



EFFECT OF ALUMINUM CONTENT ON THE HARDNESS AND MACHINABILITY OF BRASS ALLOY USED IN OXYGEN CYLINDER VALVE

Hassanein Ibraheem Khalaf

hassanein.khalaf@uobasrah.edu.iq

University of Basrah-College of Engineering-Department of Mechanical Engineering

ABSTRACT

There is high consumption of oxygen cylinder valves due to incorrect application of valves, therefore, this research will study the possibility to modify Brass alloy that used to produce cylinder valves and reduce their erosion that happens under the use of valve. The main type of brass that used to make cylinder valve is CW713R which contained aluminum with percentage of 1.3-2.3% with hardness of 174 HV. Therefore, the effect of aluminum element on the properties of brass alloy will study to find the best and the optimum percentages that can be added to improve the hardness and machinability of cylinder valve. Brass scrap was melted using oil fire furnace and aluminum element was added before it cast. Then, the melting liquid was poured on steel die casting mold. The result shows that the hardness Brass cylinder valve was increased by increasing the percentage of aluminum element. It is raised from 206 to 605 HV. But when the percentage of aluminum reached 10 % the Brass material becomes brittle and difficult to machine. The best percentage of aluminum that can be added to brass alloy lies in the range of 2.5 – 5%.

Keywords: Brass, Aluminum, Hardness, Cylinder valve, Machinability

تأثير نسبة الألمنيوم على الصلادة وقابلية التشغيل لسبيكة البراص المستخدمة في صمام اسطوانة الاوكسجين

حسنين ابراهيم خلف

الخلاصة

بسبب عدم الاستخدام الصحيح للصمامات لوحظ هناك استهلاك كبير في صمامات قناني الاوكسجين. لذلك هذا البحث سوف يدرس امكانية تحسين سبيكة البراص المستخدمة لتصنيع صمامات الاوكسجين وتقليل التاكل الفيزيائي الناتج من عملية استخدام الصمامات. من اهم انواع البراص المستخدمة في صناعة الصمام هي CW713R التي تحتوي على نسبة المنيوم تتراوح ما بين 1,3 الي 2,3%. وصالده HV174 لذلك تأثير عنصر الألمنيوم على خواص سبيكة البراص سوف تدرس لاجاد افضل النسب التي يمكن اضافتها لتحسين صلالده وقابلية التشغيل لصمام الاسطوانة. يتم صهر سكراب البراص في افران تعمل بالنفط مع اضافك الالمنيوم قبل عملية الصب في القوالب الحديديه. اوضحت النتائج بان صلالده صمام الاسطوانة يزداد بزيادة نسبة الالمنيوم من 206 الي HV605 ولكن عند وصول نسبة الالمنيوم إلى 10% تتحول سبيكة البراص إلى ماده هشه تصعب عملية تشغيلها. لذلك افضل نسبة اضافة للالمنيوم تتراوح ما بين 2,5 إلى 5%.

INTRODUCTION

Brass is defined as an alloy prepared from copper and zinc with a small amount of additional metals such as iron, lead, tin and aluminum to improve their properties. The higher percentage of copper leads to increase ductility of brass and the higher percentage of zinc lead to increase the hardness, strength and brittleness of brass Sujit et al. (2015), Nowosielski et al. (2001) and Kommel et al. (2007). Many types of brass alloys can be used in industrial application due to their properties. Different alloying elements added to brass alloys to improve their mechanical properties. Brass has good strength, ductility and corrosion resistance therefore it is applied to made numerous parts such as valves and fittings Sujit et al. (2015), Nowosielski et al. (2001), Kommel et al. (2007) and A Arigraha et al (2017). Brasses with low and high percentages of copper can be made from electrically refined copper and recycling copper alloy to minimize the amount of other materials. The pure brass alloy content 85% copper and 15% zinc. On the other hand, other brass alloys can be content 35% - 45% zinc Sujit et al. (2015), Nowosielski et al. (2001), Kommel et al. (2007), A Arigraha et al (2017) and Rajab et al (2014). Aluminum has the highest influence in increasing the hardness and strength of brass alloys because of their microstructure and ductility. Also, corrosion resistance is improved by the self-healing oxide film aluminum confers Rajab et al (2014)..

