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Simulation between Soldering and Brazing of Copper at 450 Temperature by Zn-Sn Fillet Alloy

Simulation between Soldering and Brazing of Copper at 450 Temperature by Zn-Sn Fillet Alloy

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Abstract. In this research, a comparison between Soldering and Brazing welding of pure copper metal using a (Zn-Sn) alloy filler was numerically investigated. The welding operations on the eight pieces with dimension (30mm x 20mm x 2mm) were carried out used (Auto Desk Inventor program) to prepare four samples, while the simulation was conducted on these samples by utilized the (COMSOL Multiphysics 4.1 program) to investigate the heat distribution and tensile stress. The simulation study results showed that the thermal distribution of Soldering welding was less than that of the Brazing welding in the area between (40-60 mm) and the maximum temperature of Soldering welding in that region was (405 °C), while the highest temperature for the Brazing welding in the same area reaches to (449 °C). The total displacement of the Soldering welding was up to1.9 x10-7 mm greater than that of the Brazing welding when the shedding stress equal to $5x10^4$ N/ m^2

Keywords: Soldering and Brazing; Copper; Numerically Investigated

1. Introduction

Copper consider one of the most abundant chemical elements in nature where found in golden-red color or it may be iridescent, moreover, it reflects colors such as the color of the spectrum when light falls on it, so the copper is distinguished from other minerals where it does not exist in silver color or gray color when it is present in nature as the other minerals [1].

The copper element has many properties such as; the high ability to conduct the heat and electricity, melting point (1083.45) degrees Celsius, a flexible and malleable metal that is easy to form without being broken, which make the copper one of the basic minerals for industrial benefited to thousands of years ago and plays a significant in the development of societies [2]. Among the methods that can use to welding the copper, the Soldering and Brazing welding types can be used in some work design that so difficult to use the traditional welding methods such as cold or hot pressure and melting.

The connection in the Soldering weld depends on the melting of a metal or alloy that differs from the original metal and should be melting at the low temperature, and when this alloy cooled, the two ends of the joint became metallurgical bound, which the resistance of this joint may be reaching the stresses of the original metal's or more if the joint is designed at the right way. Moreover, this method divided into two types of welding which totally depends on the melting temperature of the alloy that used in the welding, if used alloys with melt below than 450 ° C this called welding with soft alloys (soldering

welding) where used in most time the tin ingot with lead alloy, while if the alloy melt temperature exceeds than 450 ° C, it named hard alloy welding [3].
Whereas, in the Brazing welding, the permeability of the brazing metal, which may be a pure metal or an alloy, after its melting and by means of a poetic attraction to the space or permitting that exists between the base metals. In this type of welding the supporting materials or protective environments or both are included in the welding process to prevent the formation of the oxide layers and to obtain the best flowing process for the filler metal as well as a good moistening process for the two base metals, which mean the durability of the Brazing welding is higher than the Soldering weld [4]. Among the alloys that used in connection with Brazing are alloys based on copper or silver.
Fadel et al. [6] studied the stainless steel welding type (304L) with austenitic structure and pure tantalum (Ta% 9.99) via the Brazing method by used ineffective copper-based alloys in a medium of inert gas. They concluded that all Brazing alloys for similar and asymmetric samples of stainless steel and tantalum formed an intermediate compound at the interface between the Brazing alloy and the base metal as well as the appearance of bushes in enhancement a copper phase on a eutectic floor.
Mona Khudair Abbas and Hussein Musa Habib [7] studied the welding of similar and non-similar stainless steel sheets (AISI 316L) and low carbon steel (CK15) via Brazing by used the ineffective mortar alloys Copper-based in passive furnaces by placing samples in a special container (Retort) and filled with Argon gas during the welding period at a flow rate of (1-2 liters/minute). The results showed that the single and double symmetrical joints of similar stainless steel sheets have high shear resistance than the non-similar stainless steel and low-carbon steel at the same welding conditions. Moreover, the Brazing alloy types (RBCUZN-D) achieved the highest shear resistance of single and double symmetrical joints and high tensile shear compared to connections used the other Brazing alloys and at welding time between (5-10) minutes.
Fadel et al. [9] studied the bonding mechanisms in Brazing welding for the braided wires of steel tensioning and copper wires via a symbiotic interfering weld connection, in the brazing weld they used alloy fillers of (copper-phosphorus) while in the Rivet welding used alloys Filling of (tin-lead). They concluded there is a similarity between the bonding first and second phases with a difference in the movement of the filler alloy and its effect on the bonding strength. Tiziana Segreto et al. [10] studied the welding area via Brazing and Soldering types for the pure copper sheets through advanced technology (NDE) ultrasound-based scanning technology (FV) by accelerating protons and with the cross-sectional imaging of the welding region to discover the welding quality of copper alloys.
Bofang Zhou et al. [11] Studied the Brazing SiC Ceramic with Novel Zr-Cu Filler, The Researcher found out the residual stress distribution of SiC Ceramic joints brazed at 1200 with different thickness of the filler metal and cooling rate is simulated by ANSYS software.
The researcher (A. Kiretajr) [12] studied the soldering and brazing welding for the copper tubes by used different smelters and fillings, and the basic requirements for Soldering and Brazing welding were identified with high quality. The aims of this study are to perform a simulation of the Soldering and Brazing welding processes and compare them in terms of heat distribution and tensile stress by using program type (COMSOL Multiphysics 4.1).

