Available online at www.sciencedirect.com
ScienceDirect
Trans. Nonferrous Met. Soc. China 24(2014) 2815−2823

Transactions of Nonferrous Metals Society of China
www.tnmsc.cn

Asymmetric cast-rolling of 1050 aluminum alloy strip under multi-energy field

Chen SHI[1,2], Da-heng MAO[2], Zong-li FU[2]

1. School of Materials and Engineering, Central South University, Changsha 410083, China;
2. State Key Laboratory of High Performance and Complex Manufacturing, Central South University, Changsha 410083, China

Received 28 October 2013; accepted 22 February 2014

Abstract: Technological parameters of asymmetric cast-rolling under multi-energy field were investigated on horizontal twin roll caster (*d*400 mm×500 mm), and their effects on structures and properties of 1050 strips were analyzed by comparing with traditional cast-rolling. Results show that when length of cast-rolling area is 70 mm, melt temperature of head box is 670 °C, cast rolling speed is 1.3 m/min, exciting current is 10 A, center frequency is (13±1) Hz, ultrasonic power is 200 W and ultrasonic frequency is (20±0.2) kHz, the 1050 strip with the best microstructure can be prepared successfully; its center segregated layer disappears; the average grain size is reduced by about 40%; the crystal grains are distributed evenly; micro segregation decreases obviously; the precipitated phases are distributed along the grain boundaries evenly; and the tensile strength, yield strength, elongation and micro-hardness of cast-rolled strip are improved by 22.6%, 23.66%, 38.75% and 9.90%, respectively.

Key words: aluminum alloy 1050; asymmetric cast-rolling; multi-energy field; microstructure; mechanical properties

1 Introduction

Aluminum alloy has many good characteristics such as low density, high specific strength, good corrosion resistance, easy forming process and wide applicable scope, and thus has been widely used in construction, transportation, aerospace and other industries [1]. With the rapid development of social economy, the demand for aluminum alloy plate has been growing steadily, and its processing method of energy saving, high efficiency and environmental protection has been put forward [2−4]. The twin-roll continuous cast-rolling technology that has advantages of short process, low cost and large production has become one of the main methods to prepare aluminum alloy plate, but its low cast-rolling speed and small single machine production restrict its development seriously [5,6]. YUN et al [7] improved cast-rolling speed through reducing the thickness of cast-rolled plate; however, this method affected quality of plate heavily in practice. HAGA et al [8] created melt drag twin-roll caster (MDTRC) on the basis of traditional roll caster, and improved cast-rolling speed effectively, but due to the strict process conditions and the difficulty of process control, this technology was also uneasy to be applied widely, and moreover microstructure of cast-rolled plate prepared by this method was composed of columnar crystal. Therefore, it is necessary to exploit an efficient cast-rolling method which can improve cast-rolling speed and get good microstructures.

In recent years, researchers have done series of work on the application of electromagnetic field or ultrasonic wave in aluminum alloy casting or cast-rolling. METAN et al [9,10] investigated solidification structure of Al−Si alloy under the effect of electromagnetic stirring, and it was found that electromagnetic field increased nucleation quantity, restrained the growth of crystal grain, and promoted the formation of fine isometric crystal. LI et al [11] thought that the stirring effect of electromagnetic field could accelerate convective heat transfer of aluminum melt, make temperature field distribute more uniformly, and restrain grain orientation growth. MAO et al [12,13] introduced electromagnetic field to the cast-rolling area of aluminum, and it was shown that the electromagnetic stirring could peel off primary dendrites and form new crystal nucleuses in the melt, and thus improved the nucleation rate and refined the grain size. ESKIN et al

Foundation item: Project (2014CB046702) supported by National Basic Research Program of China
Corresponding author: Chen SHI; Tel: +86-731-88879044; E-mail: shichen@csu.edu.cn
DOI: 10.1016/S1003-6326(14)63413-0

[14,15] found that ultrasonic wave could break dendrites during the preparation process of high-purity aluminum by continuous casting, and it was conducive to improving the nucleation rate and refining the crystal grain. MAO et al [16,17] studied the effect of ultrasonic wave on structures and properties of cast-rolled aluminum strip, and the results showed that ultrasonic wave decreased composition segregation, and made crystal grain smaller and more uniform, and thus improved the mechanical properties.

A new method of asymmetric cast-rolling under multi-energy field was presented in this study. In order to find out the most reasonable technological parameters for asymmetric cast-rolling under multi-energy field, effects of cast-rolling speed, melt temperature of head box, length of cast-rolling area and multi-energy field parameters on microstructures of cast-rolled strips were analyzed, and then effects of asymmetric cast-rolling under multi-energy field on structures and properties of aluminum alloy strips were investigated through contrastive analysis, to discuss the feasibility and practicability of asymmetric cast-rolling under multi-energy field to prepare aluminum alloy strip.

2 Experimental

2.1 Materials and experimental process

1050 aluminum alloy was used here and its chemical composition is shown in Table 1.

Table 1 Chemical composition of 1050 aluminum alloy (mass fraction,%)

Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
0.25	0.40	0.05	0.05	0.05	0.05	0.03	Bal.

