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Acetylene Welding of Brass Materials for Radiator Cover: A Study on the Weld Quality and Performance

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Abstract. Brass material is important for all industrial parts. Brass had good ability work in cold or hot conditions, in solid state CuZn is capable of dissolving more crystals in the mixture. At temperatures of 902°C peritectic transformation occurred where Zn soluble in 32.5%. Solubility is increased up to a temperature of about 450 ° C to 39% and then in equilibrium will decrease, the length of the heating and cooling process is very long. With descriptive technique showed that the weld strength brass highest (7863.1 kgf / mm2) is that the surface of the specimen suffered welding rubbing with a gap distance of 0.2 and 0.3 mm, both with water cooling or air cooling, and the condition other relatively much lower strength (3144.89 kgf / mm2). Welding the workpiece surface is not polished strength is low. Specifically, properties - mechanical properties of brass can be improved by the addition of small amounts of other alloying elements without reducing the characteristics of the brass in general. But with a maximum limit zinc levels should not exceed 42% because it will result in a brass are fragile because of excess levels of zinc, and cannot be used commercially. with the addition of other elements as reinforcing elements of brass such as silicon, bismuth, selenium and others to improve the ability of the brass in the machining process. Welding results by using three different types of welding wire shows that, at the time of welding is performed with brass welding wire in the market there is no trouble found. Welding speed specimen is also calculated using a stopwatch, and the speed required for welding in 3 specimens, the average in the first specimen takes 5 minutes for the welding process. And the visual results produced is also satisfied.

Keywords: brass; temperature; solubility; zinc; specimen; welding process

INTRODUCTION

CuZn alloy with at least 55% Cu content is known as Kuningan (Amoldi, 2010). Brass has the property of being easy to form, both in cold and hot workmanship. But it is more profitable if it is worked with heat treatment, because in the process of formation it is easier (Sahat, 2000). This research aims to develop the basic properties that exist in brass at the time of welding. Welding is a metallurgical bond at the junction of metals or alloys that are carried out in a melted or liquid state (Wibowo, 2007). It was also found that the use of brass coating with the acetylene welding method can soften the weld metal area and HAZ thereby reducing the strength of the joint (Imai, 2009). In particular, the mechanical properties of brass can be improved by the addition of small amounts of other alloying elements without compromising the general characteristics of brass. But with a maximum zinc content limit should not exceed 42% because it will cause brass to be brittle due to excess zinc content, and cannot be used commercially (Wibisono, 2009). with the addition of other elements as reinforcement of brass such as silicon, bismuth, selenium and so on to increase the ability of brass in the machining process (Setiabudi, 2010). Based on this, the formulation of the problem from this study is whether welding using acetylene welding on brass material can be done and which type of wire gives the best results for welding with brass material.

LITERATURE

Welding brass material using acetylene welding is one method of gas welding that uses a mixture of acetylene gas and oxygen to produce a very hot flame. This method is mainly used for braze and braze welding, which involves joining two metals by using a filler metal that has a lower melting point than the parent metal. This method can also be used for cutting, forming and preparation of metals.

Welding brass materials has several challenges, such as the risk of zinc fuming, porosity, lack of fusion, and hot cracking. Zinc fuming is a phenomenon in which zinc evaporates from brass material when heated, causing zinc poisoning in workers and defects in welds. Porosity is the presence of small holes in the weld caused by gas trapped during the welding process. Lack of fusion is the failure to perfectly unite the parent metal and the filler metal. Hot cracks are cracking that form on the surface or in welds due to thermal stress or thermal mismatch between the parent metal and the filler metal (Raza et al., 2023)

To overcome these challenges, several preparatory and preventive steps must be taken before welding brass material using acetylene welding. First, brass material must be cleaned of dirt, oil, or oxides using a wire brush or sandpaper. Secondly, the brass material must be heated evenly before welding to reduce thermal stress and increase the flow of the filler metal. Third, acetylene gas and oxygen must be adjusted to the right ratio to produce a neutral flame that is neither too hot nor too cold. Fourth, fluxes should be used to protect metal surfaces from oxidation and aid in the smelting of filler metals (Khan et al., 2023)

In addition to preparation and preventive measures, the selection of suitable filler metals is also important to determine the quality of brass material welding results using acetylene welding. The filler metal used should have a melting point lower than brass material, but not so low that it causes hot cracking. Common filler metals used for braze welding brass materials are copper-zinc alloys (Cu-Zn), copper-tin alloys (Cu-Sn), copper-aluminum alloys (Cu-Al), or copper-nickel alloys (Cu-Ni). The selection of filler metals must also consider chemical and thermal compatibility with brass materials (Midawi et al., 2022).

