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Sliver Defect and Improving Measures in Rolled Al-Mg Alloy Sheet

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Abstract: *Sliver defect in Al-Mg alloy was mainly composed of spinel and spinel-like particles, which was a kind of oxide with the composition of elements Al, Mg, and Si. Some sliver defect was caused by rolled inclusions rich in element Si. Casting technique, equipment maintenance, and refractory materials were chosen to control the cleanliness of aluminum melt. Reducing the rubbing scratch and improving the alloy purity during rolling can reduce sliver defect in the sheet significantly.*

Keywords: *Al-Mg alloy sheet, sliver defect, inclusions, anodic oxidation*

I. INTRODUCTION

Nowadays with the rapid development of advanced technology, more and more digital products are widely used in everyday life. Higher quality shells are required in digital products. Low density, high strength, and elegant appearance are required in the shell of digital products, and thus the trend of development in lightweighting. Aluminum and its alloy are the fuselage materials with the best comprehensive performance and the best cost performance [1-3]. Nowadays, the processing technology of aluminum sheet can meet some requirements of digital product shells in terms of performance, shape and other indicators. However, there are still some deficiencies in the surface of shells. Aluminum alloy has a strong chemical reactivity in the air. It could form a layer of dense oxide film to isolate the air, but the corrosion resistance of the film is quite poor. Anodic oxidation is required to make up the deficiency and improve the surface appearance of aluminum sheet [4-6].

Aluminum alloys of series 5, series 6, and series 7 are the main alloys used in digital products. In Al-Mg alloy of series 5, sliver defect is obvious in the sheet after anodizing treatment, as is shown in Figure 1, which affects the appearance of electronic products [7,8].

Fig. 1. Sliver defect on Al sheet after anodic oxidation (10 x)

II. EXPERIMENTAL

Aluminum magnesium alloy was chosen in the study. The production process of Al-Mg alloy sheet was as follows. In casting, the alloy was melted first. The slag was removed and the melt was held for 10 min next. Then went the degassing processing of nitrogen and filtration purification. Aluminum sheet was obtained by hot and cold rolling, respectively, and the thickness was less than 1 mm [9]. Anodic oxidation was taken after rolling of the alloy. Optical microscopy and scanning electron microscopy were used to analyze the shapes and components of the sliver defect in the sheet. The model of SEM equipment used in the study was Zeiss EVO MA 10/LS 10.

III. RESULTS AND DISCUSSION

Causes of sliver defect

Sliver defect of Al – Mg alloy sheet is shown in Figure 2. It can be seen that the sliver defect shows a fine black line. Black lines have definite directional character and are of surface defects existing intermittently. Therefore, it can be inferred that the surface defect of the aluminum sheet is caused by some foreign matters in the sheet being broken during rolling and getting stretched along the rolling direction.

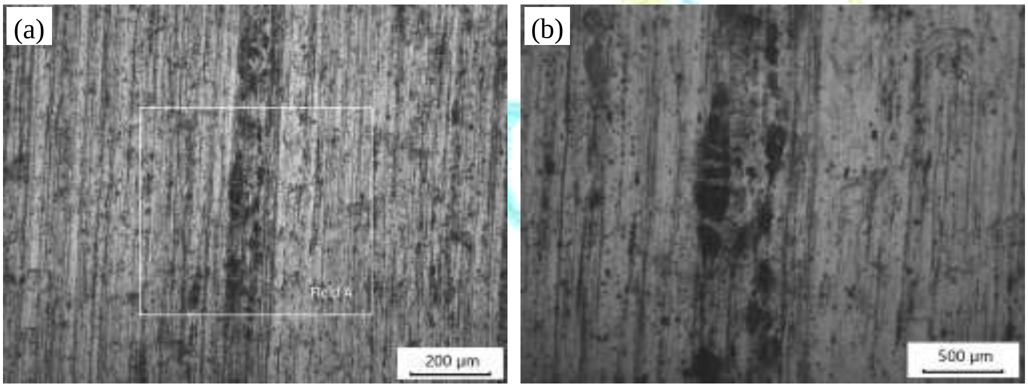

Fig. 2. Surface appearance of Al-Mg alloy sheet with a) sliver defect, and b) magnified field A

In anodic oxidation of Al – Mg alloy sheet, the formation and dissolution of oxidation film are carried out simultaneously. As the dynamic balance of formation rate and dissolution rate is established, an oxidation film with a certain thickness is formed on the sheet. The uniform of oxide film depends on the degree of sheet plainness [9,10]. The surface of Al–Mg alloy sheet is scratched by some foreign matters and caused the sliver defect. The conductivity of the surface at sliver defect is not in line with that of homogeneous surface. The electrolyte flows slowly at the lines during anodic oxidation. As a result, the surface shows uneven appearance and obvious black lines.

Obviously, the consistency of conductivity is destroyed and the inhomogeneity of current is caused by linear defect on the alloy sheet during anodic oxidation. As a result, sliver defect is generated in rolled Al – Mg alloy. There are two main sources of linear scratches. First, some impurities are deposited in the scratches during rolling. Second, inclusions generated in melt are crushed and stretched during rolling. Thus, sliver defect can be controlled by controlling the composition of inclusions.

