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# The Effect of Composition and Type of Metal Filler on Heat Resistance of Silica Rubber Matric Composites

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***Abstract.*** Thermal Tensioning is one of the methods used to minimise the occurrence of residual stress and unwanted distortion during welding. One of the thermal tensioning methods is Static Thermal Tensioning (STT), which involves countering thermal stress during welding. The STT method requires active cooling behind the welding line. Several properties are required for the coolant material, such as thermal conductivity, heat resistance, and good flexibility. To achieve the desired properties, a mixture of different materials was used, commonly called a composite. The purpose of this study is to know the effect of filler metal composition and type on the heat resistance of silica rubber matric composites. This study used 2 independent variables: the filler composition in composites with variations of K1 (60%) and K2 (70%), and the type of filler metal, aluminium and copper powder with variation J1 (100%-0%), J2 (75%-25%), J3 (50%-50%), J4 (25%-75%), and J5 (0-100%). The testing process used Thermogravimetry Analysis (TGA) with replication 2 times. The results of this study showed the specimens with K1;J1 composition,containing 60% pure aluminium filler metal, showed the best heat resistance with a final weight of 88,25%. While specimens with K2;J5 composition, containing 70% pure copper filler metal, showed the worst heat resistance with a final weight of 74,25%.

*Keywords : aluminium, composite, copper, heat resistance, silica rubber*

## 1. INTRODUCTION

Welding is one of the manufacturing processes in the industrial world, however this manufacturing process has several weaknesses such as distortion and sensitization during welding. Welding can also be defined as the process of joining two metals to the point of recrystallisation of the metal with or without the use of additional materials and to perform this welding the presence of heat energy is required [1]. Inconsistent heating and cooling during welding can result in thermal expansion and contraction, causing residual stress and desirable deformation [2]. Residual stress and distortion that occur can be reduced by using the thermal tensioning method, which is welding by adding active cooling behind the welding line and heating beside the welding line. One of the thermal tensioning methods is Static Thermal Tensioning (STT), the working principle is thermal tensioning to fight thermal stress during welding [3].

[3] has researched the effect of the temperature variation of static thermal tensioning on angular distortion and microstructure behaviour of gmaw welded sus 304 stainless steel plate where GMAW welding with the most optimal STT method is at a temperature of 250C, namely with an angular distortion value of 2° 78’.To be an active cooling must have several properties such as good thermal conductivity, heat resistance, and flexibility. To get all those properties it is needed to combine several materials that have those properties. This mixture commonly called a composite, causes the formation of a new structure that has the combined properties and characteristics of the forming materials [4].

The reinforcing phase used in this research is particles, which are aluminium and copper powder. This is because aluminium is easily found in the market. In addition, aluminium is a good conductor of electricity and heat, has a low melting point, and has good corrosion resistance [5]. Copper was also chosen as the reinforcing phase because copper with high purity is also good for conducting electricity and heat, also has a high melting point [6]. While the matrix used is elastomer or rubber because it can be elastically deformed very high [7]. However, chemical and physical modifications to rubber is needed so that it can be utilised in another sector. This is needed to overcome the limitation of rubber properties [8]. Rubber compound fillers such as Carbon Black (CB) and silica are often used to improve the mechanical properties of the rubber [9]. Silica rubber is an example of a product derived from rubber. The addition of silica to rubber has benefits compared to organic rubber such as being able to be used over a wide temperature range (-100 °C to 250 °C) [10]. [11] has conducted research effect of silica and silicone oil on the mechanical and thermal properties of silicone rubber, It was found that the fumed silica-filled sample had a higher tanδ than the precipitated silica.

The composite will be tested for heat resistance or thermal resistance. The higher the resistance of a material, the lower heat loss [12]. This heat resistance test will use the thermogravimetric analysis method, which studies mass reduction against temperature increase. The matrix and filler bonds will be released as the temperature increases causing the material to degrade [13]. Therefore, further research is needed to determine the material that has the best heat resistance to become a substitute material for active cooling in the welding process with STT method..

## 2. METHODS

### 2.1 Research Methods

The method used to find the scientific truth in this research is the experimental method. Experimental research method is a research method that investigates causes and effects by adding control variables.

### 2.2 Specimen and Equipment Preparation

The specimen made from composites with filler containing aluminium and copper powder and matrix containing silica rubber with dimensions of 96 mm in length, 13 mm in width, and 4 mm in thickness. Specimen made using acrylic mould as shown in Fig 1.

**Figure 1.** Acrylic mould

The specimens used for testing are 20 samples with a variation of 10 types and 2 replications. The specimen that has been made is clamped on an electric heater as shown in Fig 2.

**Figure 2.** Clamping the specimen

After the specimen is clamped, the next step is to switch on the thermocontrol and set it at room temperature as shown in Figure 3.