Welding brass material using acetylene welding has several advantages, such as ease of operation, application flexibility, and low equipment costs. This method can be used to weld various shapes and sizes of brass materials with high precision. This method can also produce strong, corrosion-resistant, and aesthetically pleasing welds. However, this method also has some limitations, such as requiring high worker skills, requiring respiratory protection from zinc fuming, and being prone to defects due to differences in thermal expansion coefficients between parent metal and filler metal (Zhi et al., 2021).

The level of hardness of brass material after welding with acetylene welding is one indicator of the quality of welding results. Hardness is the ability of a material to resist permanent deformation due to external forces. The hardness of brass material is influenced by several factors, such as chemical composition, heat treatment, and welding method.

Brass material is an alloy of copper and zinc with various proportions. This material has good mechanical properties, such as strength, ductility, and corrosion resistance. The hardness of brass material varies depending on the content of zinc and other alloying elements. In general, the hardness of brass materials increases with increasing zinc content and hard alloying elements, such as tin, aluminum, and nickel (How to Weld Brass, Welding of Brass and its Alloys - Material Welding, 2023).

Heat treatment is the process of heating and cooling a material to change its microstructure and mechanical properties. Heat treatment can affect the hardness of brass material in different ways depending on its type and purpose. Some types of heat treatment commonly carried out on brass materials are annealing, normalizing, hardening, and tempering. Annealing is the process of heating a material to a certain temperature and then slowly cooling it to reduce hardness and increase ductility. Normalizing is the process of heating a material to a temperature slightly above the phase change point and then cooling it airily to produce a uniform microstructure and increase strength. Hardening is the process of heating a material to high temperatures and then rapidly cooling it to increase hardness and wear resistance. Tempering is the process of reheating materials that have undergone hardening to low temperatures to reduce brittleness and increase ductility (Weldability of Materials - Cast Irons - TWI, n.d.).

The hardness of brass material after welding with acetylene welding is influenced by several factors, such as zinc content, flux, flame, and cooling rate. The zinc content affects the hardness of brass materials because zinc has a lower melting point than copper and tends to evaporate when heated, causing zinc fuming. Fuming zinc can cause porosity and less fusion in welds, which reduces weld hardness. Flux is a chemical substance used to protect metal surfaces from oxidation and aid in the melting of filler metals. Flux can affect the hardness of brass materials because flux can increase the flow of filler metal and reduce zinc fuming, which increases weld hardness. A flame is a flame produced by a mixture of acetylene gas and oxygen. The flame can affect the hardness of the brass material because the flame can determine the temperature and heating time of the parent metal and the filler metal. A flame that is too hot or too cold can cause hot cracking or lack of fusion in the weld, which reduces the hardness of the weld. The cooling rate is the rate of temperature change of the parent metal and the filler metal after welding. The cooling rate can affect the hardness of the brass material because the cooling rate can determine the microstructure and residual stress on the weld. Too fast or too slow a cooling rate can cause brittleness or deformation in the weld, which reduces the hardness of the weld (Khan et al., 2023).

METHOD

The brass plate is cut with a length of 260 mm and a width of 50 mm, then cut into 2 parts in the middle to get maximum results in the welding process using hand grinders. According to AWS code, potency will be required if the thickness of the welded plate exceeds 6 mm. Therefore, welding on plates less than 6 mm thick is more practical, there is no need to make a corner of the camp. Because the brass plate used in this study has a thickness of 3 mm. Then after all the preparation processes are complete, the welding process is carried out on the brass material with 3 different welding wires, namely: (1) brass welding wire made from the parent brass material itself; (2) brass welding wire sold in the market; (3) copper welding wire obtained from 3mm size copper wire. In figure 3.5 below can be seen copper wire for brass welding fillers.

Figure 1. copper wire for welding proses

After all welding processes were completed, a series of testing processes were carried out to see the results of this study, in this study researchers used 2 tests, namely: (1) penetrant test; (2) Hardness test. After all tests are carried out, the analysis of the research results is carried out to find out what data is obtained from the test results. All known values of the hardness test are averaged to determine the best hardness level of each specimen in this study.

DISCUSSION

The results of welding using 3 different types of welding wire show that, when welding done with brass welding wire on the market no difficulties were found. The welding speed of the specimen is also calculated using a stopwatch, and the speed required for welding on 3 specimens, on average on 1 specimen takes 5 minutes for the welding process. And the resulting visual results are also quite satisfactory.

