

# Analysis of rolling fracture of the constricted and tandem rolled blanks of low alloyed aluminum

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**Abstract.** Optical microscopy, electron microscopy and energy spectrum were used to test the morphology of grains, as-cast microstructure and secondary phases in constricted and tandem rolled planks of 8011 low alloying aluminum alloy. It can be concluded that the existence of inhomogeneous secondary FeSiAl phases lead to the fracture of planks during rolling.

## 1. Introduction

In some plants, the constricted and tandem rolled blanks with 6mm thickness can be directly rolled into foils with different size. rolling fracture often happened during the rolling process, however, the chemical ingredient of alloys was in agreement with the deviation of standard. In order to investigate the reason of fracture, the representative product 8011 aluminium alloy was analyzed by optical microscopy (OM) and scanning electron microscopy (SEM).

## 2. Samples and Experiments

Two kinds of optical microscopy samples were used, one was as-cast rolled plank of 8011 aluminum alloy with 6mm thickness (1# sample), the other were two bulks cutted from as-cast ingot of 8011 aluminum alloy (2# and 3# sample). The cooling conditions of continuous cast was simulated during casting small ingot.

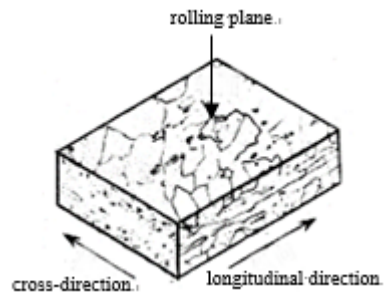
The chemical constitution of samples was in agreement to the standard of 8011 aluminum alloy, namely (wt%): Si=0.5~0.9, Ti=0.03, Fe=0.6~1.0, Cu<0.1, the content of other elements were lower than 0.05, the balance was Al.

After electrolytic polishing and anode tectorial membrane these samples were observed by POLYVAR-MET optical microscope, and the microstructure images were taken by CCD.



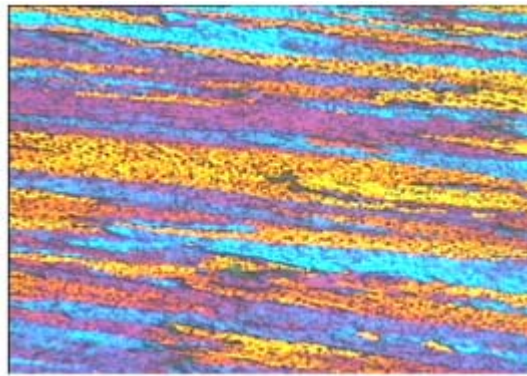
### 3. Experimental Results

#### 3.1. Grain morphology in confiscated and tandem rolled planks

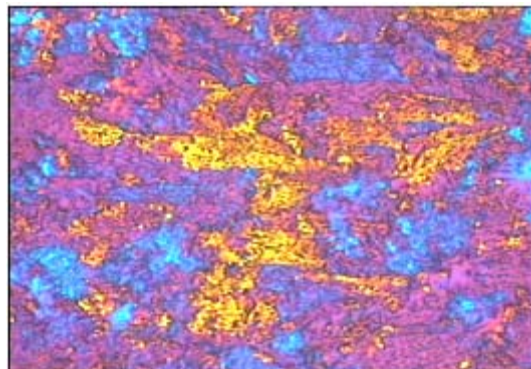


**Fig. 1** Microstructure observing plane of as-cast rolled planks.

Fig 1 showed the microstructure of 1# sample. The observing plane were longitudinal section and cross-section which were perpendicular to the rolling plane.



**Fig. 2** Longitudinal section microstructure of sample 1#, 100X



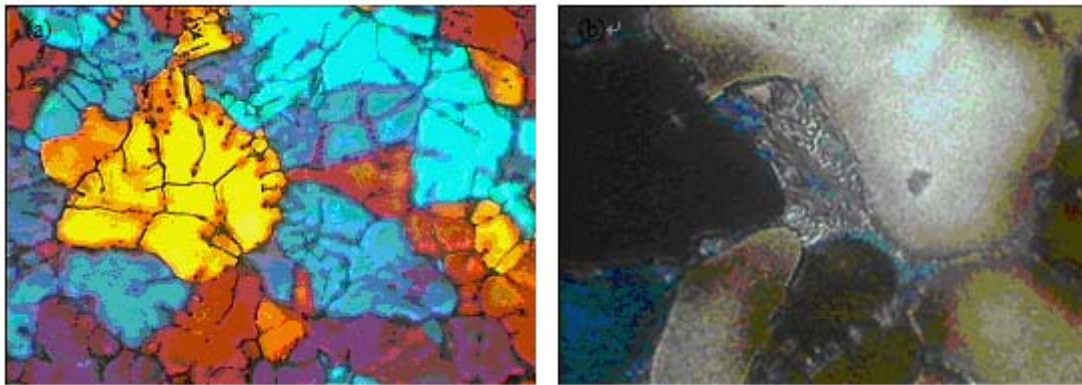
**Fig. 3** Cross-section microstructure of sample 1#, 100X

