Advances in Automobile Engineering

Ping et al., Adv Automob Eng 2017, 6:4
DOI: 10.4172/2167-7670.1000173

Research Article | Open Access

A Study on Microstructure Evolution of 7055 Aluminum Alloy Based Under Extreme Environment

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Abstract

In order to fill the mechanism of microstructure evolution and corrosion resistance of 7055 aluminum alloy in extreme environment, the 7055 aluminum alloy Which was subjected to T6I4 heat treatment was selected as the research object. High speed machining experiments were performed at low temperature (-60°C) and high temperature (350°C). The dislocation density, grain size, TEM microstructure and corrosion resistance of the cutting layer of 7055 aluminum alloy were investigated at low temperature (-60°C) and high temperature (350°C). The experimental results show that the dislocation density at low temperature is higher than that at high temperature under the same cutting speed and feed rate, and the grain size at low temperature is higher than that at high temperature too. In the low temperature environment, the continuous of the grain boundary is enhanced with the cutting speed increases, and the precipitation phase in the crystal is reduced and the precipitation phase on the grain boundary is obviously increased. Under the high temperature environment, with the increasing cutting speed, the degree of fibrosis of the grains is weakened and the dynamic recrystallization is obviously enhanced. Microstructures show significant dynamic recrystallization after high temperature cutting. And when the feed rate is 0.05 mm, the microstructure of 7055 aluminum alloy exists part of the sub-crystal; The larger the feed amount, the finer and longer the fibrous grains of the metallographic structure of cutting layer metal of 7055 aluminum alloy. There is a lot of dislocations in the cutting layer of 7055 aluminum alloy in low temperature environment. The higher the cutting speed, the smaller the dislocation density. No dislocations were found in the microstructure of the 7055 aluminum alloy cutting layer in the high temperature environment,and, the higher the cutting speed is, the less the number of precipitated phases is, and the GP region and η ‘phase were transformed into η phase.

Keywords: 7055 aluminum alloy; Dislocation density; Grain size; TEM microstructure; Corrosion resistance

Introduction

Due to its low density, higher specific strength and specific rigidity and good corrosion resistance, the 7055 aluminum alloy is used as the preferred material for lightweight; also it has been successfully applied to Boeing777. Duquesnay et al. studied the microcrack propagation properties of AA7075 aluminum alloy in the atmospheric environment [1]. The experimental results show that the longer the atmospheric corrosion time, the smaller the tensile strength of the 7075 aluminum alloy, and the smaller the depth of the stretched bile as well. Magnani et al. investigated the effect of ultra-high velocity spray on the corrosion properties of AA7050 aluminum alloy. The corrosion resistance of AA7050 aluminum alloy under the condition of simulated etching solution was mainly studied [2]. The corrosion resistance of the spray and the spray pressure were investigated, and the spraying parameters were optimized by experiment. Although the microstructure evolution and corrosion resistance of the study gradually increased, the effect of cutting temperature on microstructure and corrosion resistance of cutting layer metal of 7055 aluminum alloy was largely neglected. Therefore, considering the effect of cutting temperature on the microstructure and corrosion resistance of the cutting layer metal of 7055 aluminum alloy in this paper, and high-speed cutting experiments were carried out at low temperature (-60°C) and high temperature (350°C); The dislocation density, grain size, microstructure, TEM microstructure and corrosion resistance of the cutting layer of 7055 aluminum alloy in extreme environment were investigated. It will play a strong guiding significance on high-speed machining of 7055 aluminum alloy [3,4].

Material and Methods

In this paper, the 7055 aluminum alloy which was subjected to T6I4 heat treatment was selected as the research object. The material composition of 7055 aluminum alloy shows in Table 1. High-speed machining experiments were carried out at low temperature (-6°C) and high temperature (350°C). The cutting speed and feed rate were chosen as the research variables for the cutting experiment, and the single factor test scheme was set as shown in Tables 2 and 3, respectively [5].