Brass Welding with Copper Welding Wire Filler. In copper welding wire, researchers use copper wire with a diameter of 3 mm for filler. Difficulties occur when welding takes place, because the boiling points of brass and copper are different, this is because the temperature required for copper material to melt is about 1357.6 K (or about 1984.3 °F). While brass has a melting point that is not the same as copper, which is around 1080ºC - 1130ºC for its melting point. The time needed for welding is also quite long, which is about 10 minutes. This causes the welding results to be less than optimal, because the brass melts first than the copper wire. As a result, in the welding area, holes are formed because of this. The results of welding using copper welding wire can be seen in figure 2 below:

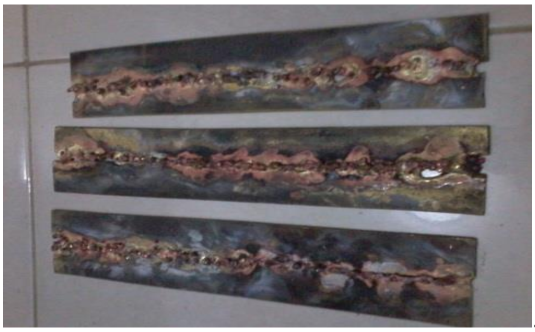
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Figure 2. welding using copper welding wire filler on brass plates

Welding Using Welding Wire Filler Made of Brass Mother Itself. Welding with filler made from the mother, researchers make welding wire by cutting the brass with a width of 3 mm. Then after cutting, researchers form the welding wire into a circle to facilitate the welding process. In the welding process, no difficulties were found during the welding process on the brass, but on the surface of the weld there are many small basin basins. The time required for this welding is very different from the previous welding, the time range for this welding is about 5 minutes.

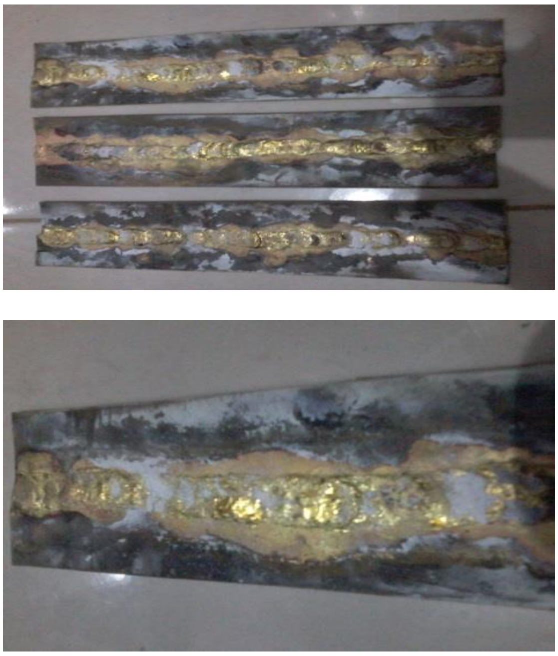

Figure 3. Welding using welding wire filler made from the brass mother itself

Welding Using Welding Wire on the market. In welding using brass welding wire fillers on the market, there are no difficulties as the previous welding. Because this welding wire is indeed made specifically for this type of welding. The time needed for welding is also relatively fast, which is about 3 minutes.

Figure 4. welding using welding wire on the market. with brass welding wire on the market

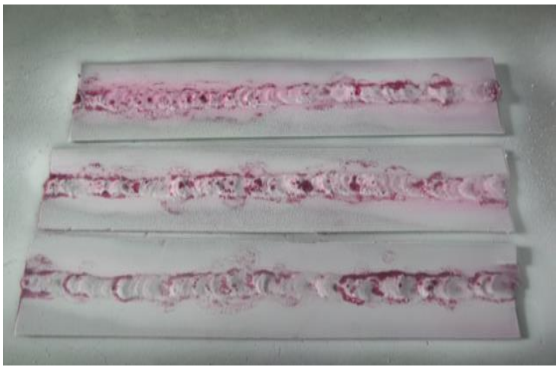

Figure 5. Results of penetrant tests on specimens welded with welding wire made from the parent itself