The longitudinal section microstructure and cross-section microstructure were shown in Fig2 and Fig3, respectively, from which it can be known that: (1) grains of conticasted and tandem rolled planks were broken and elongated along with the rolling direction, fracture happened in some grains. The microstructure owned the charateristic of fibrous microstructure. At the same time, it can be observed

that recrystallization was incomplete (See Fig2.); (2) grains of conicast and tandem rolled planks were bruised along with the vertical direction to rolling plane, some grains were broken up (See Fig3).

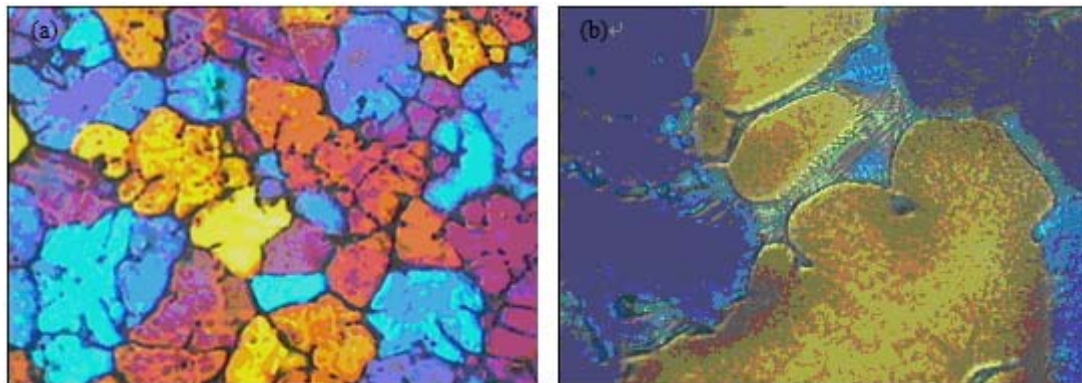
### 3.2. As-cast microstructure and second phases

In order to determine the second phases, small bulks (sample 2# and 3#) cutted from casting ingot were used to investigate the as-cast microstructure and second phases, the results were showed in Fig4, Fig5, Fig6 and Fig7, respectively. The microstructure of sample 2# and 3# were showed in Fig4 and Fig5, respectively, the samples were electrolytic polished and anode tectorial membraned. Fig6 and Fig7 showed the microstructure of two different fields in sample 3# which were only electrolytic polished (without etching).



**Fig. 4** As-cast microstructure of sample 2#

- (a) dendrite crystal AlFeSi phases of 8011 alloy ingot, 100X
- (b) interdimeric AlFeSi phases of 8011 alloy ingots, 500X

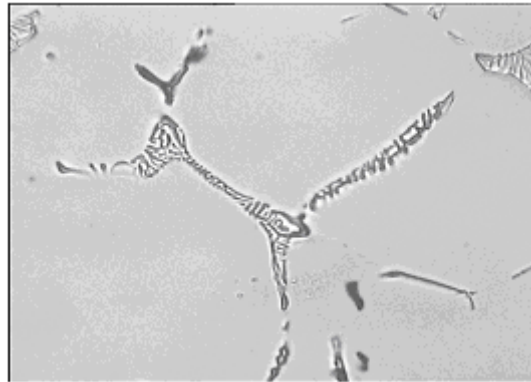


**Fig. 5** As-cast microstructure of sample 3#

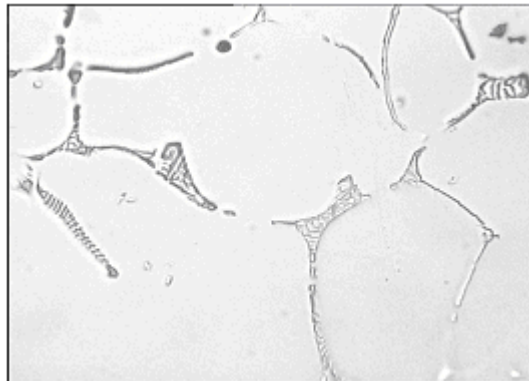
- (a) dendrite crystal AlFeSi phases of 8011 alloy ingot, 100X
- (b) interdimeric AlFeSi phases of 8011 alloy ingots, 500X

In order to determine the second phases further, SEM was used to observe the microstructure of sample 3#, the results were showed in Fig8 and Fig9, respectively. It could be seen clearly that the second phases distributed in aluminum matrix.