Results and Discussion

Study on dislocation density and grain size of cutting layer metal at low and high temperature

Figure 1 shows the effect of the cutting speed on the dislocation density and grain size of the cutting layer metal of the 7055 aluminum alloy in extreme environments. Figure 1a shows the effect of cutting speed on the dislocation density of the cutting layer metal of the 7055 aluminum alloy at -60°C. Figure 1b shows the effect of cutting speed on grain size of cutting layer metal of 7055 Aluminum Alloy at -60°C. Figure 1c shows the effect of cutting speed on the dislocation density of the cutting layer metal of the 7055 aluminum alloy at 350°C; Figure 1d shows the impact of cutting speed on the grain size of the metal of the

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Received November 02, 2017; **Accepted** November 06, 2017; **Published** November 10, 2017

Citation: Ping Z, Yuanyuan L, Youqiang W (2017) A Study on Microstructure Evolution of 7055 Aluminum Alloy Based Under Extreme Environment. Adv Automob Eng 6: 173. doi: 10.4172/2167-7670.1000173

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Alloy elements	Zn	Mg	Cu	Zr	Fe	Si	Cr	Mn	Al
Measured levels	7.76	1.94	2.35	0.12	0.061	0.055	0.005	0.008	Others
About content	7.6~8.4	1.8~2.3	2.0~2.6	0.08~0.25	<0.15	0.10	<0.04	<0.05	Others

Table 1: Chemical composition of 7055 Al-alloy (wt. %).

No.		Cutting speed (m/min)	Cutting depth (mm)	Feed rate (mm/z)
T6I4	1	300	2	0.05
	2	600	2	0.05
	3	900	2	0.05
	4	1200	2	0.05
	5	1500	2	0.05
	6	1800	2	0.05

Table 2: Specific experimental scheme of cutting speed.

No.		Cutting speed (m/min)	Cutting depth(mm)	Feed rate (mm/z)
T6I4	1	1200	2	0.25
	2	1200	2	0.5
	3	1200	2	0.75
	4	1200	2	1
	5	1200	2	1.25
	6	1200	2	1.5

Table 3: Specific experimental scheme of feed rate.

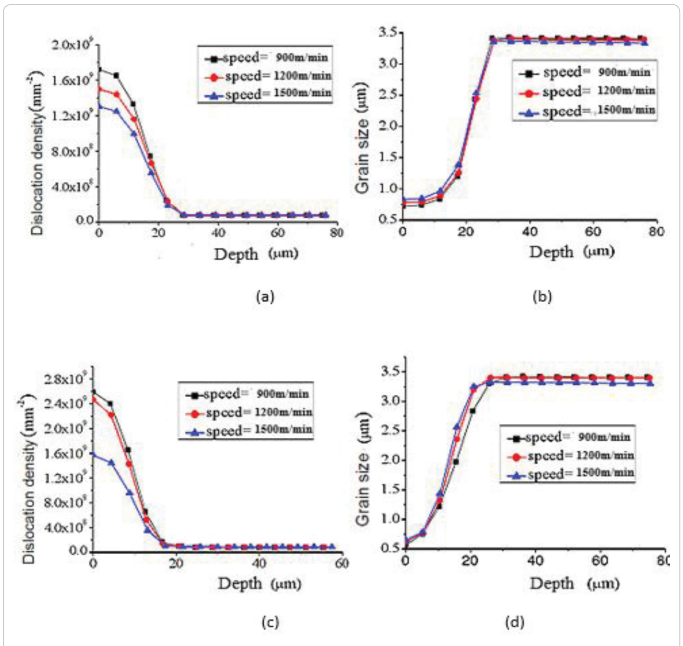

Figure 1: Effect of cutting speed on dislocation density and grain size of cutting layer metal (a) -60°C dislocation density; (b) -60°C grain size; (c) 350°C dislocation density (d) 350°C grain size.

cutting layer of 7055 aluminum alloy at 350°C. The experimental results show that the greater the cutting speed [6], the smaller the dislocation density of the cutting layer metal of 7055 aluminum alloy at low temperature and high temperature. With the increasing cutting speed, grain size [7] showed a tendency to increase first and then decrease. Under low temperature, the dislocation depth is 28 um; under high temperature, the dislocation depth is 18 um. At the same cutting speed, the dislocation density at low temperature is higher than that of high temperature, and the grain size at low temperature is higher than that of high temperature as well.