Composition of sliver defect

Sliver defect of Al-Mg alloy sheet is observed by SEM. Figure 3 shows energy spectrum analysis on sliver defect. Table 1 the EDS of Point 1, and Table 2 show the EDS of Point 2 corresponding to Figure 3. Some fine granular substances are found in sliver defect seen in Figure 3 (a) and Figure 3 (c). The main elements analyzed by energy spectrum are such elements as Al, Mg, O, and Si shown in the tables.

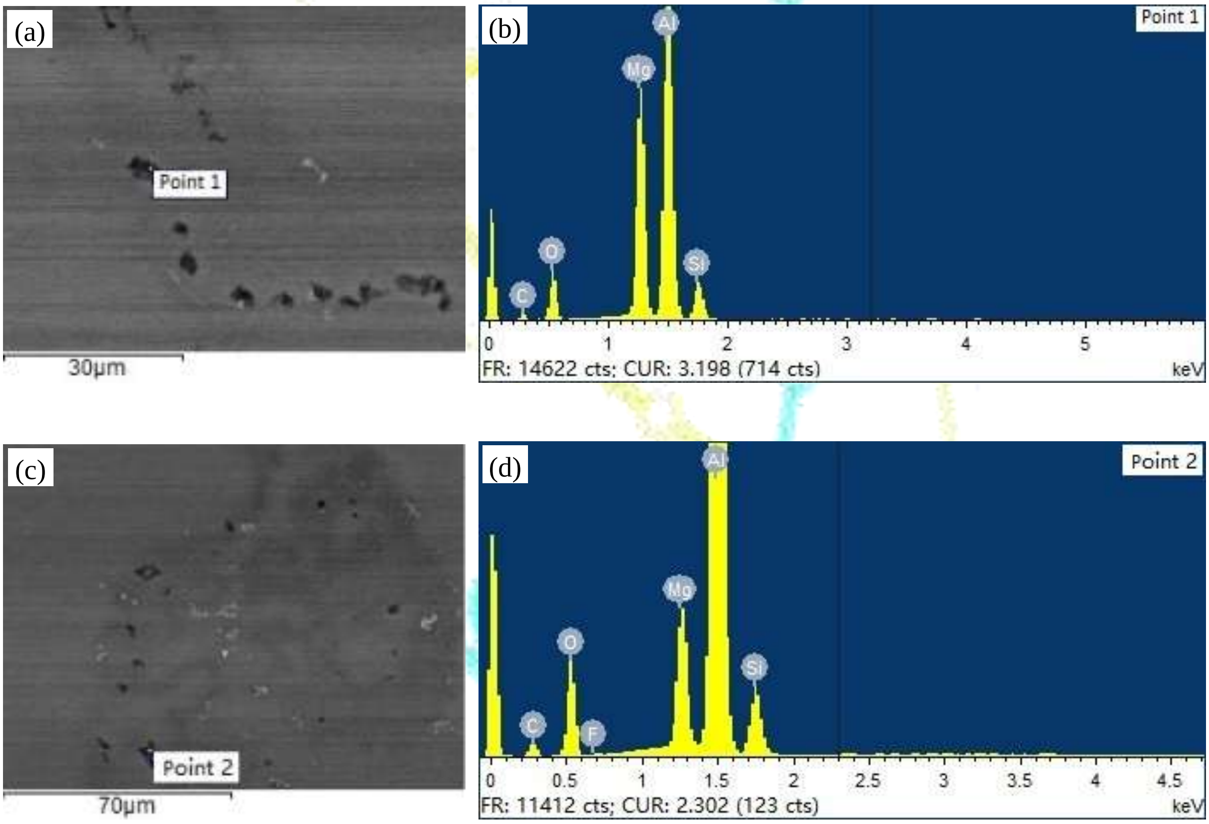

Fig. 3. Energy spectrum analysis on sliver defect of Al-Mg alloy sheet with a) SEM image and point 1, b) energy spectrum of Point 1, c) SEM image and Point 1, and d) energy spectrum of point 2

Table 1 EDS of Point 1 corresponding to Figure 3 (b)

Element	C	O	Mg	Al	Si
W%	0.77	22.92	21.75	46.73	7.83
Atom %	1.45	32.55	20.32	39.35	6.33

Table 2 EDS of Point 2 corresponding to Figure 3 (d)

Element	C	O	F	Mg	Al	Si
W%	0.98	24.05	0.58	7.11	59.58	7.70
Atom %	1.86	34.25	0.70	6.66	50.29	6.24

In Al-Mg alloy, element Mg has an active chemical property and is easy to be oxidized and burned into a compound MgO in melting. The compound MgO will make the oxide inclusion Al_2O_3 unstable. Spinel and spinel-like particles are formed by the action of oxide inclusion Al_2O_3 together with compound MgO. The reactions which have higher hardness are smaller particles. They can not be filtered fully during melting, and retained as inclusions in ingots. Spinel and spinel-like particles are elongated, and broken during rolling [11-13]. The surface of the sheet is scratched in a certain depth and thickness. Sliver defect of aluminum alloy sheet after anodic oxidation is observed obviously in the end.