Experiments were done on horizontal twin-roll caster (d400 mm×500 mm), which was modified to carry out asymmetric cast-rolling under multi-energy field, as shown in Fig. 1: the upper and lower plate of casting mouth were fixed asymmetrically; the upper plate was short and didn't contact the roller; the central plane of casting mouth was lower than that of cast-rolled strip; and the contact area of aluminum melt and bottom roller were increased compared with traditional cast rolling; ultrasonic energy field acted directly on the solidification front from the gap of the upper casting mouth plate. Firstly, the casting mouth was preheated to the temperature between 140 °C and 160 °C, the head box and diversion trench were preheated to 500 °C, the roll gap was adjusted to 5.5 mm, the preloading of roll caster was set to 60 t, raw materials of 1050 aluminum alloy were melted in melting furnace at the temperature between 720 °C and 725 °C, the deslagging agent was added during smelting, and the argon was passed into furnace, after that, the aluminum melt was heated to 730 °C and held for 0.5 h. Then melting furnace was tipped over and aluminum melt flowed through the diversion trench, head box and casting mouth into the roll gap, thus the asymmetric cast-rolled aluminum strip under multi-energy field was prepared, whose thickness was 5.8 mm and width was 200 mm. During cast-rolling, the center frequency of composite electromagnetic field was (13±1) Hz; its exciting current was 0−12 A; the max power of ultrasonic wave was 2000 W; ultrasonic frequency was (20±0.2) kHz.

In addition, the traditional cast-rolled aluminum strip with thickness of 5.8 mm and width of 200 mm was prepared by method of traditional symmetric cast-rolling, to compare with the asymmetric cast-rolled aluminum strip under multi-energy field.

2.2 Test methods

According to GB/T3246.1−2000 and GB/T3246.2−2000, the samples were prepared and the crystal grains on normal plane, cross section and longitudinal section were observed and measured on DMI−5000M metallo-scope. According to GB/T228−2002, standard tensile samples in 0° direction (cast-rolling direction), 45° direction and 90° direction (transverse direction) were manufactured and tested on the WPL−300 universal testing machine at the rate of 2 mm/min. According to

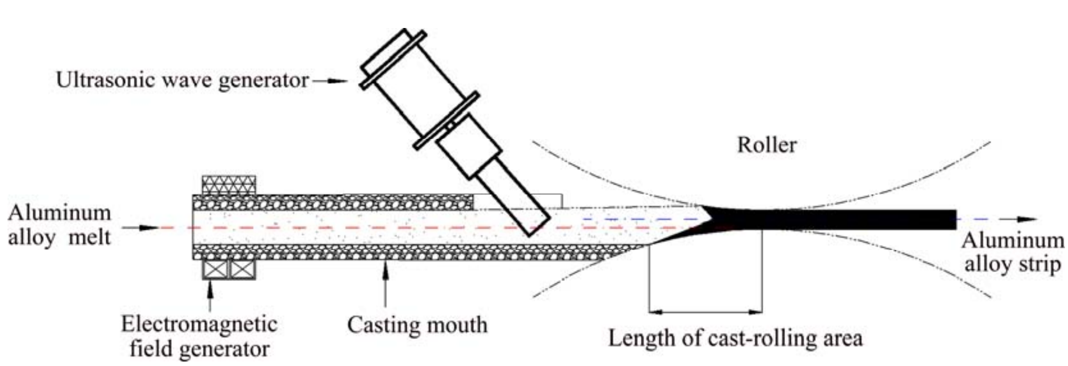

Fig. 1 Schematic of asymmetric cast-rolling of 1050 aluminum alloy strip under multi-energy field

GB/T4340.2−1999, standard samples were prepared and measured by HV−1000 Vickers hardness tester under the load of 1.96 N.

3 Results and discussion

3.1 Effect of technological parameters on microstructure of asymmetric cast-rolled strips under multi-energy field

3.1.1 Cast-rolling speed

Figure 2 shows the metallographs of asymmetric cast-rolled strips under multi-energy field with different speeds. It is found that when the cast- rolling speed is 1.1 m/min, the metallographic structures are composed of big crystal grains shaped as long strip with the size of 50−55 μm, but when the cast-rolling speed is 1.3 m/min, the big columnar crystal grains turn into fine isometric crystal grains whose distribution is uniform and grain size is from 30 μm to 35 μm because the central plane of casting mouth was lower than that of cast-rolled strip; when the cast-rolling speed increases, backflow of aluminum melt arises in casting area and makes the crystal nucleuses on the surface of bottom roller not easy to connect into initially solidified shell, which are washed into the molten pool and form new crystal nucleuses, and then grow into isometric crystal grains ultimately; when the cast-rolling speed is increased to 1.5 m/min, the crystal grains become big because of the partial hot strip phenomenon, and the grain size is from 70 μm to 75 μm. Thus it can be seen that during asymmetric cast-rolling under multi-energy field, the speed of 1.3 m/min is most reasonable, and the cast-rolling speed is increased by about 30%, compared with traditional symmetric cast rolling.