The main types of brass alloys that can be used to manufacture oxygen cylinder valve include C36000, C46400, C48500 and C68700 brass. C36000 is a free machining brass is suited for high-speed machining operations with its superior machinability, thread rolling and knurling characteristics which have good resistance to corrosion. However, C46400 is a Nava brass is composed of 60% copper, 39.2% zinc which can be considered a typical brass alloy with the duplex alpha + beta structure. It has good strength and rigidity, high corrosion resistance to seawater, high resistance to wear, fatigue, galling, and stress corrosion cracking. On the other hand, C48500 is a naval brass with high leaded which obtained by added lead which are responsible for machinability, castability and corrosion resistance. It has high ductility and high impact strength with good creep resistance. Finally, C68700 is aluminum brass alloy that called arsenical that applied in the industrial field as condenser tube, evaporator tubes, heat exchanger tubes M. Kondracki et al (2003) and Muna et al (2001). Different alloying elements that include lead, tin, silicon, arsenic, iron, manganese, nickel and aluminum alloys will be added to brass to improve their properties. Lead with percentage up to 3% added to brass to provide free machining properties without any effect on their corrosion resistance. On the other hand, tin with percentage of 1% was added to improve the corrosion resistance for brass. Moreover, silicon added to increase the strength and wear resistance of brass. Furthermore, arsenic is added with small amounts to provide protection against dezincification corrosion. Also, iron and manganese added to increase the hardness, tensile strength and reduce the ductility. On the other hand, hardness and strength can be improved by added Nickel without any significant effect on ductility Muna et al (2001) and James (2013). A Arisgraha et al (2014), studied the effects of aluminum addition on the characteristics of Cu-28Zn brass produced by gravity casting. They found that add of 1.9 and 5.7 wt. % Al increased the tensile strength of Cu-28Zn alloy from 209 MPa to 415.7 and 545.25 MPa, respectively. Also, hardness increased from 53 VH to 77.46 and 356.23 VH, respectively. Zhuangzhuang et al (2020). with his colleagues have been considered the effect of aluminum element on the microstructure and the mechanical properties of brass as well as wear performances of a newly developed Ni-Si-containing complex brass. Results presented that with increasing the percentage of aluminum up to 3%, the mechanical properties of brass will increase. In addition, it shows the best solidification microstructure with uniform distribution phase and wear resistance.

Aluminum with percentage in the range of 1.5 to 8% added to brass to increase its hardness and modulus elasticity. It will make brass easily worked for any purpose. However, brass containing 8% of aluminum has the valuable property of being but slightly affected by acids or gases. A larger percentage of aluminum makes the brass brittle M. Kondracki et al (2003) & Zhuangzhuang et al (2020). The aim of this research is to study the effect of aluminum element on the properties of oxygen cylinder valve to improve its mechanical properties and find the best percentage of aluminum that should be added to brass alloy.

EXPERIMENTAL WORK

Sample Preparation by Casting Process

The mould used to cast melting brass in casting process is manufacturing from carbon steel plates. The mould contains two parts with thickness of 50 mm for each one and dimension of 250 x 300 mm as shown in figures (1) and (2) to produce cylinder valve shape as shown in figure 3.

Melting Procedure

Raw materials that used to make new brass alloy with aluminum element include scrap of brass and copper pipes with aluminum scrap. They cut to be suitable for melting in furnace and added to furnace with percentage of aluminum as shown in figure (1). The melting process was done by oil crucible furnace with temperature of 1250 °C which takes 50 minutes to melt scraps. Then, the melting liquid was transfer by crucible and pour into steel mold. The pouring operation was relatively slow cast to avoid any defects that might be happened like air gaps and porosity. It is left for 20 min. for cooling inside the mold then opened the mold to get the casting valves. Five heats with different percentages of aluminum were done.

