Effect of annealing temperature on the mechanical property and micro-structure of Bundy brazed tube

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Abstract

The effect of annealing temperature which ranged from 800℃ to 920℃on mechanical property and micro-structure of Bundy brazed tube(BBT) were studied. The results showed that high temperature annealing could significantly improve the plasticity of BBT. With the augment of annealing temperature, the yield strength of BBT decreased and the plasticity increased and tensile strength changed a little. Whether annealing or not , the micro-structure of BBT were consisted of blocky ferrite and a little intragranular ferrite. The ferrite grain size of BBT changed a little.

Keywords

Bundy brazed tube, annealing temperature, mechanical property, micro-structure.

1. Introduction

Copper tube is an important raw material for air-conditioner industry.According to the latest statistics,the number of copper pipe in air conditioner is more than 100,000 tons every year, accounting for about 30 percent of total copper consumption[1]. As copper prices have reached to a high level in recent years and the high manufacturing costs, exploring a new type of tube has become an urgent problem to be solved in current air-conditioner industry. The raw material of BBT is the low carbon steel strip whose double surface is plated by the copper and then the steel strip will be used to form tubes on the special forming machine, after which they will be brazed in reducing atmosphere.At last BBT will be received corrosion inhibitive treatment[2]. BBT is an ideal tube to replace copper tube because of its high dimensional precision,good anti-vibration fatigue and clean inner surface. However, compared with copper tube, BBT has high strength and insufficient plasticity which is not good for molding. Annealing process could effectively improve the mechanical property of BBT. The influence of annealing process on micro-structure and mechanical property of steel were studied by many researchers.Such as Wenyuan Guo[3] had already researched annealed IF steel by using EBSD technique.But the research about the annealing process on BBT has not appeared.To this end, this paper analyzed the influence of annealing temperature on the mechanical property and micro-structure of BBT.The results which would provide theoretical support for the foundation of industrial annealing process,are good for large-scale application in future.

2. Experimental material and method

2.1 Experimental material

The BBT came from the same factory and was produced in the same batch.The dimension of BBT was Φ9.52×0.7mm.The chemical compositions of BBT were tested by using PMI-MASTER PRO. Specific results were as follows.

Table 1 Chemical compositions of BBT (wt %)

Fe	C	Si	Mn	Cr	Ti	Nb
99.7	0.0048	0.0078	0.110	0.0136	0.0452	<0.003

2.2 Experimental method

The annealing process of BBT was carried out in certain tubular resistance furnace,which was filled with protective atmosphere. The protective gas was composed of 70% N2 and 30% H2. The type of stove was YFK60×400 /16Q-YC.The annealing process included three stages which contained different dealing methods. In the first stage,BBT would be heated in the furnace. Five groups of BBT would be heated to 800℃,830℃,860℃,880℃and 920℃ correspondingly. In stage two,the temperature of BBT would be kept unchanged. The heat preservation process lasted 30 minutes in the furnace.In stage three, the power of furnace would be closed down and the BBT would be cooled down to room temperature in the furnace.

To make suitable samples, The cross sections of BBT were taken from the original tubes and annealed tubes.All the samples would be settled in four steps namely inlay,sand finish,burnish and erosion by using Nital. After these preparations, some samples would be put in invert optical microscope to observe micro-structure. The other samples would be used to test the mechanical property by microcomputer control electron universal testing machines. According to national standard GB/T228-2002,the shape of tensile specimen were curved as follows.In addition, the tensile speed should be controlled in 3mm/min.

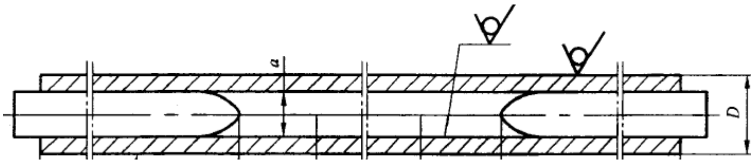


Fig.1 The tensile specimen shape of BBT

3. Results and analysis

3.1 Mechanical property

Figure two depicted the curves of mechanical property VS annealing temperatures at same holding time. The yield strength of BBT after annealing decreased by 30%~43%, while the fracture elongation increased by 15%~33%.With the augment of annealing temperature, the yield strength of BBT was decreasing and the elongation rate of BBT was increasing but the variation of tensile strength was small. when the annealing temperature was 860℃,The yield strength was at the lowest level.