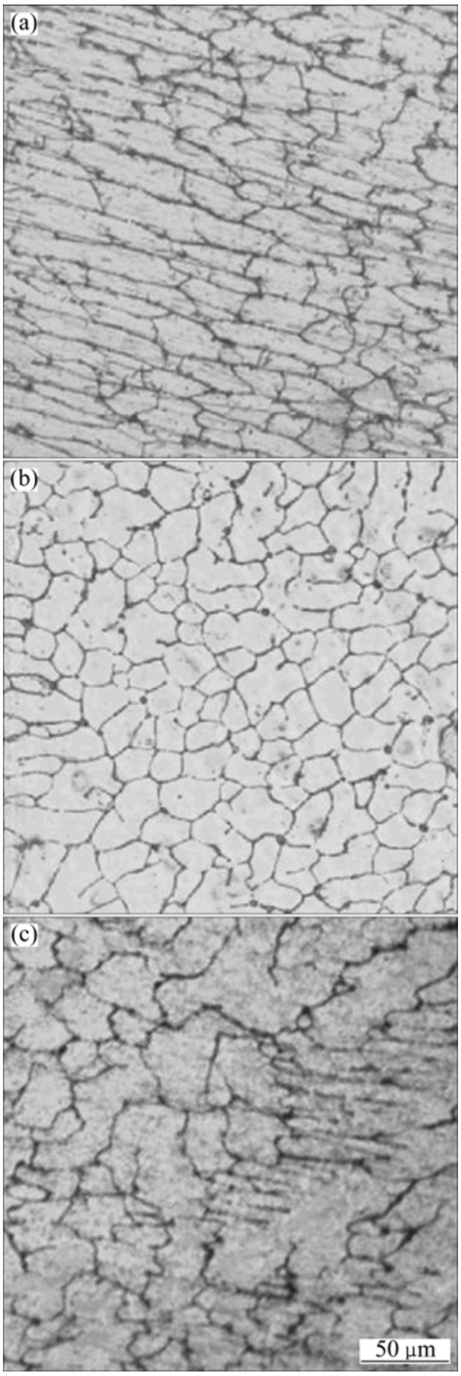

Fig. 2 Metallographs of cast-rolled aluminum strips with different speeds: (a) 1.1 m/min; (b) 1.3 m/min; (c) 1.5 m/min

3.1.2 Melting temperature of head box

Metallographs of asymmetric cast-rolled strips under multi-energy field with different melt temperatures of head box are shown in Fig. 3. It is observed that when the melt temperature of head box is 700 °C, the microstructures are composed of big crystal grains with the size from 70 μm to 80 μm and the dendrites are developed, and when the melt temperature of head box is 685 °C, the microstructures are composed of columnar crystal grains. There is no dendrite, some big columnar crystal grains turn into long grains, and the average grain size is between 45 μm and 50 μm. But when the melt temperature of head box is 670 °C, the microstructures are composed of fine and uniform isometric crystal grains with the size from 35 μm to 40 μm. Therefore, melt temperature of head box has great effect on metallographic structure of asymmetric cast rolled strips under multi-energy field, and the most reasonable temperature is 670 °C. The main reason is as follows: when the melt temperature of head box is high, degree of super cooling at solid liquid interface decreases and nucleation rate drops, which results in big and developed dendrites; in addition, high melt temperature of head box makes solid liquid interface move to exit direction of cast-rolled strip, which shortens the rolling zone and decreases the rolling deformation, and fails to refine the grains finally; however, when the melt temperature of head box decreases, the degree of super cooling at solid liquid interface increases, crystal nucleuses increase, the initial solidifying point drops, thickness of solidified shell increases, and the rolling deformation increases, which is advantageous to refining the grains evenly.

3.1.3 Length of cast-rolling area

Figure 4 gives metallographic structures of asymmetric cast-rolled strips under multi-energy field with different lengths of cast-rolling area, and it illustrates that when the length of cast-rolling area is 60 mm, the crystal grains are composed of big columnar