Besides, there is still a big content of element Si in sliver defect by energy spectrum analysis. The inclusions with element Si are hard with high brittleness. Obviously, some inclusions with element Si come from shed refractory material during melting. Other inclusions with element Si are the diatomite particles kept in scratches because of unfiltered metal rolling oil during rolling, and the content of element Mg in sliver defect is usually fairly low, which is shown in Figure 4 and Table 3.

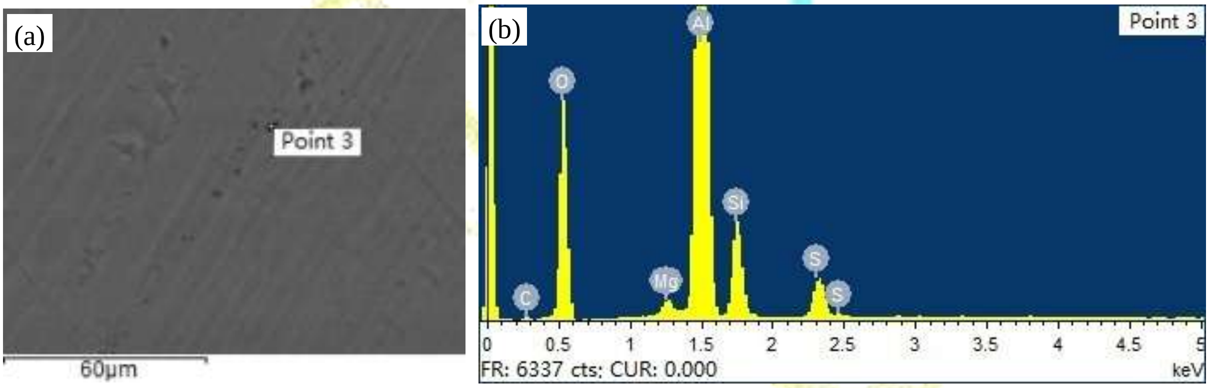

Fig. 4. Energy spectrum analysis on sliver defect of Al-Mg alloy with a) SEM image and Point 3, and b) energy spectrum of Point 3

Table 3 EDS of Point 3 corresponding to Figure 4 (b)

Element	C	O	Mg	Al	Si	S
W%	0.22	42.76	0.70	45.47	8.85	2.00
Atom %	0.37	55.89	0.60	35.24	6.59	1.31

In brief, the inclusions causing the sliver defect in Al-Mg alloy sheet mainly comes from two ways. First, hard brittle spinel and spinel-like particles formed in the melt, are stretched in rolling. The aluminum sheet surface is scratched by the particles in the process. Second, the metal rolling oil is not filtered fully, and the corresponding diatomite particles remain in the scratches.

Improving Measures

Based on the causes of sliver defect in Al-Mg alloy sheet, improving measures can be drawn as follows.

Spinel and spinel-like particles are generated during melting of Al-Mg alloy. The inclusions can not be filtered out in smelting. They can be broken and stretched in the rolling process, and resulting in scratch on surface of the rolled sheet. It is easy to cause sliver defect after anodic oxidation of the sheet [1,7]. In order to reduce sliver defect in the alloy, the uniformity of melt composition is strictly controlled during melting of Al-Mg alloy. Effective measures are taken to reduce local component fluctuation. At the same time, the online melt filtration treatment capacity should be strengthened, such as the use of high-grade filtration (deep-bed filtration or tubular filtration), and even the use of multistage filtration, as far as to prevent coarse spinel and spinel-like particles from keeping in ingots.

It is important to prevent element Si in melting equipment from falling into Al-Mg alloy melt. Cleaning of flowing tank and maintenance of refractories exposed in liquid aluminum during casting should be is strictly regulated [9,14]. Refractories with high content of compound Al_2O_3 can effectively resist the erosion of element Mg, and weaken the possibility of the refractories peeling off in aluminum melt.

During hot and cold rolling, the cleanliness of the emulsion and rolling oil should be controlled strictly [15,16]. Means of filtration for preventing heterogeneous suspended particles in emulsion and rolling oil should be chosen appropriately, which can reduce the probability of sliver defect in Al-Mg alloy sheet after anodic oxidation effectively.

IV. CONCLUSIONS

The main components of sliver defect of Al-Mg alloy sheet are such elements as Al, Mg, O, and Si. Sliver defect is caused by spinel particles and other Si-rich inclusions being broken and stretched during rolling. The uniformity of melt composition should be strictly controlled during melting of the alloy. Online melt filtration treatment ability should be strengthened, as far as to prevent coarse spinel and spinel-like particles from keeping in ingots. It is also important to prevent element Si of melting equipment from falling into Al-Mg alloy melt.

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