2. Numerical Procedures

The copper metal with a purity of (99.99%) was selected in this study as a plate with a dimensional of (30mm x 20mm x 2mm) as shown in Figure 1, while the filling material was a (Zn-Sn) alloy and the melting point assumed (450 °C) to simplify the simulation. Eight pieces of copper were drawn by used (auto desk inventor) program and welded via Soldering and Brazing method to produced four samples (two samples by Soldering and two by Brazing as shown in Figure 2. The temperatures for the base metal copper was (300K), while the temperature of the welding alloy was (723K) sit as input for the program to study the heat transfer on the samples during the welding. The axial stress for the copper was 5 x104 N/m2 applied in opposite directions. The mesh generated via COMSOL Multiphysics 4.1. The total elongation and the elongation curve were computed and collected of the model.

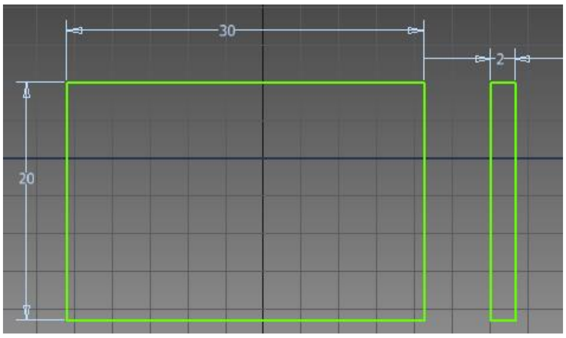

Figure 1. Dimensions of the piece

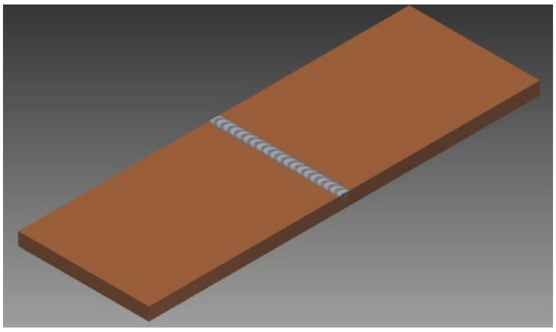

Figure 2. Sample welded by the method (soldering, brazing)

3. Results and discussion

Figure 3 draws the amount of temperature distribution of the soldering welding that represents the gradation of colors from red (highest temperature) to blue (room temperature). The variation of the temperature distribution with respect to the sample length shown in Figure 4. The highest temperature register of soldering weld was to 705K near the welding area and then decreases to reach the lowest temperature equal to 300K at the end of the sample.

