The Investigation Status Quo of the Environmental and Free-cutting Brass

XiaoJuan Wang[1, a *], RuiQing Liu[2, b *]

[1]College of Applied & Science, Jiangxi University of Science &Tecnology, Ganzhou, Jiangxi Province,341000, China

[2]Institute of Engineering & Research, Jiangxi University of Science &Tecnology, Ganzhou, Jiangxi Province,341000, China

[a*] e-mail：wangxj0203@163.com

[b*] e-mail：liuruiqing66@126.com

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Abstract：The Lead brass is used in various fields of machinery manufaeturing widely because of its superior performanee,easy molding cutting and ability corrosion resistanee.However,the lead is harmful in the environment.The purpose of this research is to produce a kind of environmental and free-cutting brass,which can used to instead of the traditional lead brass.The research and development of lead free brass has been the important task in the metal materials manufacturing industry of the word. The investigation status quo of the environmental and free-cutting brass was reported, and the main problem of environmental brass was also presented.

Introduction

Most of the traditional free-cutting brass contains lead and the main designations include HPb59-1, HPb63-3 etc. Among them HPb59-1 is the most widely used brass in fabricating gate valve and tap faucet for water supply system. However, lead is easily leached from brass in the water. Due to the hazardous properties of lead to human health and environment, governments from different countries published restrictions toward applications of leaded brass. Lead content in copper alloy and leaching amount in drinking water were strictly restrained in America, Japan and European Union. Thus, utilizations of leaded copper will face rigorous limit and development of lead-free copper alloy to replace leaded brass becomes important task for non-ferrous metallic material manufacturers. Many studies were performed to add Bi , Si , graphite to replace Pb in Cu-Zn alloy by which several environmentally-friendly and free-cutting brass including Bi series, Si series and graphite series were developed. In the review, development of lead-free brass was summarized.

Results and Discussion

Free-cutting principle of traditional brass

Fig.1 shows that in the conventional free-cutting brass, like HPb59-1 and HPb63-3, lead is the only element which can improve mechanical cutting property. The solubility of lead in brass is low and it distributes evenly in uncombined tiny separate phase in brass matrix at (α +β) phase. Moreover, as soft particle, the uncombined lead particles have not only lubricating effect but also present crumble state after cutting which makes high-speed cutting possible and significantly enhances mechanical properties. Thus, a smooth surface can be obtained.

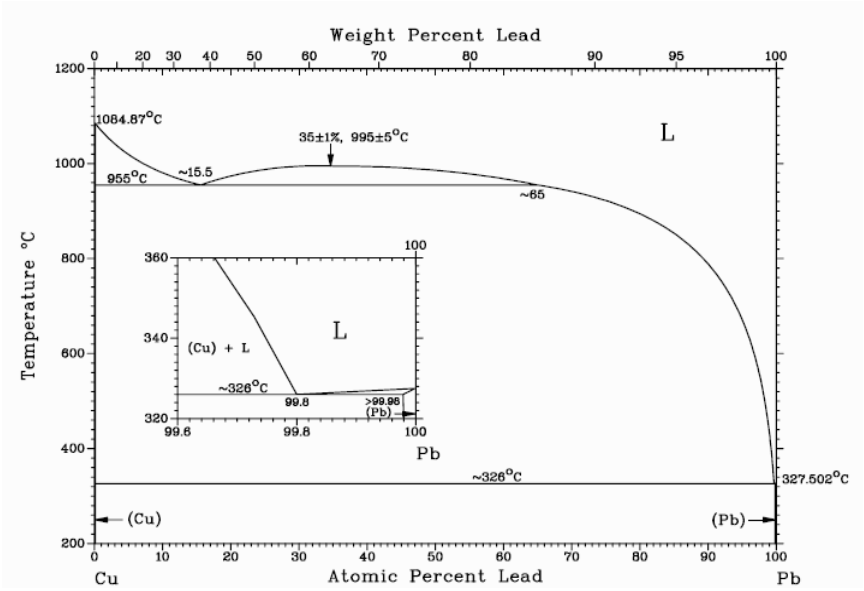

Fig.1 Phase diagram of Cu-Pb alloy

Bismuth series brass

Bismuth, adjacent to lead in the periodic table, is non-poisonous silver-white metal with brittle and hard properties. Its melting point is 271℃ and boiling point is 1560℃. Bi is so called "green metal" that can be used safely. Fig.2 shows that the solubility of Bi in copper alloy is very low, even when temperature reaches 800℃, the solubility is only 0.01%. Therefore, its solubility is almost neglectable. Bi forms eutectic with Cu at 70℃which makes it the first choice in replacing lead to produce environmentally- friendly brass.