Condition	$R_{p0.2}$/MPa	R_m/MPa	A_{50}/%
Origin	214.8	332.3	35.8
800℃, 30min	138.7	268.9	41.2
830℃, 30min	128.5	264.9	42.5
860℃, 30min	122	261.8	47.5
880℃, 30min	150.2	269	44.5
920℃, 30min	128.9	272.4	45.6

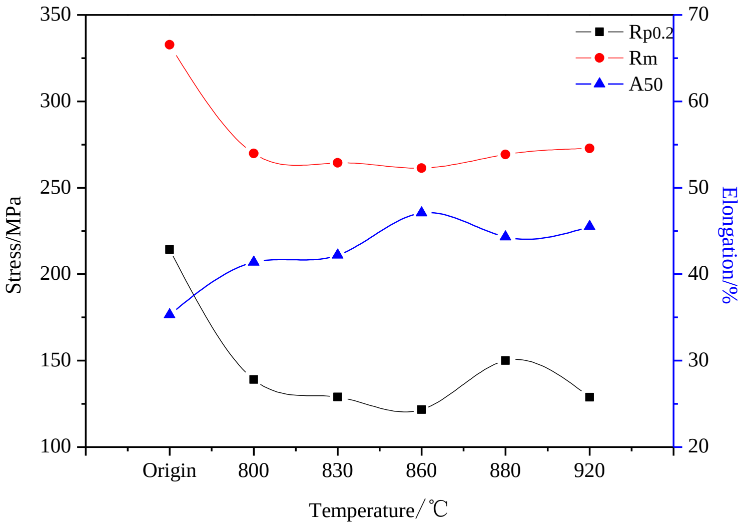
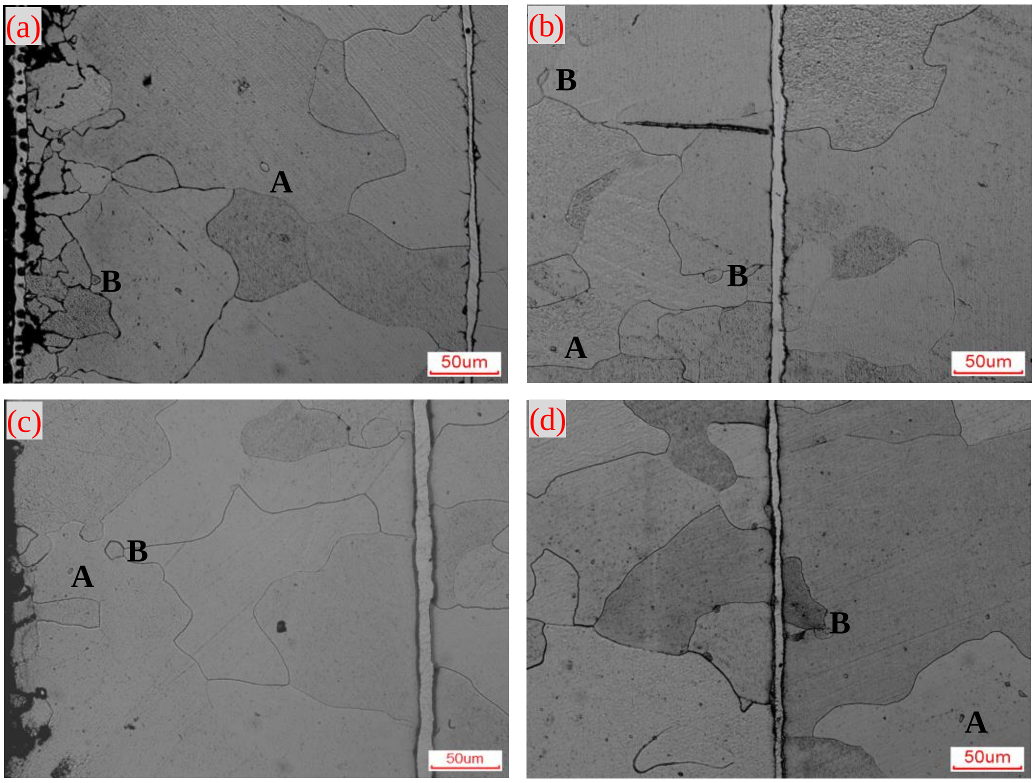