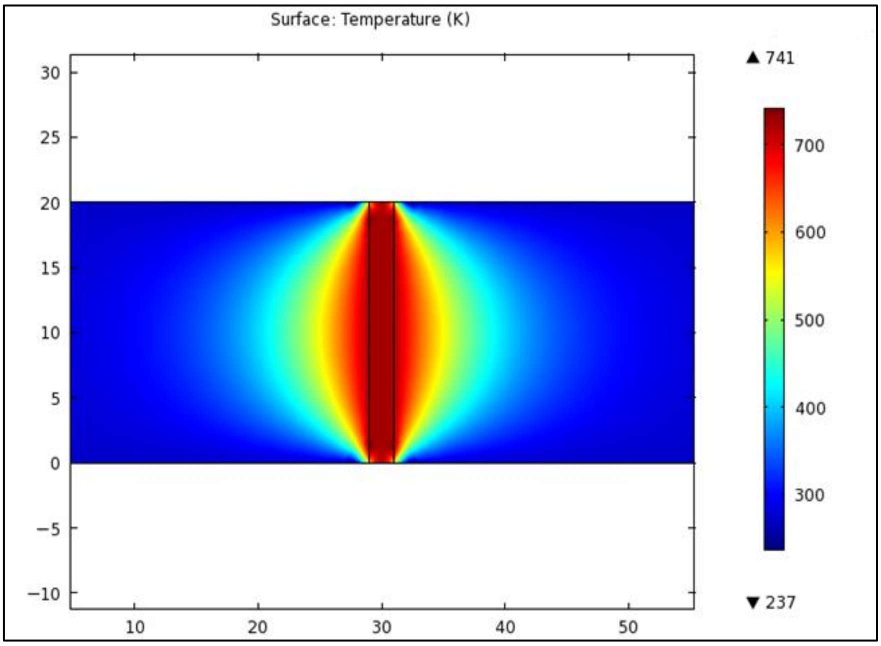

Figure 3. Gradation of colors for the distribution of temperatures for soldering welding.

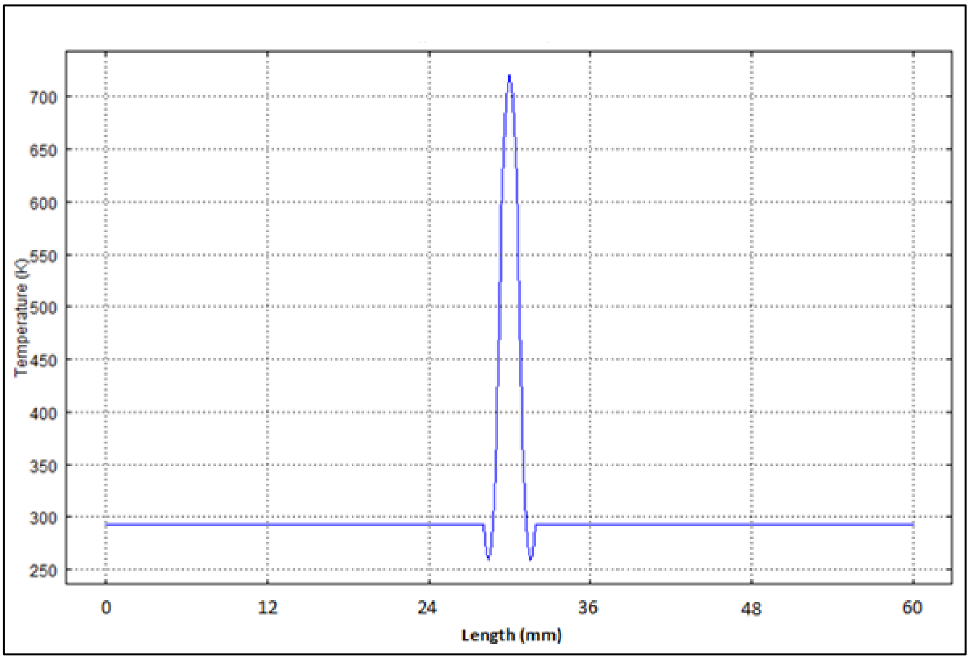

Figure 4. Temperature distribution for soldering welding.