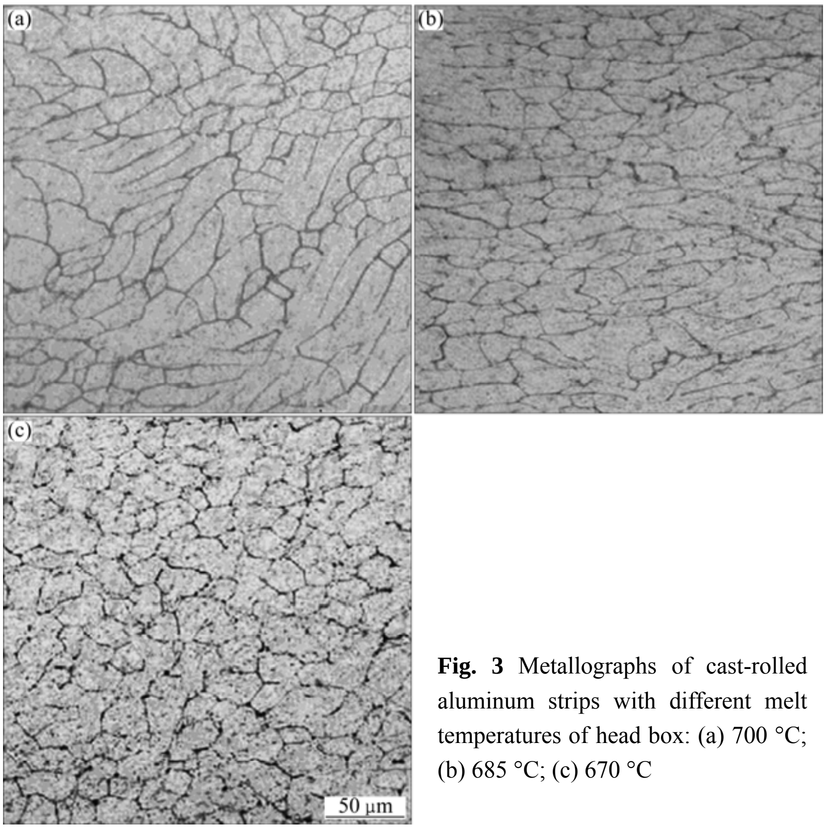

Fig. 3 Metallographs of cast-rolled aluminum strips with different melt temperatures of head box: (a) 700 °C; (b) 685 °C; (c) 670 °C

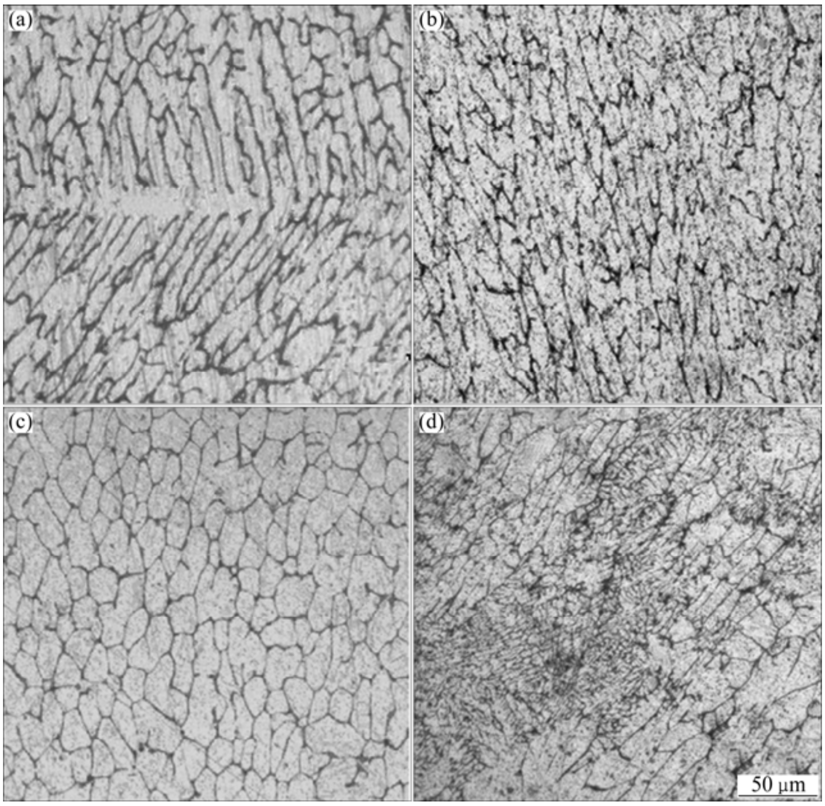

Fig. 4 Metallographs of cast-rolled aluminum strips with different lengths of cast-rolling area: (a) 60 mm; (b) 65 mm; (c) 70 mm; (d) 75 mm

crystal grains and dendrites have grain size from 70 μm to 75 μm; when the length of cast-rolling area is 65 mm, the crystal grains are columnar crystal grains, some of them turn into long grains, and the grain size is from 40 μm to 45 μm; when the length of cast-rolling area is 70 mm, the crystal grains are fine and uniform isometric crystal grains with the size from 35 μm to 40 μm; but when length of cast-rolling area is 75 mm, the crystal grains become uneven, whose average size is between 40 μm and 45 μm. So, it can be concluded that increasing the length of cast-rolling area is conducive to refining grains to a certain extent because the increase of the length of cast-rolling area requires to lower the central plane of casting mouth, and makes the contact area of aluminum melt and bottom roller increase; and moreover, the rolling zone increases, the rolling deformation increases, thus the grains are refined more effectively, but when the length of cast-rolling area exceeds a certain value, the more heat transfers through the bottom roller, and heat transfer becomes uneven for the limitation of cooling water flow in roller, causing some grains too small and some too bulky. Experiment results show that the best length of cast-rolling area here is 70 mm.

3.1.4 Multi-energy field parameters

Figure 5 shows metallographic structures of asymmetric cast-rolled strips under multi-energy field with different exciting currents and ultrasonic powers. It is found that when the exciting current is 5 A and ultrasonic power is 100 W, the crystal grains of cast-rolled strip are big and develop into dendrites with the size from 70 μm to 75 μm; when the exciting current is 10 A and ultrasonic power is 200 W, the crystal grains are fine and uniform isometric crystal grains, the dendrites disappear, and the average grain size is between 35 μm to 40 μm; but when the exciting current is 15 A and ultrasonic power is 300 W, the crystal grains are columnar crystal grains, there is no dendrite, and the average grain size is between 45 μm to 50 μm. This is because with the increase of the exciting current and ultrasonic power, electromagnetic and ultrasonic composite energy field increases the solidification temperature of aluminum alloy, improves the convective heat transfer of aluminum melt and roller, and shortens solidification time, which reduces temperature gradient of aluminum melt and increases the degree of super cooling, and thus promotes solidification structure to transform from columnar crystal to isometric crystal. But when the exciting current and ultrasonic power are too high, it is easy to cause the oscillation of casting mouth and make surface of meniscus unstable, and lead to the defects. Therefore, it can be concluded that the most reasonable exciting current and ultrasonic power are 10 A and 200 W, respectively.