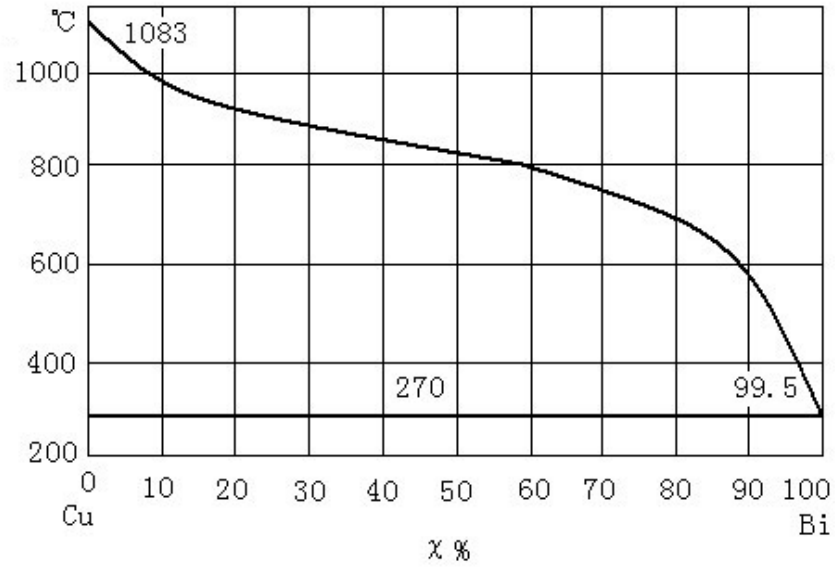

Fig.2 Phase diagram of Cu-Bi alloy

In 1994, Kohler Company successfully developed bismuth-contained low-lead brass and applied it in making water pipe instruments. So far, 8 designations of bismuth brass had been produced. In Japan, Sumitomo Metal co-developed NB series products of lead-free and low-lead brass in 2002. Lead was replaced by bismuth and tin in these brasses and samples were supplied to many companies after batch production. The British developed low lead content brass by replacing lead with bismuth, selenium and tin. Tensile strength of this new alloy is 241MPa, yield strength is 124MPa, extensibility is 20% and hardness is HB55. It is mainly used in water supply system with favorable mechanical, casting, elastic properties.

In 2004, Zhejiang Hailiang Group developed lead-free brass HB220 with similar cutting property

to C3604 brass bar while its anti-corrosion property is better than that of the other leaded brass bar. Bin Yang et al. from Jiangxi University of Science and Technology systematically studied the casting techniques and mechanical properties of Bi series brass and had made significant progress.

Silicon series brass

Fig.3 shows that low addition of silicon in brass can improve hardness and strength. When Si addition is over 4%, alloy flowability becomes lower due to the massive eduction of Si atγphase, resulting **i**n lower liquidus temperature, which further decreases the horizontal distance between liquidus and solidus. A compact casting structure thus can be formed. Besides, SiO_2 film was generated on the surface of cast product thereafter enhancing the anti-corrosive property.

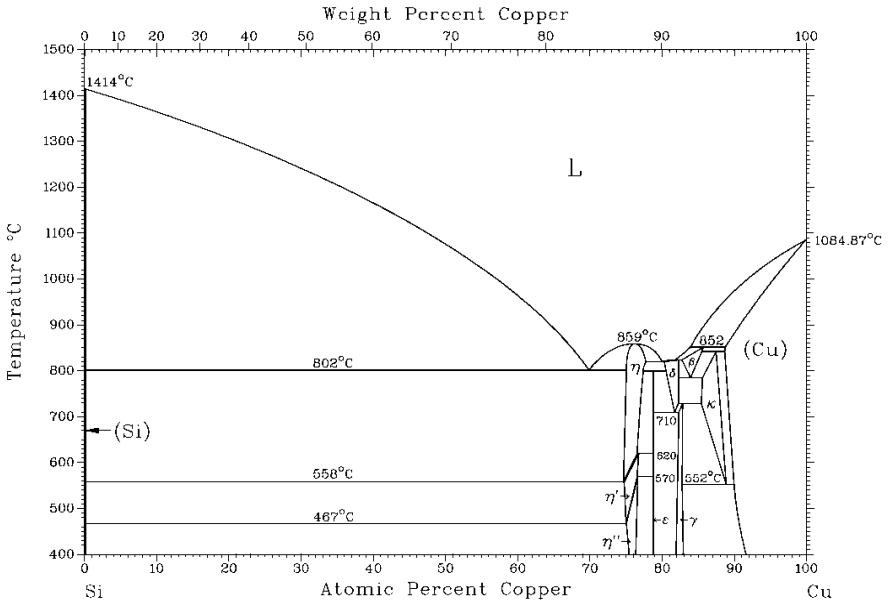

Fig.3 Phase diagram of Cu-Si alloy

Yin Xiao etc. from Guangdong Industrial University obtained impressive results in Si series brass. Mechanical property was improved when they replaced lead with silicon and increased zinc content to 50%. Cutting property of this lead-free and high-zinc brass is 70%-80% of HPb59-1. Japan Copper and Brass Association also developed silicon addition and low lead brass in 2002 with the composition of 75%Cu, 2-4%Si, less than 0.1%Pb and Zn allowance. Extensibility and yield strength of this brass are almost 1.4 times of C3604, similar to C6782 and SUS304, and the anti-dezincification property is similar to C83600.

Conclusions

With the research and development of lead-free and free-cutting brass becoming a trend, some technical problems appear which deserve further investigation:

For Bi series brass, bismuth is used to replace lead but often segregate in melting process due to big density of bismuth. Elastic property is also severely influenced because of Bi addition. Therefore, casting segregation and elastic property are key problems for Bi series brass production.

For Si series brass, it is critical to improve the smelting and heating process to reduce influence on elastic property caused by the shape, quantity and distribution of γ phase generated from silicon addition.

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