RESULTS AND DISCUSSION

Casting Shapes

Figures (4) and (5) show the shape of casting valves that cast with different percentages of aluminum element.

Chemical Composition

The melting process for brass alloy and aluminum leads to losses of Al% which happened because the present white layer of Al_2O_3 will evaporate during melting operation. The losses of aluminum element that happened during the melting process are equal to 40% as shown in table(2). The main chemical composition of casting brass alloy after melting and casting is shown in table 3 which have been examined by using spectrum analyzer device model Spectrotest TXC25 that available in Mechanical Engineering department at university of Basrah.

Hardness

The hardness was increased by increasing the percentage of aluminum element to brass alloy. It was increased to be 605 HV when the percentage of Al equal to 10% as shown in table (4) and figure(6). This is because the refinement of grains and reduce their size with more uniform distribution which agree with the results found by Rajab et al (2014).

Machinability

Machinability is defined as an indicator of one engineering material how easy or difficult to be machined using a cutting tool to achieve an acceptable surface finish, which could be considered as a material property. The main factors that affecting machinability include microstructure, grain size, heat treat condition, chemical composition, fabrication methods, hardness, yield and tensile strength of the work piece. Table (5) shows the state of each percentage of aluminum and its effect of the machinability of samples or valves. When the percentage of aluminum increase the hardness increased too which led to difficulty to operate and machine the casting valve. Therefore, the percentage of aluminum is 2.5% and can be increased to be 7.5% as maximum percentage of aluminum that can be added to brass casting.

Microstructure

Samples were cutting to prepare by wet grinding using emery paper grades in the range of 320, 400, 600, 800, 1000, 1200, 1500 and 2000 grit (sic) with water. Then, samples were polished by using alumina powder suspended solution with particle size of 0.5 μm , and napless cloth. After that samples were cleaned with water. Finally, etching was done by using 2.5% HNO_3 , 1.5% HCl , 1% HF and 95% H_2O for 15 seconds. The microstructure of samples was done by using an optical microscope and digital camera as shown in figures 7 and 8.

CONCLUSIONS

1. The best percentages of aluminum can be used to produce suitable brass alloy are 2.5 and 5 % Al because it has good hardness and machinability.
2. Aluminum added with percentage of 10% is not good for manufacturing cylinder valves because the metal will be hard and brittle. It is not easy to machine in all types of machines which can be cut and machine by grinding machine only.
3. There is a gradual increase in the hardness with increasing the percentage of added aluminum.

Acknowledgment

This work was supported and funded by University of Basrah, College of Engineering, Department of Mechanical Engineering.

Table(1) Percentage of Aluminum element added to cast brass alloys

Heat No.	1	2	3	4	5
Al wt%	0	2.5	5	7.5	10

Table(2) Losses of aluminum element after melting with brass alloys

Heat No.	1	2	3	4	5
Al% before melting	0	2.5	5	7.5	10
Al% after melting	0	1.38	3.02	5.82	7.76

Table(3) Chemical analysis of casting brass alloys

Heat No.	Chemical Composition wt%		
	Al %	Zn %	Cu %
1	0		
2	7.76	30.86	61.38
3	5.82	28.50	62.17
4	3.02	35.28	60.93
5	1.38	28.81	66.60

Table(4) Hardness of casting brass alloys

Heat No.	Al %	Hardness HV (kgf/mm ²)
1	0	206
2	2.5	260.7
3	5	340.5
4	7.5	394.9
5	10	605.4

Table(5) Machinability of casting brass alloys

Al %	Machinability
2.5	The best sample in operating ability.
5	It can be operating in all machines.
7.5	It can be operating in all machines.
10	Could not be operating, but only in grinding machines.