The amount of temperature distribution of the Brazing welding that represents the gradation of colors from red to blue shown in Figure 5. The temperature distribution regarding the sample length represents in Figure 6. The highest temperature was 749K, while the lowest temperature registered as 300K at the end of the sample. The reason of this behavior is with the soldering welding the alloy (Zn-Sn) is melted and when it cooled performs the binding function, while brazing welding the area first wetting and then the alloy melting with the reaction of smelting aids will penetrate the base metal (copper) [3].

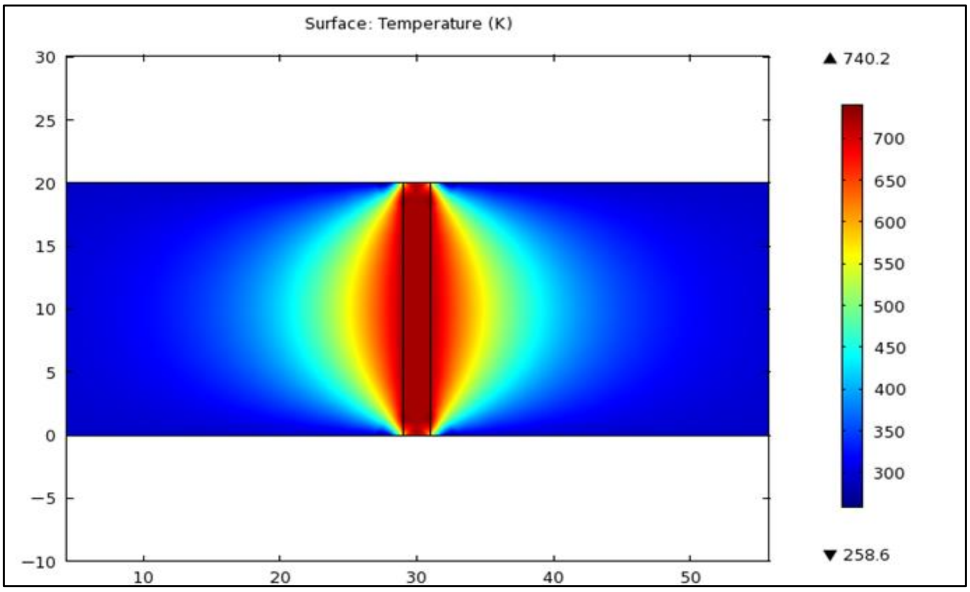

Figure 5. gradation of colors for the distribution of temperatures for brazing welding.