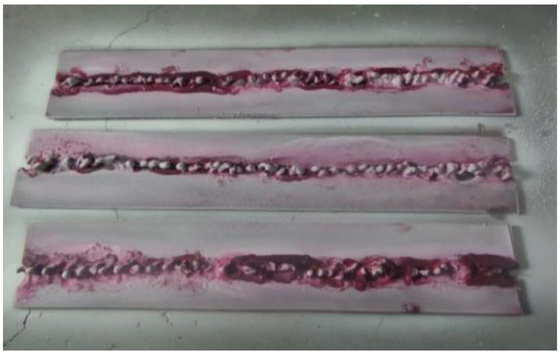

Figure 6. Penetrant test results on specimens welded with copper wire

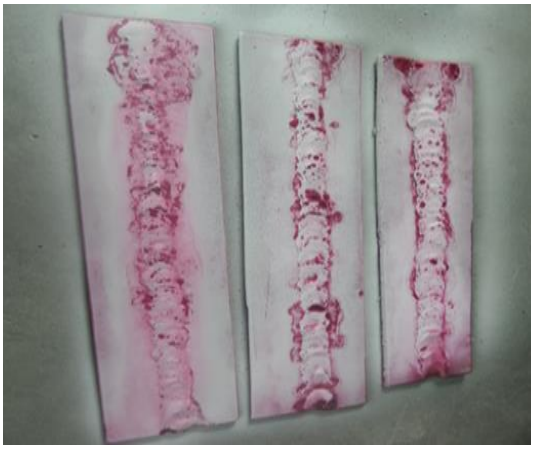

Figure 7. Penetrant Test Results on Welded Specimens

In the picture above, porosity and crack welding defects were found, it can also be seen in the welding area of the copper wire material welds also cannot melt perfectly on the brass plate. copper has a melting point of about 1357.6 K (or about 1984.3 °F) and brass requires about 1080ºC - 1130ºC for its melting point. Because of these factors, the results of welding brass plates with copper wire filler can be declared unsatisfactory. In the table below, you can see the results of the penetrant test on each brass plate welded with different fillers. Penetrant test results on all average specimens have almost no good results. In brass welding with brass welding wire fillers on the market, the results of the penetrant test show porosity defects in the welding area and HAZ (heat affected zone) area.

However, in welding using the same filler as the parent found different results, in the welding area only a few porosity defects were found, even on plate 2 there were almost none. However, in the HAZ (heat affected zone) area, porosity defects are still found but not as much as in welding using brass welding wires on the market. Then on the brass plate welded with copper wire filler, the results can be ascertained not to meet the requirements on the penetrant test, because the weld results can be ascertained if the results of the copper wire are not satisfactory. In the penetrant test, the welding results using copper wire filler show 2 defects, namely porosity defects and crack defects. This is because copper and brass melting points are very different. After going through the penetrant spray test, all specimens are cut with a length of 35 mm for the hardness test process. Then in the welding area, grinding is carried out to smooth the brass surface so that hardness tests can be carried out.

After smoothing, each specimen took 1 best result by visual selection. Because the welding results on each specimen that have been welded are less satisfactory as in the results of welding using copper welding wire, because the results of welding found holes caused by the melting point of different copper welding wires and kunigan. The hardness test in this study used the brinnel method hardness test. Hardness testing with the Brinnel method aims to determine the hardness of a material in the form of material resistance to steel balls pressed on the surface of the test material (specimen). This test was carried out a loading of 613 kgf. Then to find out the desired research results, researchers take a little brass material that has not been welded and test the hardness of the material first to be compared with the hardness test results after the welding process.

Then the brass is smoothed to the surface to test its hardness. Because in the hardness test, the surface of the specimen must really have a smooth surface because it can affect the results of the test object's own hardness. All specimens that have been smoothed surface, including brass that have not been welded will be subjected to a hardness test process. All specimens are tested in 3 areas, namely: weld area, HAZ area, and outer welding area. Then testing is carried out at 3 different points in each region. Then the resulting values at each point are averaged to find out the best results from each of these tests. The results of the testing process on brass that have not been welded are then taken flat and used as a reference to compare which results are the best. From the test above, all hardness test results are taken flat to determine the hardness of brass material that has not been welded. In table 4.3 below can be seen the results of the hardness test and the average.

Table 1. Hardness test results on brass plates that have not been welded

MATERIAL	HASIL UJI KEKERASAN (HB)			RATA RATA
	PENGUJIAN 1	PENGUJIAN 2	PENGUJIAN 3	
PLAT KUNINGAN	47,7	45,9	46,7	46,7

From the data above, the number 46.7 HB is obtained, this number will be a comparison for the results of hardness tests on brass plates that have been welded with 3 different fillers.