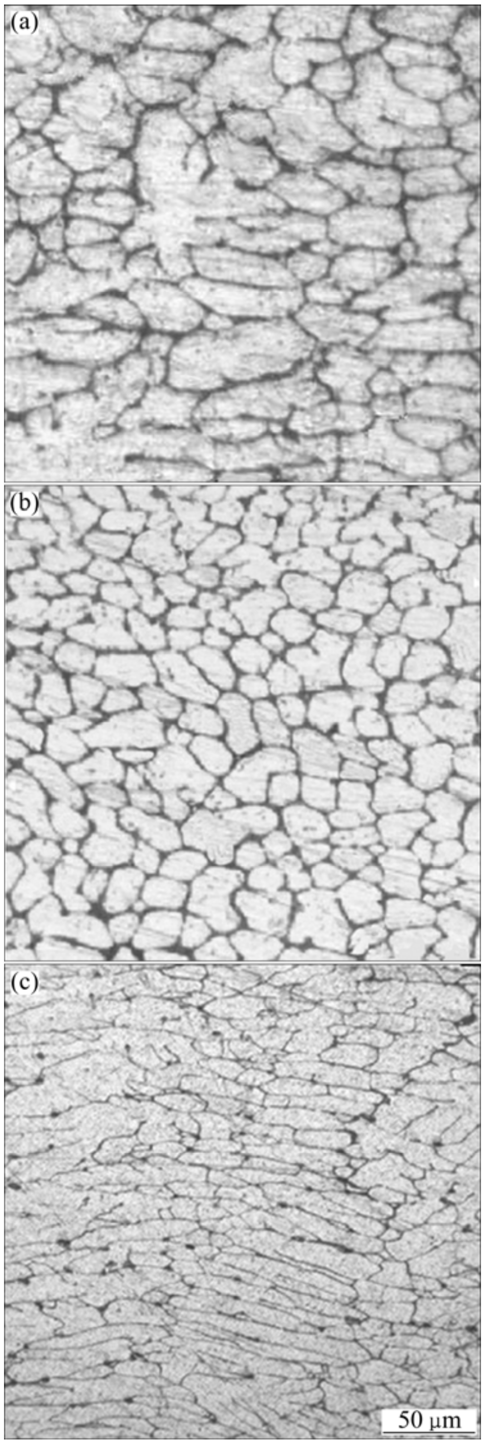

Fig. 5 Metallographs of cast-rolled aluminum strips with different multi-energy field parameters: (a) I=5 A, P=100 W; (b) I=10 A, P=200 W; (c) I=15 A, P=300 W

In conclusion, when the length of cast-rolling area is 70 mm, the melt temperature of head box is 670 °C, the cast rolling speed is 1.3 m/min, the exciting current is 10 A, the center frequency is (13±1) Hz, the ultrasonic power is 200 W and ultrasonic frequency is (20±0.2) kHz, the aluminum alloy strip with the best microstructure can be prepared successfully by asymmetric cast-rolling under multi-energy field, whose thickness is 5.8 mm and width is 200 mm.

3.2 Contrast with traditional cast rolled strip

3.2.1 Macro- and microstructures

Figure 6 shows macrostructures of cast-rolled aluminum strips on longitudinal section. As illustrated in Fig. 6, there is an obvious segregation layer on longitudinal section of traditional cast-rolled strip, which appears at the center of cast-rolled strip and is bad to strip's properties, but there is not segregation plane on longitudinal section of asymmetric cast-rolled strip under multi-energy field. This is because during asymmetric cast-rolling under multi-energy field, the upper plate of casting mouth is short and does not contact the roller, which is conducive to releasing heat into air, and the central plane of casting mouth is lower than that of cast-rolled strip, which increases the contact area of aluminum melt and bottom roller and enhances the heat convection between aluminum melt and bottom roller. Stirring effect of electromagnetic field and strong impact effect of ultrasonic wave destroy the directional thermal conduction of aluminum melt, and all of these restrain "herringbone" distribution phenomenon. This indicates that asymmetric cast-rolling under multi-energy field can improve the temperature field distribution of solidification front and restrain center segregation, and thus enhances the integrated performance of cast-rolled strip.