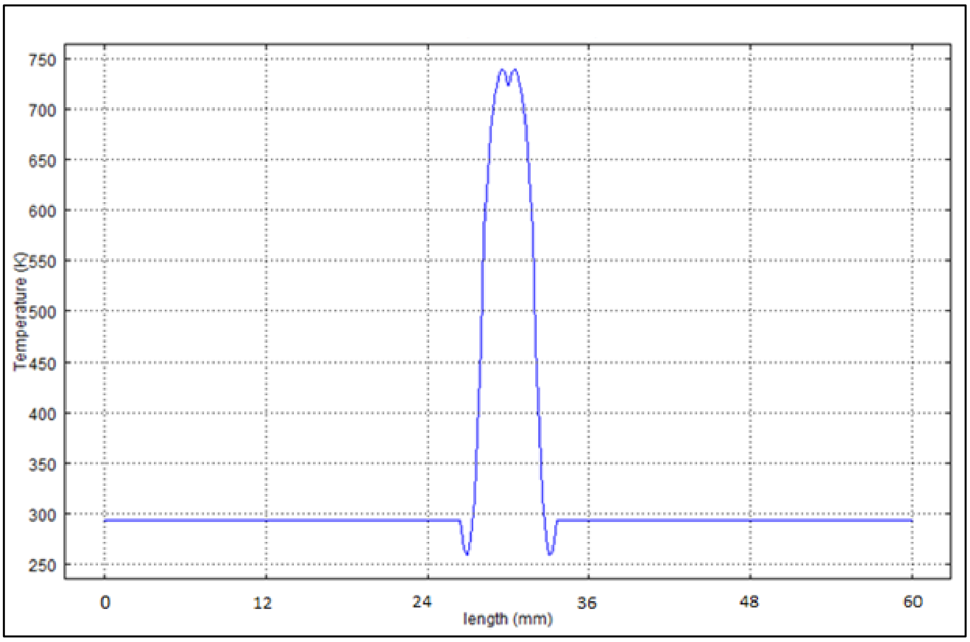

Figure 6. Temperature distribution for brazing welding.

Figure 7 shows the temperature distribution on the sample in soldering at shed stress equal to ($5x10^4$ N/m^2), where the dark red color represents the highest elongation obtained on the base metal (copper) and then grades in the colors until it ends in the welding area in blue color. Figure 8 shows the highest elongation at the base metal (copper) is 1.9 $x10^{-7}$mm at the beginning of the stress shedding and the lowest registered was 0.9 $x10^{-7}$mm at the joint area.

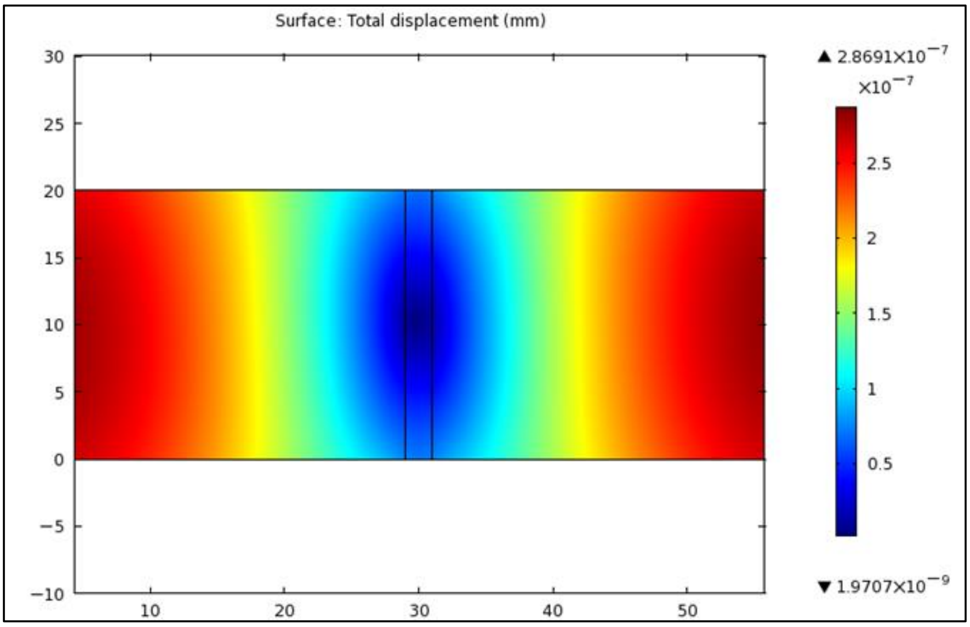

Figure 7. Colors are given to distribute the elongation of the soldering weld at a stress of 5 * 10^4N / m^2.