**Figure 3.** Set the Thermo control at room temperature

**2.3 Research Variable**

The independent variables in this study are the composition of filler metal in the composite and the type of filler metal. The composition of filler metal in the composite used in this research is as follows:

a. 60% filler metal and 40% matrix (K1)
b. 70% filler metal and 30% matrix (K2)

The type of filler metal used is aluminium and copper powder with variation:

a. 100% aluminium-0% copper (J1)
b. 75% aluminium-25% copper (J2)
c. 50% aluminium-50% copper (J3)
d. 25% aluminium-75% copper (J4)
e. 0% aluminium-100% copper (J5)

The dependent variable in this study is heat resistance, the good and bad heat resistance of a specimen is determined by the percentage of the remaining weight of the specimen after testing by giving a pressing load from the clamp. the sample used has a size of 96×13×4mm.

The controlled variable used in this study is testing temperature, the peak temperature for this research is 500 °C

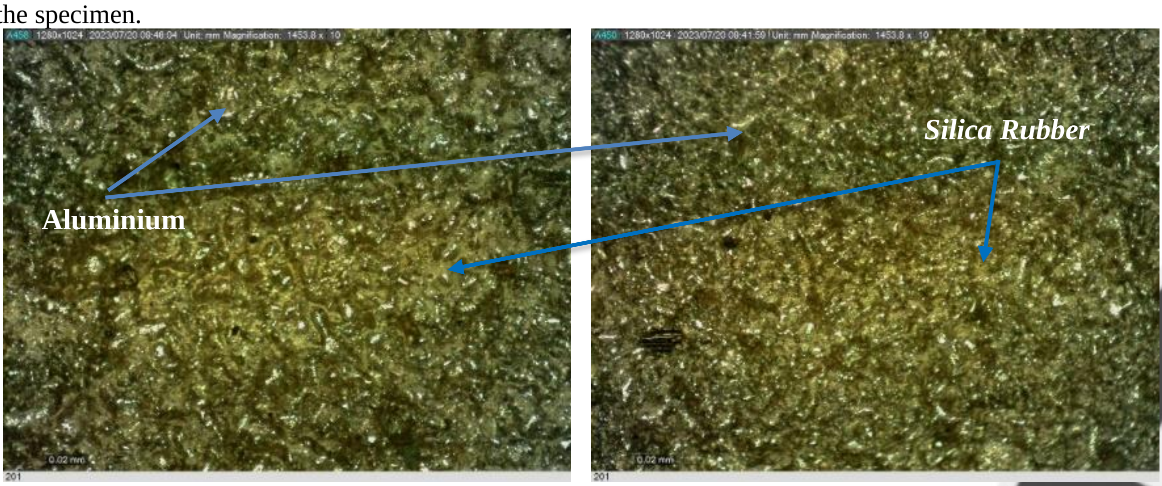
**2.4 Method of Collecting Data**

The testing process is performed on specimens with two replications for each variation. Before testing it is necessary to weigh the initial weight of the specimen. After that do the testing process and record the weight change of the specimen at each temperature. After the testing process is complete weigh the specimen again and compare it with the records.

## 3. RESULTS AND DISCUSSION

**3.1 Microstructure**

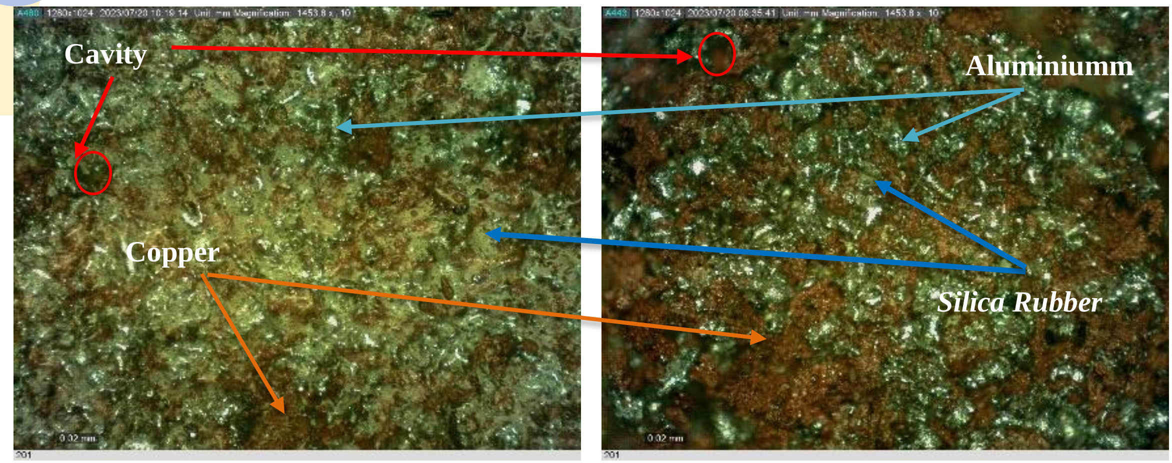
To strengthen the discussion of this research, micro photos are also used to determine the bonding structure of the specimen.




