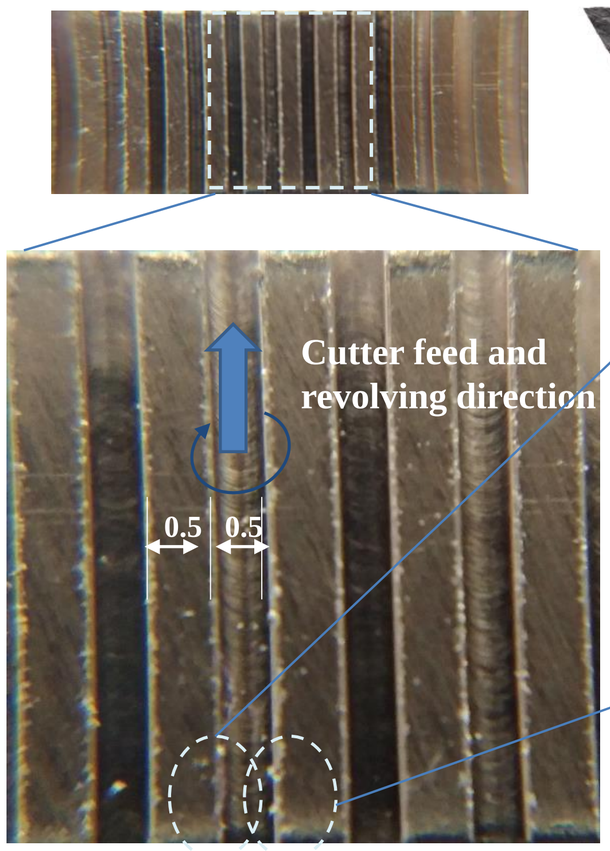
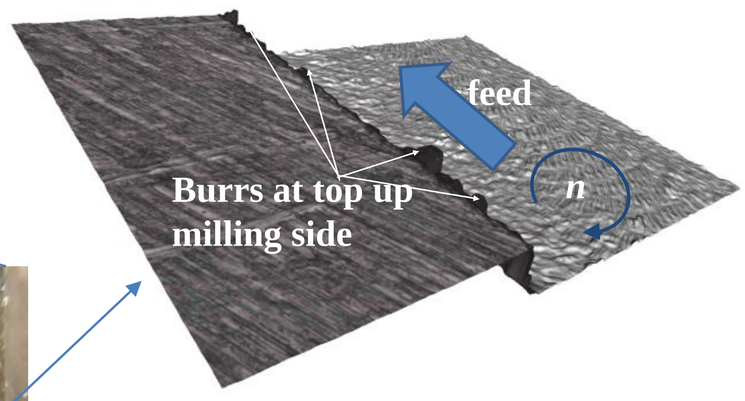


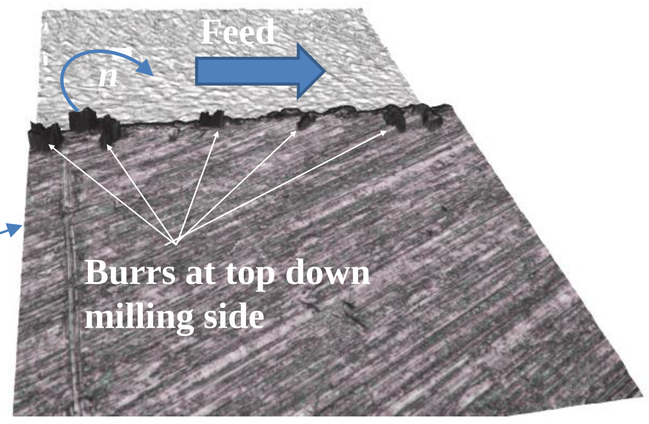
Fig.3 Micro slot milling simulation setup



(a) slot-milled workpiece



(b) Burrs of up-milled top side



(c) Burrs of down-milled top side

Fig.3 Burrs on the top sides of slot-milled walls: up-milling & down-milling

Conclusions

- The burr formations at the top edge of the milled slot are investigated via corresponding experiments. The machined surface quality and burr's geometry are analyzed and compared considering that both walls actually experienced different milling processes: down-milling and up-milling.
- The result indicates that more volume of top side edge burrs are generated in the down-milling process, while less volume of top side edge burrs are generated in the up-milling process. It is different with the conventional recognition that down-milling generally produce surface with better surface quality when comparing with that of up-milling at the same cutting condition.

References

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[2] Seyed Ali Niknam, Victor Songmene. Burr formation and correlation with cutting force and acoustic emission signals. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 2015, Vol 231, Issue 3, pp. 399 – 414