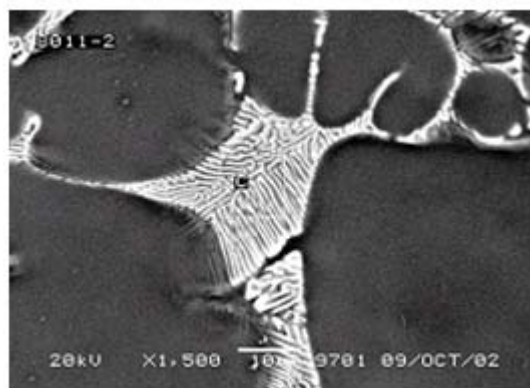
Fixed-point EDS was performed on C point in Fig8. The result (See Fig10) showed that the main components of second phase were Al, Fe and Si, this proved that the second phase was AlFeSi.



**Fig. 6** dendrite crystal and interdimeric AlFeSi phases of sample 3#, 500X

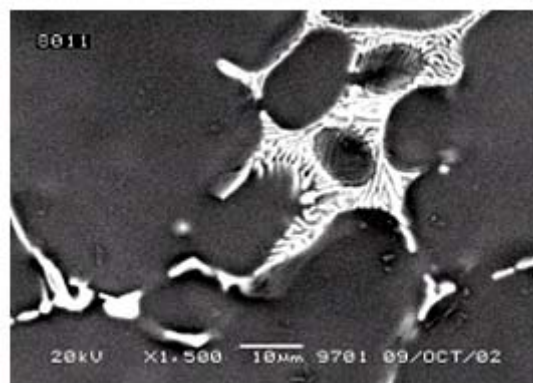


**Fig. 7** dendrite crystal and interdimeric AlFeSi phases of sample 3#, 500X (another field of view)

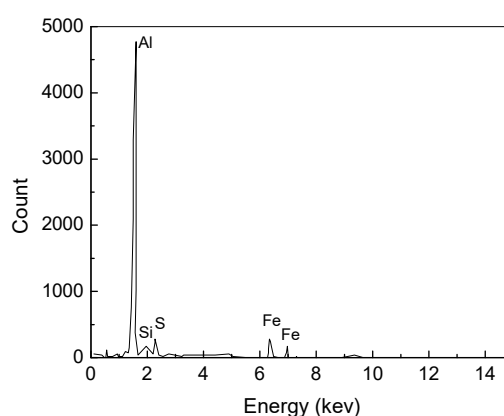


**Fig. 8** SEM image of sample 3#





**Fig. 9** SEM image of sample 3# (another field of view)



**Fig. 10** EDS pattern of C point in Fig8

### 3.3. Non-metal impurities

Non-metal impurities in sample 2# were observed in different fields of view by EDS, the results were almost same with Fig10. It could be seen that in 8011 alloy there were little content and fine non-metal impurities.

## 4. Analysis and Discussion

From the experimental results it could be known that:

(1) the microstructure of confiscated and tandem rolled planks was hot-rolling microstructure, however, the existence of fibrous microstructure which was composed of bruised and elongated grains and broken grains showed that the microstructure of alloys was hot-rolling microstructure far from complete recrystallization. Although cogging temperature (about 600 °C ) was higher than recrystallization temperature, tandem rolling velocity reached above 1000M/min. During this high velocity rolling process, the velocity of work-hardening in metals was far higher than that of recrystallization softening, so it was impossible to complete the recrystallization. When this kind of planks were rolled into a certain thickness (especially rolling temperature gradually decreased), strain hardening accumulated significantly, so in some brittle micro-regions (for example, local area inwhere large brittle AlFeSi phases existed) fracture happened. The existence of broken crystal in microstructure (See Fig2 and Fig3) also proved this.

(2) the investigation on as-cast microstructure, the second phases and non-metal impurities showed that: this kind of material included trace content of non-metal impurities with very fine size, namely

that the alloy was clear, however, AlFeSi phases with different size and component distributed in homogeneously in microstructure. The case of tandem rolled planks was different to that of small ingot, but the inhomogeneous distribution of second phases was inevitable. During the tandem rolling process, in high deformation degree these brittle AlFeSi (especially those AlFeSi phases at the place of triangle grain boundaries) probably became the first origin of fracture and led to ultimate fracture. The broken grains in casted and tandem rolled planks probably resulted in the fracture during the subsequent processing (as-cast rolled planks were directly rolled into foils), especially when planks were rolled into smaller thickness.

## 5. Conclusion and Suggestion

(1) The inhomogeneous distribution of brittle AlFeSi phases was the internal reason of fracture during subsequent cold-rolling of casted and tandem rolled planks in 8011 alloy. The microstructure without recrystallization in casted and tandem rolled planks was the condition of fracture during subsequent cold-rolling process.

(2) If suitable technology could be performed to change the size, morphology and distribution of AlFeSi phases and acquire complete recrystallization microstructure, it was possible to avoid the fracture during subsequent rolling process.

## References

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