(a) (b)

**Figure 4.** Micro photo specimen K1;J1 (a) and K2;J1 (b)

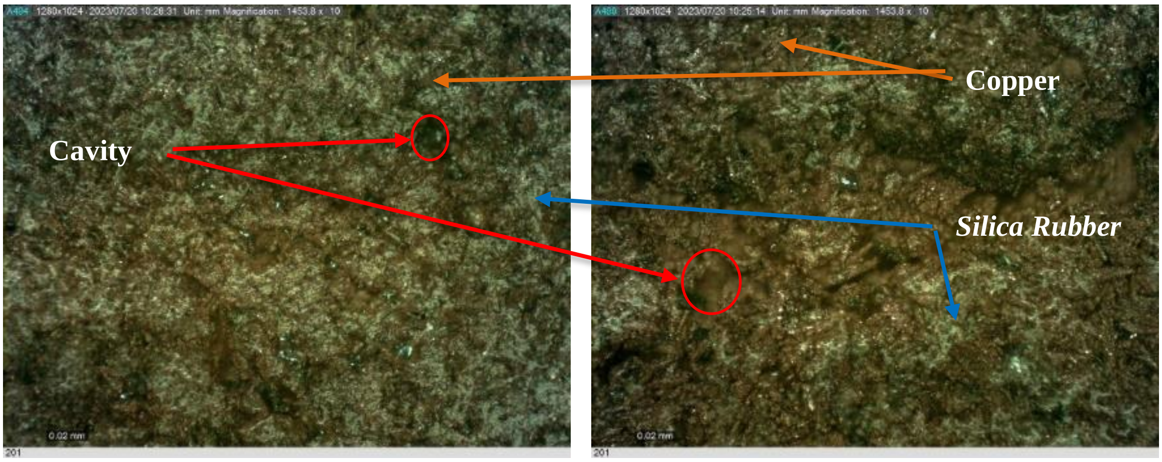
In Figure 4 which shows a micro photo of specimen J1, it is shown that the filler metal and matrix attach nicely. This causes no air trapped inside and the specimen has a smooth surface.




(a) (b)

**Figure 5.** Micro photo specimen K1;J3 (a) and K2;J3 (b)

A micro photo of specimen J3 is shown in Figure 5. It can be seen that the filler metal is attached to the matrix, but the aluminium and copper powder cannot be merged. In specimens K2;J3 some parts are slightly blurred, this indicates there are differences in height or cavity in the specimen. Air will enter the cavity in the specimen.




(a) (b)

**Figure 6.** Micro photo specimen K1;J5 (a) and K2;J5 (b)

Specimen J5 is the most brittle specimen, it can be seen in Figure 6 that the copper powder is grouped and difficult to attach to the matrix. This causes the specimen to be brittle and easily broken. In specimen K2;J5 it can be seen there are more cavities when compared to specimen K1;J5. These cavities will be entered by air which makes the specimen combustion process faster.

### 3.2 Discussion

Figure 7 shows the weight change of all types of specimens. It can be seen the K1;J1 specimen has the most residual weight. This is because aluminium has a smaller thermal conductivity than copper and also the filler used in the specimen is only 60%. In addition, the structure of this specimen shown in Figure 5 (a) shows that air is difficult to enter the bond between filler and matrix, which causes the combustion process to occur only at high temperatures. This causes the specimen to still have a residual weight of 88,25%. The K2;J5 specimen has the smallest residual weight percentage which means this specimen has the worst heat resistance. This is because copper has a bigger thermal conductivity than aluminium, it is also supported by the large use of filler in the specimen which reaches 70%. In addition the structure of the specimen shown in Figure 7 (b) shows the copper is difficult to attach with the matrix which causes many cavities in the specimen. This cavity will be filled with oxygen which can accelerate the combustion process. These factors make the matrix in the specimen burn faster and reduce, this causes the specimen to only have residual weight of 74,25%.