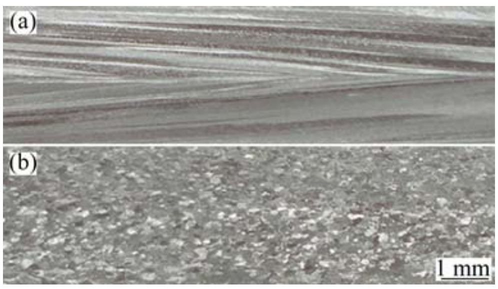

Fig. 6 Macrostructures of traditional cast-rolled strip (a) and asymmetric cast-rolled strip under multi-energy field (b)

Figure 7 gives the metallographic structures of cast-rolled aluminum strips. It is found that the traditional cast-rolled strip has big, uneven crystal grains and develops into dendrite structure, whose crystal boundary is shaped as long strip and crystal grain size is between 50 μm and 55 μm, but the asymmetric cast-rolled strip under multi-energy field has small and uniform crystal grains, whose grain boundary is regular and the grain boundary shaped as long strip is not observed, and the crystal grain size is between 30 μm and 35 μm. The reasons of generating fine grain structure are the effects of electromagnetic and ultrasonic composite energy field: the Lorentz force generated by electromagnetic field, and the shock wave generated by ultrasonic wave for the cavitation phenomenon oscillate and stir the aluminum melt, which can break the growing dendrites and columnar crystals, and form a large number of new crystal nucleuses dispersing in the metastable melt, and thus the fine isometric crystals are obtained.

Distribution of precipitated phase of cast-rolled strips is shown in Fig. 8. It can be seen that micro segregation of traditional cast-rolled strip is serious, and the precipitated phases gather at the crystal boundaries; while micro segregation of asymmetric cast-rolled strip under multi-energy field decreases obviously, and the precipitated phases are distributed evenly at the crystal boundaries. This is because during asymmetric cast rolling under multi-energy field, the central plane of casting mouth is lower than that of cast-rolled strip, which makes aluminum melt impact on the surface of bottom roller and generates turbulent flow. The turbulent flow and the stirring effect of electromagnetic and ultrasonic composite energy field lead to the redistribution of solute elements, and reduce the gathering of solute elements and impurity elements at crystal boundaries, and thus restrain the micro segregation and improve the quality of cast-rolled 1050 aluminum alloy strip.

3.2.2 Mechanical properties

Tensile properties of cast-rolled aluminum strips are shown in Table 2, and it can be seen that compared with traditional cast-rolled strip, the tensile strength, yield strength and elongation of asymmetric cast-rolled strip under multi-energy field are improved by 22.6%, 23.66% and 38.75%, respectively; moreover, the max differences of tensile strength and elongation of traditional cast-rolled strip in 0° direction, 45° direction and 90° direction are 10.6% and 35.0%, but those of asymmetric cast-rolled strip under multi-energy field in three directions are only 2.4% and 5.2%. Therefore, asymmetric cast-rolling under multi-energy field not only can improve the tensile properties of cast-rolled strip, but also can weaken the anisotropy of cast-rolled strip, which is resulted from the smaller isometric crystal grains of asymmetric cast-rolled strip under multi-energy field and the stirring effect of electromagnetic and ultrasonic energy field.

Table 3 shows micro-hardness of cast-rolled aluminum strips. And it is observed that compared with traditional cast-rolled strip, the micro-hardness of asymmetric cast-rolled strip under multi-energy field is