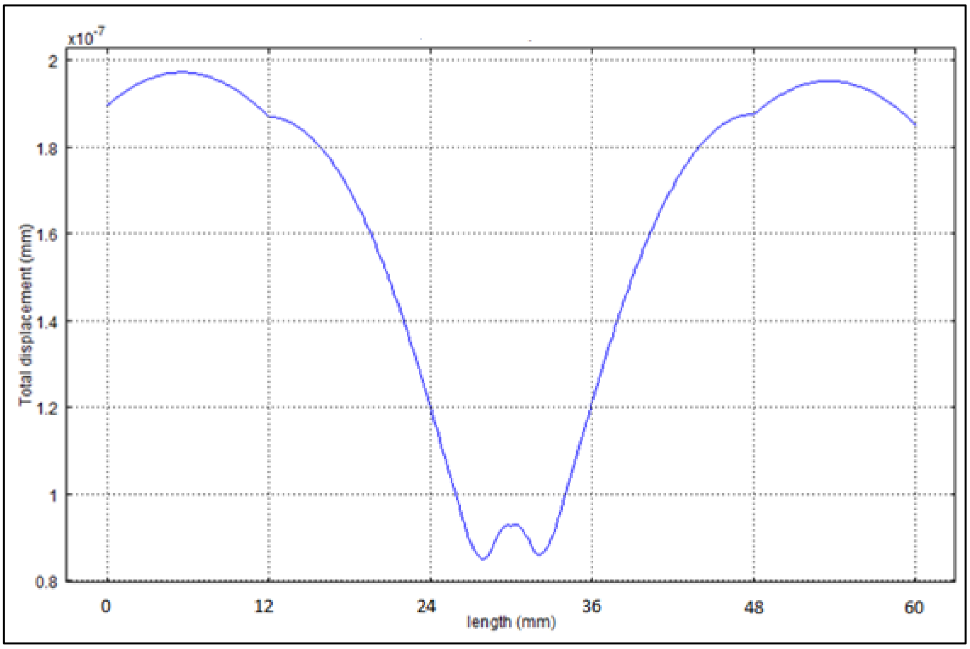

Figure 8. Elongation distribution for soldering welding at a stress of 5 * 10^4N / m^2.

Figure 9 shows the temperature distribution on the sample in brazing weld at shed stress equal to (5*104 N/m2), where the sampling trend exactly similar to that soldering weld except the amount of color distribution. Figure 10 shows the highest elongation at the base metal (copper) is 1.6 * 10-7mm at the area of 24-36 mm at the curve narrower than that in soldering welding, the reason is that the durability of the brazing weld is higher than it is in soldering welding due to the high permeability for welding brazing [3,5].