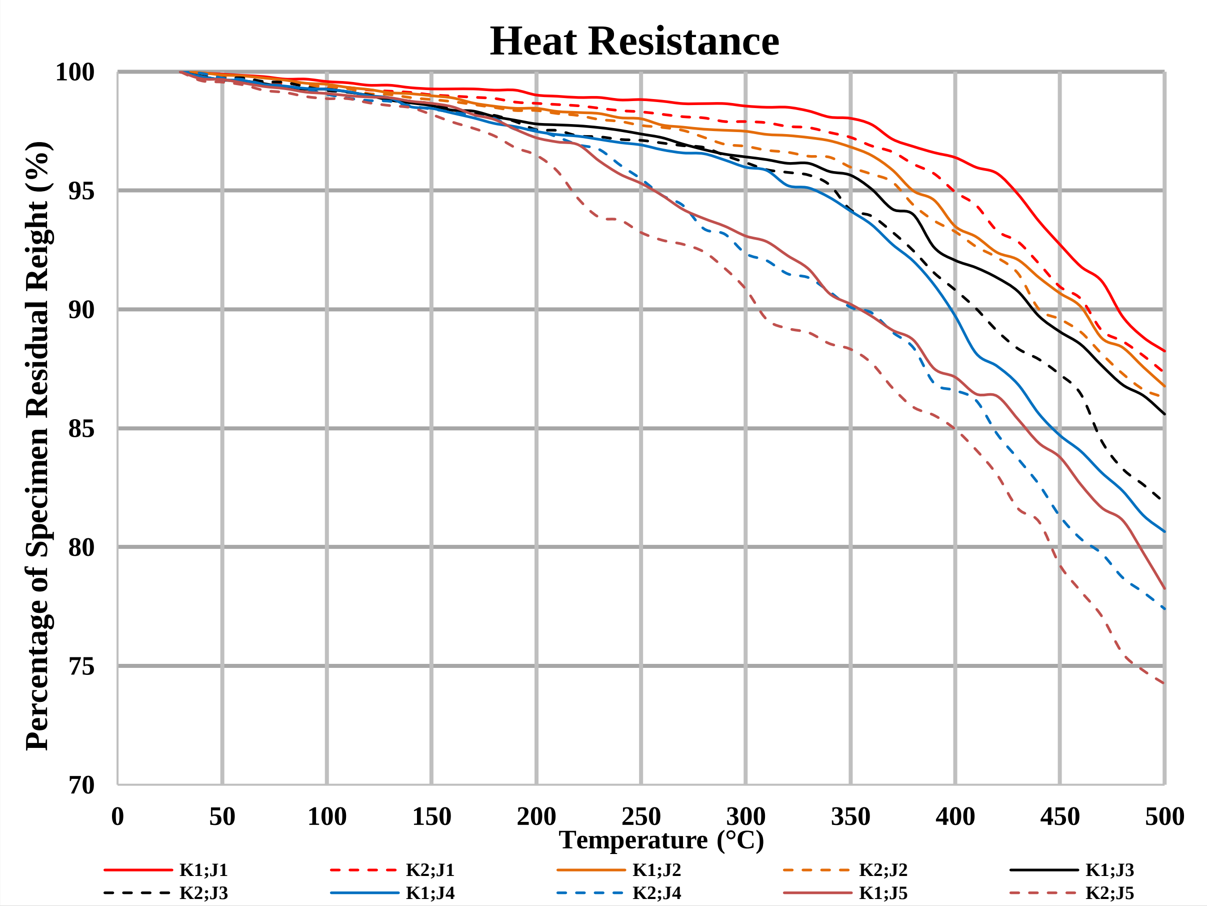



**Figure 7.** Heat resistance test result data

## 4. CONCLUSION

Based on research on the effect of composition and type of filler metal on the heat resistance of silica rubber matric composite, the conclusions obtained are as follows:

1. The composition of filler metal in the composite affects the heat resistance of the composite with silica rubber matrix. The less filler metal composition used in the composite, the better the heat resistance. The best heat resistance is in specimen K1; J1 where the composite contains 60% filler metal and the type of filler metal used is pure aluminium which has a final weight of 88.25%. Specimen K2;J5 is the specimen with the worst heat resistance where the composite contains 70% filler metal and the type of filler metal used is pure copper with a final weight of 74.25%.
2. The type of filler metal affects the heat resistance of silica rubber-matric composites. The best heat resistance is possessed by specimen K1;J1, which is a specimen containing 60% filler in the form of 100% aluminium metal with an average final weight of 88.25%. The poorest heat resistance belongs to specimen K2;J5, which is the specimen containing 70% filler in the form of 100% copper metal with an average final weight of 74.25%.
3. The interaction of metal composition and metal type has a significant effect on the heat resistance of silica rubber-matched composites. The decrease of filler metal composition in the composite and the more use of aluminium as filler metal will increase the heat resistance of silica rubber matched composite. The best heat resistance is obtained in specimens K1; J1, namely specimens with a filler metal composition of 60% in the form of 100% aluminium with an average final weight of 88.25%. The worst heat resistance was obtained in specimens K2; and J5 with 70% filler metal composition in the form of 100% copper with an average final weight of 74.25%.

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