After the numbers on the hardness test on the brass plate that have not been welded have been carried out, the next test is carried out on the brass plate that has been welded with 3 different fillers. This is done to find out how much influence welding with 3 different fillers has on the hardness test. Testing on brass plates welded with brass welding wire fillers on the market is carried out by taking 3 points in 3 areas, the purpose of the 3 areas, namely: welding area, HAZ area, outer welding area. This is done to determine the average hardness of brass plates after being welded with brass welding wire fillers on the market. From the data above, the number 46.7 HB is obtained, this number will be a comparison for the results of hardness tests on brass plates that have been welded with 3 different fillers. After the numbers on the hardness test on the brass plate that have not been welded have been carried out, the next test is carried out on the brass plate that has been welded with 3 different fillers. This is done to find out how much influence welding with 3 different fillers has on the hardness test. Testing on brass plates welded with brass welding wire fillers on the market is carried out by taking 3 points in 3 areas, the purpose of the 3 areas, namely: welding area, HAZ area, outer welding area. This is done to determine the average hardness of brass plates after being welded with brass welding wire fillers on the market. This test is carried out at 3 points in the welding area, and the result:

Analysis of Hardness Test Results in the Welding Area in each Specimen. From all the hardness test results obtained, the average on all specimens can be determined. The average hardness test results on each specimen in the welding area can be seen in table 3 below.

Table 3. Hardness test results in the welding area

jenis kawat las	hasil uji (kg/mm²)pada daerah las			rata rata
	1	2	3	
kawat las yang ada di pasaran	62,7	63,9	75,1	67,2
kawat las yang sama dengan induknya	66,8	49,4	58,1	58,1
kawat las tembaga	57,6	66,2	55,3	59,7

After the average data is obtained, the overall value of this study can be seen. From table 3 above, it can be seen that the average obtained from all hardness tests in the welding area produces a value of 61.6 HB in each specimen. An increase in the hardness value of brass plates that have been welded with 3 different fillers is produced. Because on brass plates that have not been welded with 3 different fillers produce an average value of 46.7 HB. While the results of the hardness test in the welding area produced an average value of 61.6 HB. Analysis of Hardness Test Results in HAZ (Heat Affected Zone) Areas in each Specimen.

Table 4. hardness test results in the HAZ (heat affected zone) area of each specimen

Jenis kawat las	Hasil uji kekerasan (kg/mm²) didaerah HAZ			Rata rata
	Pengujian 1	Pengujian 2	Pengujian 3	
Kawat las yang ada dipasaran	82,6	79,6	78,7	80,3
Kawat las yang sama dengan induknya	77,5	78,7	79,6	78,6
Kawat las tembaga	75,1	75,1	74,7	74,9

In table 4 above, it can be seen the results of the hardness test in the HAZ area on each plate that has been welded with 3 different fillers. The results shown in table 4 above show a very high increase in violence. On brass that has not been welded, it shows a figure of 46.7 on average. While the average obtained from all hardness tests conducted on all specimens showed a figure of 77.9. This result can be said to have increased hardness values in the HAZ (heat affected zone) area after the brass plate is welded with 3 different fillers.

From all the hardness test results obtained, the average on all specimens can be determined. The average hardness test results on each specimen in the outer area of the welding can be seen in table 5 below.

Table 5. Hardness test results on the outside area of the weld in each specimen

jenis kawat las	hasil uji kekerasan (kg/mm²) pada daerah luar pengelasan			rata rata
	pengujian 1	pengujian 2	pengujian 3	
kawat las yang ada dipasaran	71,3	69,2	68,2	69,5
kawat las yang sama dengan indukn	75,7	69,5	71,7	72,3
kawat tembaga	68,2	70,6	70,2	69,6

From table 5 above, it can be known the results of hardness tests from the outer area of welding in each specimen. The average value produced is then added up and taken the average again to be compared with the test results on brass plates that have not been welded, which is 46.7 HB. After calculation, the average number obtained resulted in a value of 70.4 HB. In these results, an increase in the hardness value of the material was found to have been welded with 3 different fillers.

CONCLUSION

From the results of the penetrant test on brass material carried out by welding process with 3 different fillers (for application to radiator covers). For welding brass material welded with 3 different fillers showing, welding on brass material can cause a lot of porosity in the welded brass material. This is because during the welding process, the union of filler is coupled with the mixing of borax material against the filler. So that in the weld area a pattern such as a defect is formed in welding. This is known from the results of hardness tests carried out on all brass specimens that have been welded with 3 different fillers showing results above the average value of brass before the welding process. Likewise, when brass material is tested for hardness. The results obtained in the hardness test show an increase in hardness on the brass plate after welding. Because the value obtained at the time of the hardness test gradually increases on average. So that brass welding can be done to repair damaged radiator covers.

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