Figure 2 shows the influence of the feed rate on the dislocation density and grain size of the cutting layer metal of the 7055 aluminum alloy in extreme environments. Figures 2a and 2b show the impacts of the feed rate on the dislocation density and grain size of the cutting layer metal of the 7055 aluminum alloy at -60°C. The impact of the feed rate on the dislocation density and grain size of the cutting layer metal of the 7055 aluminum alloy is shown in Figures 2c and 2d, respectively [8]. With the increase of the feed rate, the maximum dislocation density of the cutting layer metal of the 7055 aluminum alloy shows the tendency to decrease first and then increase in the low temperature and high temperature environment [9,10], and the maximum dislocation density of f=0.15 mm is higher than that of f=0.5 mm at a low temperature. When the feed rate is 0.05 mm, the maximum dislocation density is 2.58×10^9 mm^2 at low temperature, the maximum dislocation density is 2.47×10^9 mm^2 at high temperature, When the feed rate is 1 mm, the maximum dislocation density of the cutting layer metal of the 7055 aluminum alloy is 1.76×10^9 mm^2 at low temperature, the maximum dislocation density of the cutting layer metal of the 7055 aluminum alloy is 1.52×10^9 mm^2 at high temperature; when the feed rate is 1.5 mm, the maximum dislocation density of the cutting layer metal of the 7055 aluminum alloy is 2.81×10^9 mm^2 at low temperature, the maximum dislocation density of the cutting layer metal of the 7055 aluminum alloy is 2.38×10^9 mm^2 at high temperature. With the increase of the feed rate, the minimum grain size of the cutting layer metal of the 7055 aluminum alloy shows the tendency to increase first and then decrease under the low temperature and high temperature environment. When the feed rate is 0. 5 mm, 1 mm and 1.5 mm, the minimum grain size is 0.75 μm, 0.83 μm and 0.67 μm at low temperature, respectively; and the minimum grain size is 0.54 μm, 0.75 μm and 0.55 μm at the high temperature environment, respectively [11]. At the same feed rate,

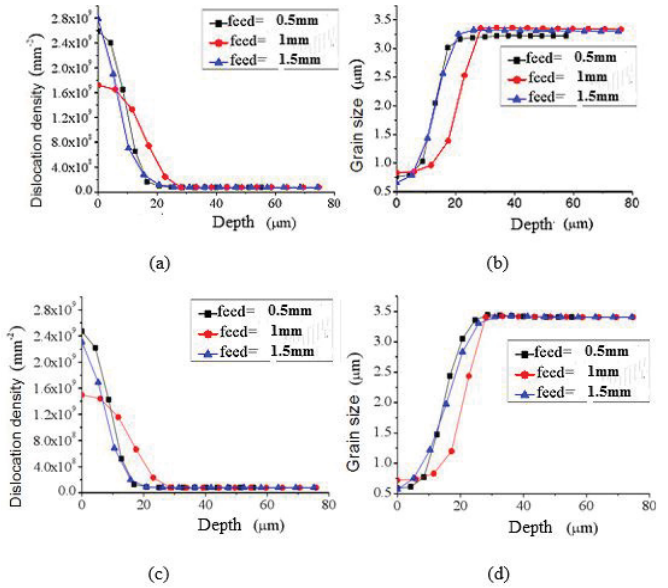

Figure 2: Effect of feed rate on dislocation density and grain size of cutting layer metal (a) -60°C dislocation density; (b) -60°C grain size; (c) 350°C dislocation density; (d) 350°C grain size.

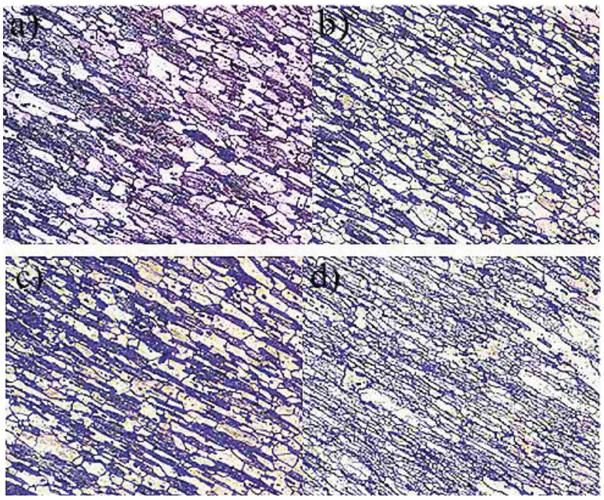

Figure 3: Effect of cutting speed on microstructure of cutting layer metal (a) -60°C, v=1200 m/min; (b) 350°C, v=1200 m/min; (c) -60°C, v=1500 m/min.