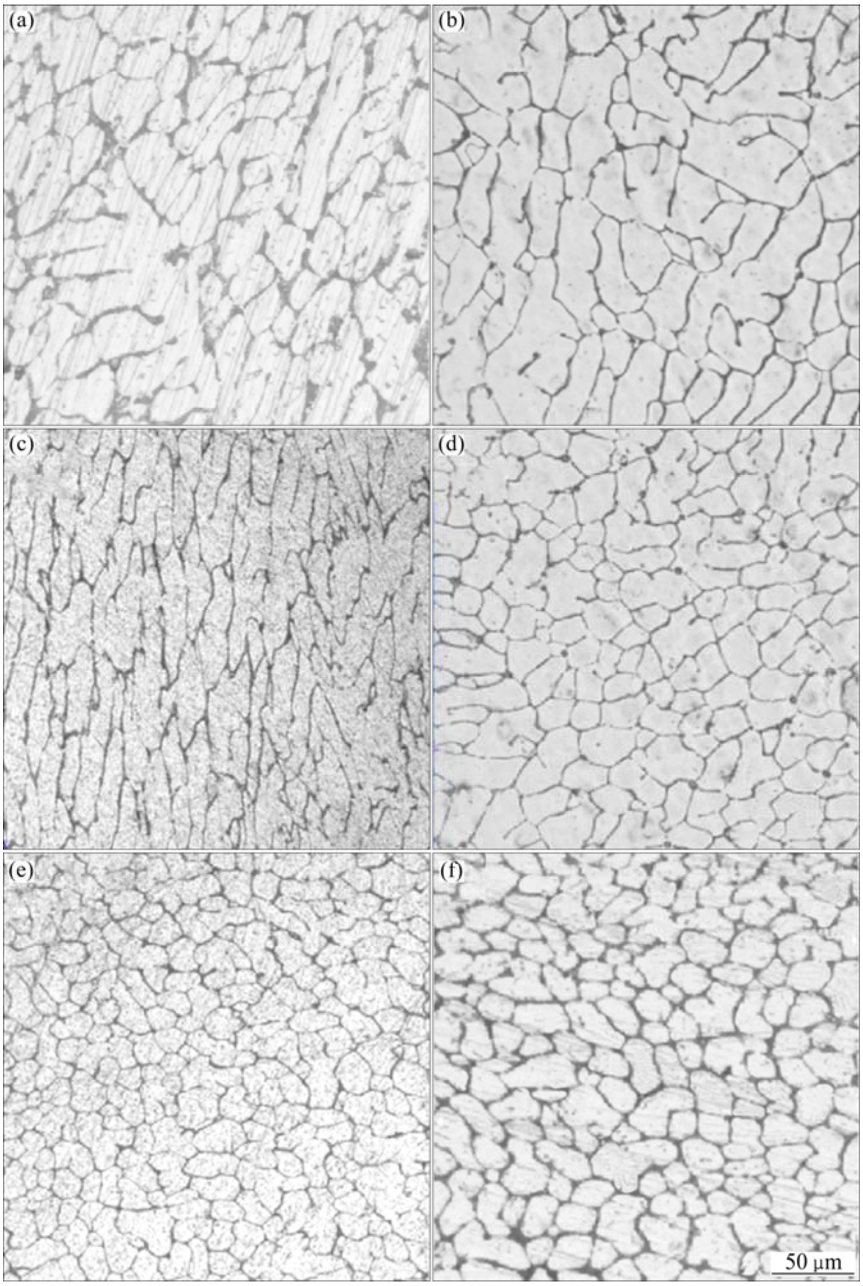

Fig. 7 Metallographs of cast-rolled strips prepared by different processes: (a) Normal plane by traditional cast-rolling; (b) Cross section by traditional cast-rolling; (c) Longitudinal section by traditional cast-rolling; (d) Normal plane by asymmetric cast-rolling under multi-energy field; (e) Cross section by asymmetric cast-rolling under multi-energy field; (f) Longitudinal section by asymmetric cast-rolling under multi-energy field

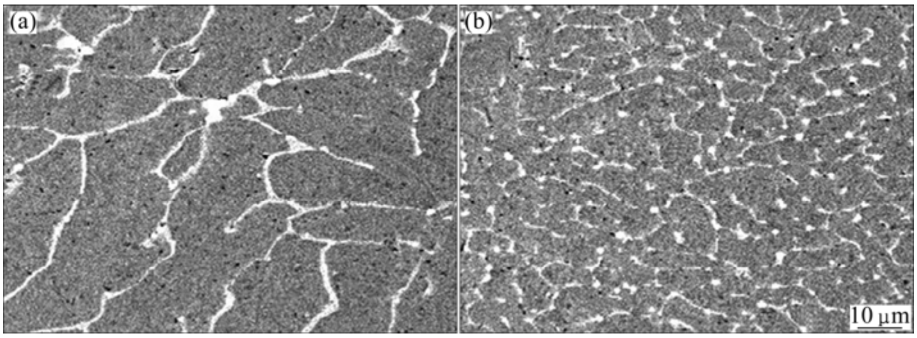

Fig. 8 Distribution of precipitated phases of traditional cast-rolled strip (a) and asymmetric cast-rolled strip under multi-energy field (b)

Table 2 Tensile properties of cast-rolled aluminum strips

Sample	Direction/(°)	Tensile strength/MPa	Yield strength/MPa	Elongation/%
Traditional cast-rolled strip	0	98.8	55.1	23.6
	45	95.9	54.1	26.9
	90	90.8	53.0	21.6
Asymmetric cast-rolled strip under multi-energy field	0	118.1	66.8	33.5
	45	117.7	67.5	33.7
	90	117.6	66.5	32.7

Table 3 Micro-hardness of cast-rolled aluminum strips

Sample	Micro-hardness/MPa					
	Point 1	Point 2	Point 3	Point 4	Point 5	Average value
Traditional cast-rolled strip	27.1	27.0	27.4	27.5	27.6	27.3
Asymmetric cast-rolled strip under multi-energy field	30.1	30.4	29.9	30.0	29.8	30.0

increased by 9.90%, which is due to the fine crystal strengthening effect of isometric crystal grains on asymmetric cast-rolled strip under multi-energy field.

4 Conclusions

1) When the length of cast-rolling area is 70 mm, the melt temperature of head box is 670 °C, the cast rolling speed is 1.3 m/min, the exciting current is 10 A, the center frequency is (13±1) Hz, the ultrasonic power is 200 W and the ultrasonic frequency is (20±0.2) kHz, the aluminum alloy strip with the best microstructure can be prepared successfully by asymmetric cast-rolling under multi-energy field, whose thickness is 5.8 mm and width is 200 mm.

2) Compared with traditional cast-rolled strip, center segregated layer of asymmetric cast-rolled strip under multi-energy field disappears, the crystal grains are distributed evenly and the average grain size is reduced by about 40%. The grain boundaries are regular, the long grain boundaries are not observed, micro segregation decreases obviously and the precipitated phases are distributed along grain boundaries evenly.

3) Asymmetric cast-rolling under multi-energy field can improve tensile strength, yield strength, elongation and micro-hardness of cast-rolled strip by 22.6%, 23.66%, 38.75% and 9.90%, respectively.

References

[1] PAN Fu-sheng, ZHANG Ding-fei. Aluminum alloy and application [M]. Beijing: Chemical Industry Press, 2007: 70−79. (in Chinese)

[2] MONETTA T, ACQUESTA A, MARESCA V, SIGNORE R, BELLUCCI F, DIPETTA P, LOMASTI M. Characterization of aluminum alloys environmentally friendly surface treatments for aircraft and aerospace industry [J]. Surface and Interface Analysis, 2013, 45(10): 1522−1529.