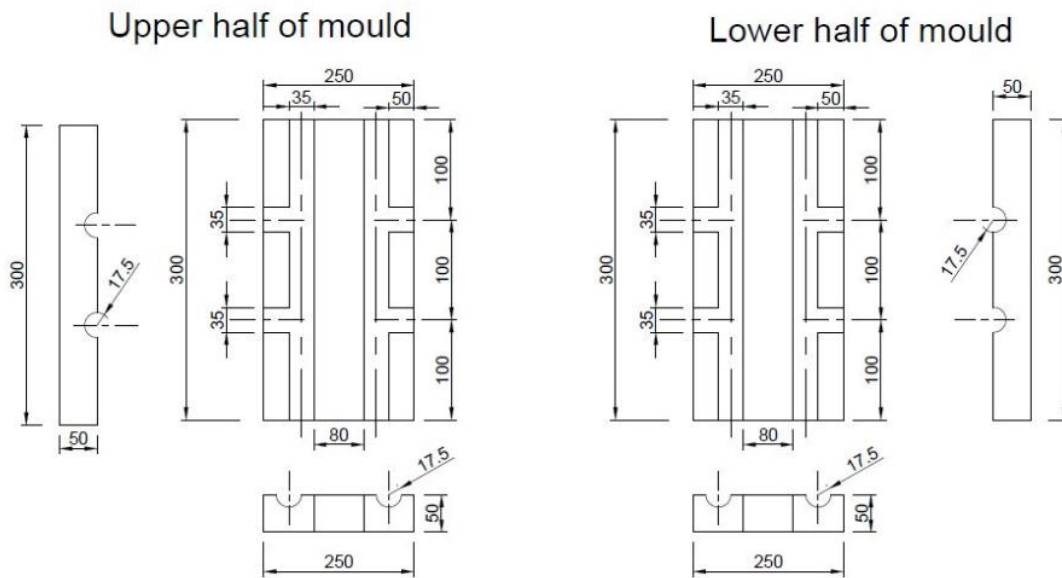


Fig. (1) Dimension of Carbon steel Mold



Fig. (2) Carbon steel Mold



Fig. (3) Oxygen cylinder valve [10]