Fig.2 Curves of mechanical property VS annealing temperatures at same holding time

3.2 Micro-structure

Figure three described optical microscope images of BBT at different annealing temperatures. Whether annealing or not , it was clear that the micro-structure of BBT were blocky ferrite and a little intragranular ferrite. Obviously, intragranular ferrite could be divided in two types, named A intragranular and B intragranular respectively.The previous research articles have already proved that inclusions, precipitated phases and the ferrite grain boundary are the effective nucleic positions for intragranular. It was speculated that the core of A intragranular ferrite grew up on the inclusions and precipitated phases. While B intragranular ferrite was predicted to form on the previous ferrite grain boundary.The formation of intragranular ferrite increases the surface density of ferrite. The forming temperature of ferrite is low.



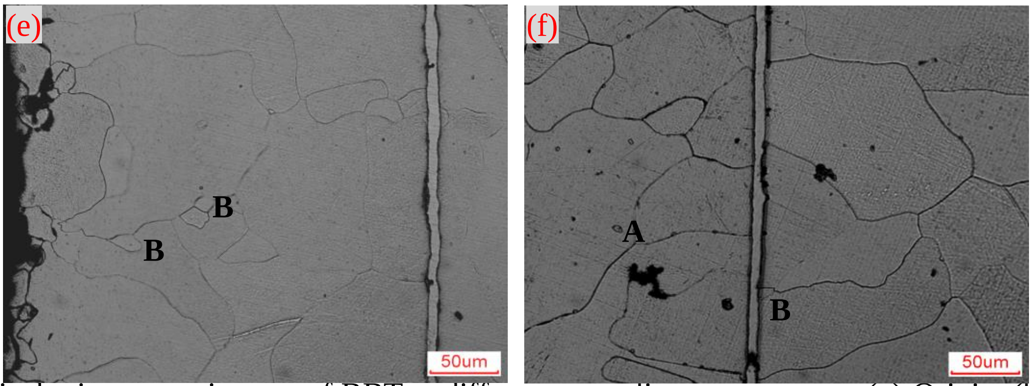


Fig.3 Optical microscope images of BBT at different annealing temperatures (a)-Origin (b)-800℃ (c)-830℃ (d)-860℃ (e)-880℃ (f)-920℃

In general, only small needle-shaped intragranular ferritic could be used to refine the micro-structure and to improve strength as well as toughness.When annealing temperature was increasing, the ferrite grain size of BBT at first increased and then decreased, but the overall changing amplitude of grain size was small. Therefore, there were no obvious static re-crystallization process when BBT was annealing.The research,dominated by Barnett,illustrated that rolled steel whose rolling parameters were 700℃and 65% reduction experienced the total re-crystallization when the annealing temperature was 660℃ and the holding time was 10 minutes[4,5].The above references described that low carbon and low alloy steel which experienced thermal deformation or cold deformation should have a considerable static re-crystallization as long as the strain was sufficient. Therefore,The reason may be that the power of BBT at deformation storage process was limited due to high-temperature brazing.

4. Conclusion

Based on the mechanical property and micro-structure of BBT that were observed at different annealing temperature, the following conclusions could be reached.

(1)High temperature annealing could obviously improve the deformability of BBT. With the augment of annealing temperature, the yield strength of BBT decreased and the plasticity increased and the tensile strength changed a little.

(2)Whether annealing or not, the micro-structure of BBT were blocky ferrite and a little intragranular ferrite.

(3)The ferrite grain size of BBT changed a little.

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