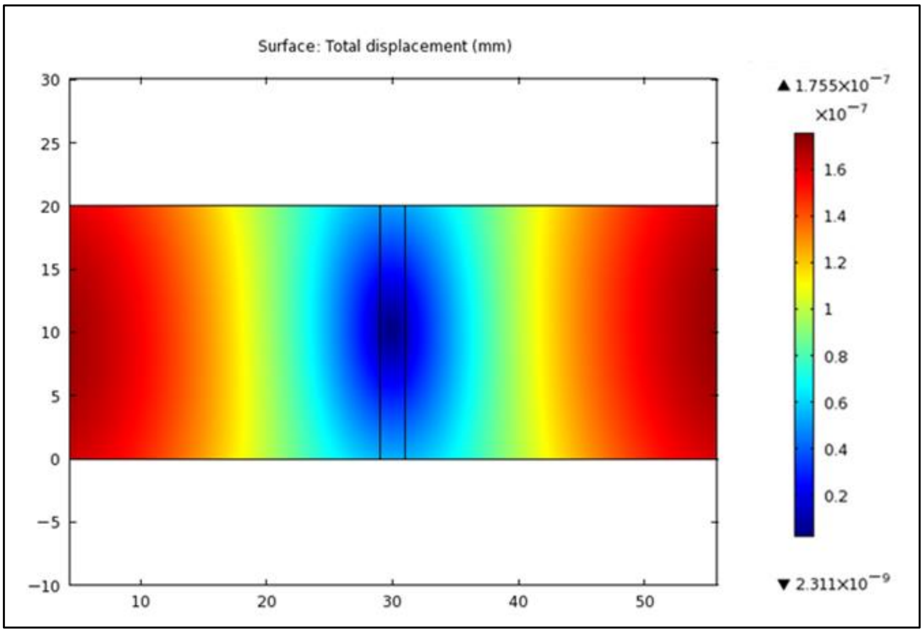

Figure 9. Colors are given to distribute the elongation of the brazing weld at a stress of 5 * 10^4N / m^2.

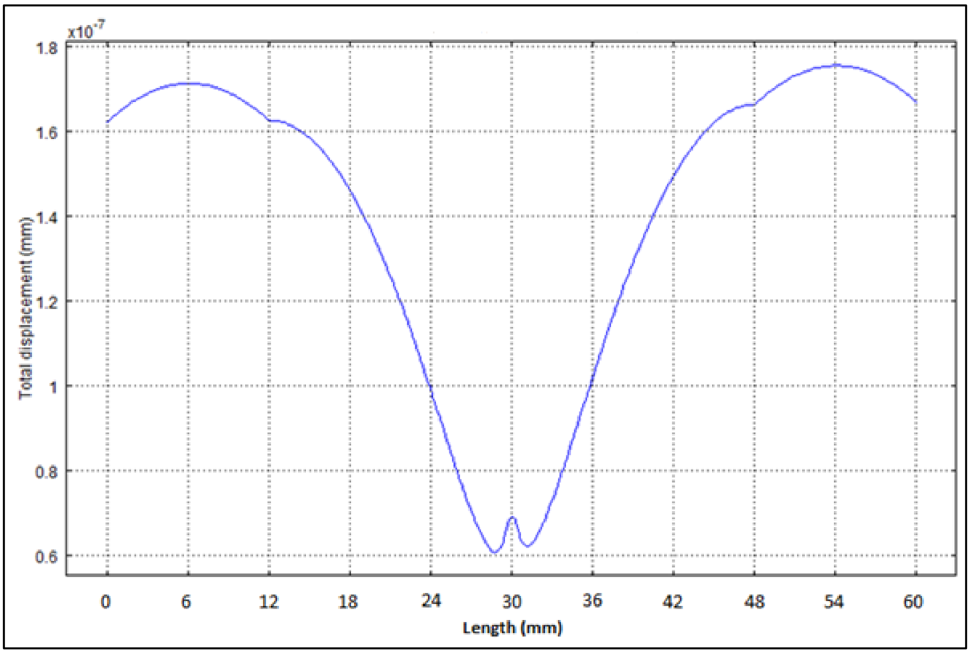

Figure 10. Elongation distribution for brazing welding at a stress of 5 * 10^4N / m^2.

4. Conclusion

A numerical study was prepared to investigate the difference between the soldering and brazing welding of copper at 450 temperatures when using the Zn-Sn Fillet Alloy. The main conclusions are draw as the following:

1. The possibility to simulate the soldering and brazing welding at very small size of copper samples via COMSOL Multiphysics 4.1.
2. The durability of brazing welding was higher than that of soldering.
3. The results showed by simulation that the thermal distribution of soldering welding is less than brazing welding in the area between (40-60) mm of samples and the highest temperature of soldering welding in that region is (405) degrees Celsius while the highest temperature with the brazing welding in the same area reaches (449° C)
4. The total elongation of the soldering weld is greater than the brazing weld and reaches (1.9 *x* 10^{-7}mm) when applied the shedding stress equal to (5 *x*104 N / m^2).

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