Heat No. 1

Heat No. 2

Fig. (4) Shapes of casting valves for heats number 1 and 2



Heat No. 3

Heat No. 4

Fig. (5) Shapes of casting valves for heats number 3 and 4

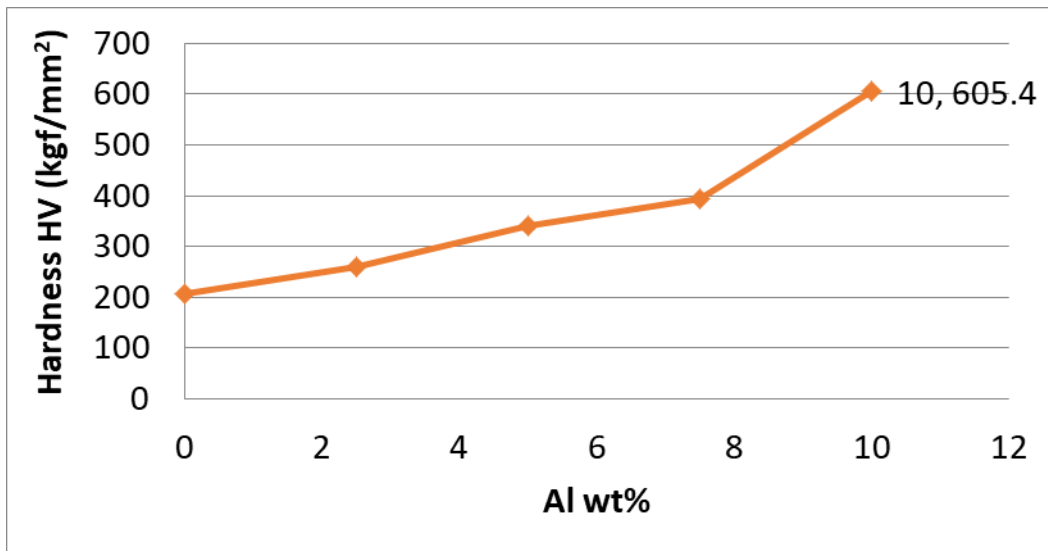
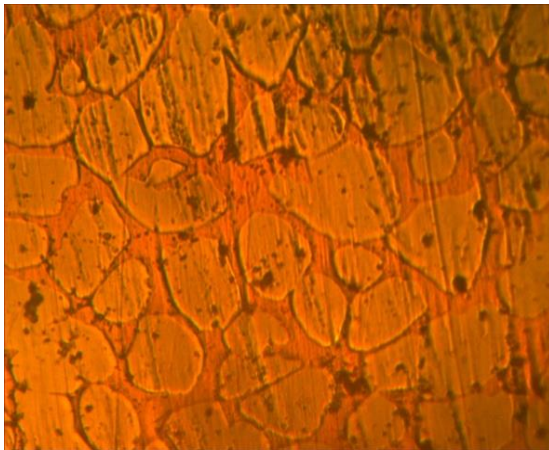
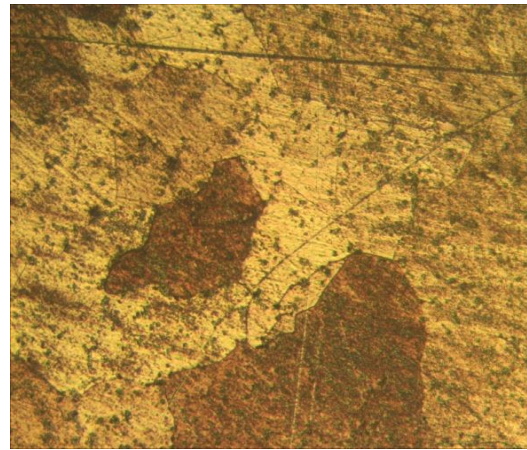


Fig. (6) Relationship between hardness and aluminum for casting brass.

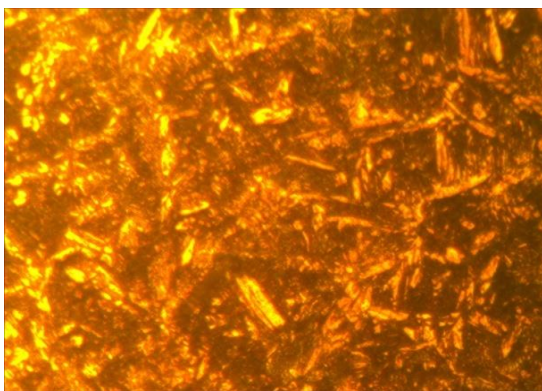


Casting brass alloy with Al of 2.5%

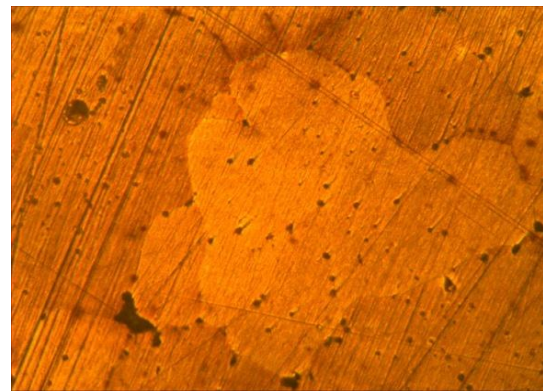


Casting brass alloy with Al of 5%

Fig. (7) Microstructure of casting brass alloy with Al% of 2.5 and 5% (X1600).



Casting brass alloy with Al of 7.5%



Casting brass alloy with Al of 10%

Fig. (8): Microstructure of casting brass alloy with Al% of 7.5 and 10% (X1600).

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