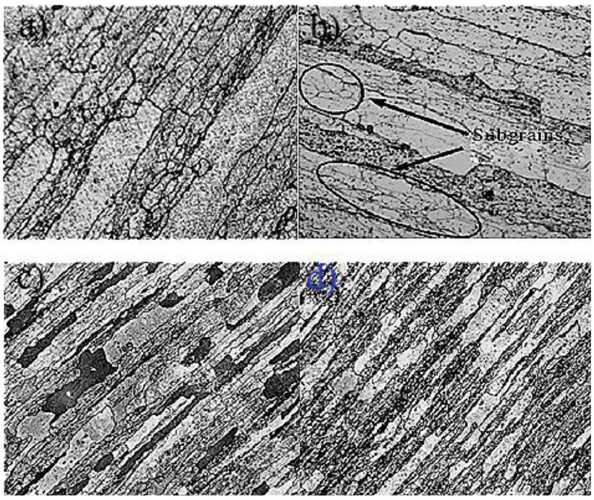

Figure 4: Effect of feed rate on microstructure of cutting layer metals (a) -60°C, f=0.5 mm; (b) 350°C, f=0.5 mm; (c) -60°C, f=1.5 mm; (d) 350°C, f=1.5 mm.

the dislocation density at low temperature is higher than that of high temperature, and the grain size at low temperature is higher than that of high temperature too.

Microstructure observation of cutting layer metal under low and high temperature

Figure 3 shows the microstructure of the cutting layer metal of 7055 aluminum alloy in extreme environments. Figure 3a shows the microstructure of the cutting layer metal of a 7055 aluminum alloy with a cutting speed of 1200 m/min at -60°C; Figure 3b shows the microstructure of the cutting layer metal of a 7055 aluminum alloy with a cutting speed of 1200 m/min at 350°C; Figure 3c shows the microstructure of the cutting layer metal of a 7055 aluminum alloy with a cutting speed of 1500 m/min at -60°C; Figure 3d shows the microstructure of the cutting layer metal of a 7055 aluminum alloy with a cutting speed of 1500 m/min at 350°C. It can be seen from the comparison that when the cutting speed is the same, the fibrous structure of the metallographic structure of the cutting layer of the 7055 aluminum alloy is higher after high temperature cutting than that of the low temperature cutting, Moreover, the microstructure of the cutting layer after the high temperature cutting shows a smaller size dynamic recrystallized grains. Under low temperature, the higher the cutting speed, the better the grain boundary continuity, The higher the cutting speed, the less the precipitation within the crystal, the more precipitation on the grain boundary. Under low temperature, With the increasing cutting speed, the degree of fibrosis of the grains is weakened and the dynamic recrystallization is obviously enhanced.

Figure 4 shows the effect of the feed rate on the microstructure of the cutting layer metal of the 7055 aluminum alloy at low and high temperature. Figure 4a shows the microstructure of the cutting layer of 7055 aluminum alloy of f=0.5 mm at -60°C; Figure 4b shows the microstructure of the cutting layer of 7055 aluminum alloy of f=0.5 mm at 350°C; Figure 4c shows the microstructure of the cutting layer of 7055 aluminum alloy of f=1.5 mm at -60°C; Figure 4d shows the microstructure of the cutting layer of 7055 aluminum alloy of f=1.5 mm at 350°C.It can be seen from the experimental results that the microstructure is elongated along the deformation direction and is fibrous after the low temperature cutting with the increasing feed rate, The incomplete recrystallization occurs in the metallographic structure of the cutting layer metal. Metallographic organization showed a significant dynamic recrystallization structure after high temperature cutting, and when the feed rate is 0.05 mm, there is a partial sub-crystal; when the feed rate is 0.15 mm; the fibrous grains of the metallographic structure of the cutting layer of the 7055 aluminum alloy are more elongated [12].

Conclusion

The dislocation density and grain size at low temperature is higher than that at high temperature under the same cutting speed and feed rate. In the low temperature environment, the continuous of the grain boundary is enhanced with the cutting speed increases, and the precipitation phase in the crystal is reduced and the precipitation phase on the grain boundary is obviously increased. Under the high temperature environment, with the increasing cutting speed, the degree of fibrosis of the grains is weakened and the dynamic recrystallization is obviously enhanced.

There are a lot of dislocations in the cutting layer of 7055 aluminum alloy in low temperature environment. The higher the cutting speed, the smaller the dislocation density. No dislocations were found in the microstructure of the 7055 aluminum alloy cutting layer in the high temperature environment, and, the higher the cutting speed is, the less the number of precipitated phases is, and the GP region and η ‘phase were transformed into η phase.

Acknowledgments

The work was supported by the National Natural Science Foundation of China (No. 51575289) and the Natural Science Foundation of Shandong Province (No. ZR2016EEP03).

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