Experimental Study on Contact Heating Method in Solid Solution Process of Aluminum Alloy

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Abstract. In this paper, the contact heating method was adopted to heat the aluminum alloy instead of furnace heating. During the process, the aluminum alloy sheet was placed in the preheated flat die under a certain press force for several seconds until the sheet reach the preset temperature. The heating curves were recorded by thermal couples buried in the heating die blocks. Microstructure after contact heating was observe by transmission electron microscope. The results show that sheet temperature rises quickly after the heating die closed and the temperature can reach 475 °C in 10 s which is much faster than furnace heating. Microstructure evolution confirms that solid solution is almost completed after contact heating.

Keywords: Contact heating · Furnace heating · Aging · Aluminum alloy

1 Introduction

In order to save energy and reduce CO_2 emission, high strength and heat treatable aluminum alloys such as 6/7 series are widely studied in automobile industry. One of the famous methods to achieve high strength up to 600 MPa is called hot forming and die quenching (HF&Q) technology invented by Lin et al. [1]. This process consists of solution heat treatment, forming and die quenching and artificial aging. However, solution heat treatment always takes several minutes or hours to achieve a full single phase solid solution state [2–6]. The traditional solution heat treatment is indeed a time-consuming work which hindered its wide application. It is known that there are two factors reducing solution time, one is higher solution temperature and the other is heating rate. However, high solution temperature may overburnt the material causing material failure. Therefore, increasing heating rate may be the only way to reduce solution time. Researchers in literature [7] coated 7075 aluminum alloy with BN or graphite on the surface of the material before heating. These coatings can greatly improve heat absorption efficiency when the aluminum alloy was heating in the radiant heating furnace. Compared with the working condition without coating, at least half of the heating solid solution time is saved. The shortest solution time is less than 150 s. But for industrial applications, the heating time is still very long. Heat conduction is one of high efficient

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heating methods when compared with radiation. Therefore, contact heating has great potential in rapid solid solution of aluminum alloys.

This article experimentally investigates the feasibility of contact heating aluminum alloy instate of traditional used radiant furnace heating to realize short time heat solution. First a flat heating die with resistance bars inside the die blocks was self-developed and manufactured. The effective heating area is 300 mm × 300 mm. Then several sheets of 7075-T6 aluminum alloys with thickness 2 mm were prepared. They were cut into square shape of 200 mm × 200 mm. Finally, the contact heating solution was carried out and the heating curves were recorded.

2 Materials and Experiments

The commercially used 7075-T6 aluminum alloy was selected and its chemical composition is listed in Table 1. Its ultimate tensile strength is 568 MPa.

Microstructure inside the as received material is observed by transmission electron microscope (TEM) and is shown in Fig. 1. It can be seen from Fig. 1 that strengthening phase Mg_2si is almost evenly distributed in the material.

A contact heating die was developed and manufactured as shown in Fig. 2. Heating units are fixed on upper die and lower die respectively. A temperature control system is connected with thermal couples buried in the heating units and electric input system. Its function is to control the temperature of the heating units.

Table 1. Chemical composition of the as received steel (wt. %).

Zn	Mg	Mn	Cu	Fe	Cr	Si	Al
5.902	3.159	0.179	1.625	0.129	0.207	0.029	balance

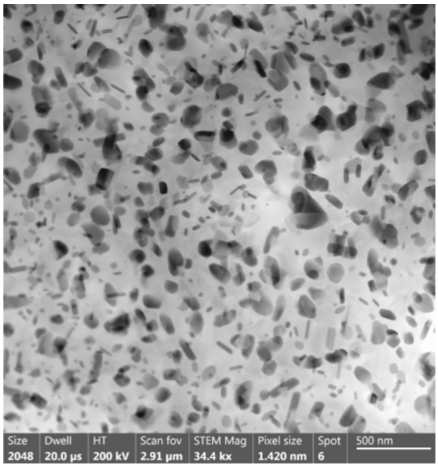

Fig. 1. Microstructure of the as received material.