[3] HONG Jian-ping, WANG Jun, CHEN Hai-yan, SUN Bao-de, LI Jia-jing, CHEN Chong. Process of aluminum dross recycling and life cycle assessment for Al−Si alloys and brown fused alumina [J]. Transactions of Nonferrous Metals Society of China, 2010, 20(11): 2155−2161.

[4] SAGISAKA Y, NAKAMURA T, HAYAKAWA K, ISHIBASHI I. Evaluation of environmentally friendly lubricant for aluminum cold forging using friction test based on spline extrusion [J]. Journal of Manufacturing Processes, 2013, 15(1): 167−179.

[5] CHEN Shou-dong, CHEN Jing-chao. Simulation of microstructures in solidification of aluminum twin-roll casting [J]. Transactions of Nonferrous Metals Society of China, 2012, 22(6): 1452−1456.

[6] VUKELJA E K, DUPLANCIC I, LELA B. Continuous roll casting of aluminium alloys—Casting parameters analysis [J]. Metalurgija, 2010, 49(2): 115−118.

[7] YUN M, LOCKYER S, HUNT J D. Twin roll casting of aluminium alloys [J]. Materials Science and Engineering A, 2000, 280(1): 116−123.

[8] HAGA T, NISHIYAMA T, SUZUKI S. Strip casting of A5182 alloy using a melt drag twin-roll caster [J]. Journal of Materials Processing Technology, 2003, 133(1−2): 103−107.

[9] METAN V, EIGENFELD K, RABIGER D, LEONHARDT M, ECHERT S. Grain size control in Al−Si alloys by grain refinement and electromagnetic stirring [J]. Journal of Alloys and Compounds, 2009, 487(1−2): 163−172.

[10] METAN V, EIGENFELD K. Controlling mechanical and physical properties of Al−Si alloys by controlling grain size through grain refinement and electromagnetic stirring [J]. European Physical Journal Special Topics, 2013, 220(1): 139−150.

[11] LI Jin-tao, XU Guang-ming, CUI Jian-zhong. Effect of magnetostatic field on microstructure of 5005 aluminum alloy sheet by roll-casting [J]. Advanced Materials Research, 2011, 189−193: 4018−4021.

[12] MAO Da-heng, YAN Heng-zhi, ZHAO Xiao-ling, ZHU Zhi-hua, ZHONG Jue. The principle and technology of electromagnetic roll casting [J]. Journal of Materials Processing Technology, 2003, 138(1−3): 605−609.

[13] MAO Da-heng, XIAO Li-long. Effects of electromagnetic field on casting-rolling strip breakdowns [J]. Transactions of Nonferrous Metals Society of China, 1997, 7(4): 5−11.

[14] ESKIN G I. Broad prospects for commercial application of the ultrasonic (cavitation) melt treatment of light alloys [J]. Ultrasonics Sonochemistry, 2001, 8(3): 319−325.

[15] ESKIN G I, ESKIN D G. Production of natural and synthesized aluminum-based composite materials with the aid of ultrasonic (cavitation) treatment of the melt [J]. Ultrasonics Sonochemistry, 2003, 10(4−5): 297−301.

[16] MAO Da-heng, ZHANG Yun-fang, NIE Zhao-hui, LIU Qiao-hong, ZHONG Jue. Effects of ultrasonic treatment on structure of roll casting aluminum strip [J]. Journal of Central South University of Technology, 2007, 14(3): 363−369.

[17] MAO Da-heng, ZHAO Su-kun, LI Jian-ping, FU Zong-li, SHI Chen. Effect of cold rolling reduction on texture and properties of cast-rolled aluminum strip under electromagnetic and ultrasonic field [J]. Journal of Materials Engineering, 2013(6): 12−17. (in Chinese)

1050 铝合金板带的多能场非对称铸轧

石 琛[1,2]，毛大恒[2]，扶宗礼[2]

1. 中南大学 材料科学与工程学院，长沙 410083；
2. 中南大学 高性能复杂制造国家重点实验室，长沙 410083

摘　要：在 *d*400 mm×500 mm 水平式双辊铸轧机上，研究了采用多能场非对称铸轧方法制备 1050 铝合金板带的最合理工艺参数，并对比分析了多能场非对称铸轧对组织和性能的影响。结果表明：在铸轧区长度 70 mm、前箱温度 670 °C、铸轧速度 1.3 m/min、励磁电流 10 A、中心频率(13±1) Hz、超声功率 200 W、超声波频率(20±0.2) kHz 的条件下，制备出具有最佳组织和性能的 1050 多能场非对称铸轧板带，铸轧板带的中心分凝面消失，晶粒尺寸减小约 40%，且分布均匀，微观偏析明显减少，析出相均匀分布于晶界处，铸轧板带的抗拉强度、屈服强度、伸长率和显微硬度分别提高了 22.6%、23.66%、38.75%和 9.90%。

关键词：1050 铝合金；非对称铸轧；多能场；显微组织；力学性能

(Edited by Hua YANG)