Fig. 2. Contact heating die: 1 upper die; 2 lower die; 3 heating units; 4 temperature control system.

The temperature of the heating units was set as 525 °C and the target aluminum sheet was set as 475 °C. First, power on until the temperature of the heating units reaches 550 °C. Then put the blank with square shape of 200 mm × 200 mm on the lower heating unit and close the two heating units to heat the blank. To ensure repeatability, the same process was repeated four times. When the temperature of the blank reaches 475 °C, open the die and take out the heated blank and put it into cold water to keep the instantaneous phase. The phase inside the material was observed by optical microscope.

3 Results and Discussion

3.1 Temperature Rise Curves

Temperature rise curve with standard deviation is derived from data recorded by four thermal couples and is shown in Fig. 3.

It is known from Fig. 3 that sheet temperature rises quickly after the heating die closed with 500 kN press. The temperature rise curve is nearly linear with a slope of 48.129. After about 10 s, the temperature of aluminum sheet reaches around 475 °C which is much faster than furnace heating. The heating process was repeated four times to eliminate experimental errors.

3.2 Microstructure Observation

To view the solid solution effect, the heated blanks are quickly put into cold water to maintain internal microstructure of materials. Four samples are cut from four heated blanks. Solid solution effect is observed by TEM and shown in Fig. 4.

Compared with original material, solid solution is almost completed after contact heating. Only a small amount of Fe rich phase left inside the grain. It proves the feasibility of contact heating technology.

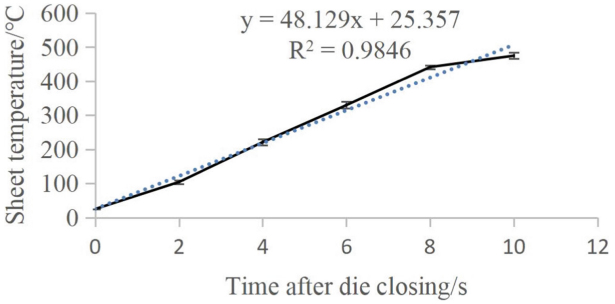

Fig. 3. Temperature rise curves.

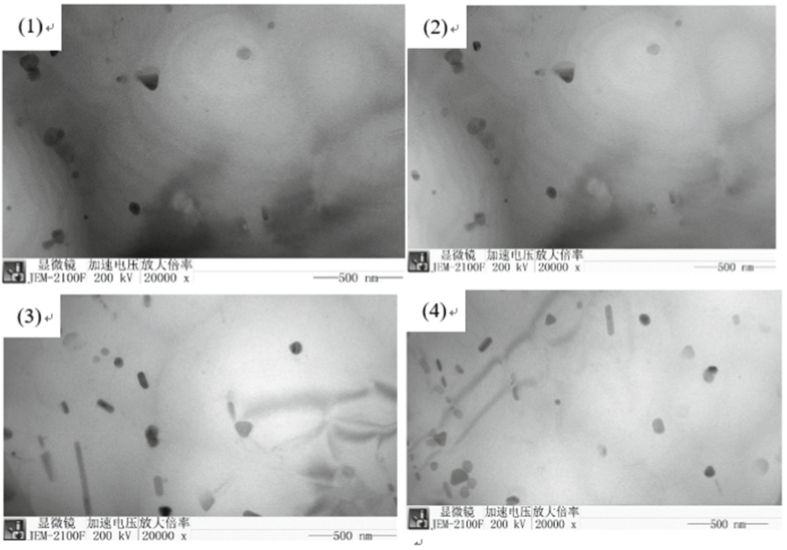

Fig. 4. Microstructure after contact heating.

4 Conclusions

This article experimentally investigated the feasibility of solid solution by contact heating technology. The 7075-T6 aluminum alloy with thickness of 2 mm can be heated from ambient temperature to 475 °C in about 10 s. Microstructure confirmed the feasibility of contact heating technology in solid solution process.

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