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The Relative Tensile Outcome of E60 and E70 Electrodes Deposits on Low Carbon Steel Welded Joints

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ABSTRACT

The responsive nature of low carbon steel to various applications such as fabrication works, construction and maintenance cannot be overemphasized. In most applications of low carbon steel there is the necessity to provide welding joints. In the majority of cases, the E6013 and E7018 electrodes are generally used. This study was designed to examine the influence of these electrodes on the tensile characteristics of welded low carbon steel of grade, AISI 1018. The test was conducted after preparing the joints and welding with shielded metal arc welding (SMAW) process. The results showed that the yield point for E6013 was 392.8N/mm² and that of E7018 deposits was 443N/mm², suggesting that E7018 deposit is relatively higher in yield point than the E6013. The results also revealed that the E7018 electrode has higher tensile deposit in relation to E6013 electrode. Clearly, the E6013 deposit has lower UTS as compared with E7018. Basically the E6013 deposit will fracture before the E7018 deposit when a tensile force is applied. It is therefore recommended that the E7018 electrode be used for when higher tensile deposit on low carbon steel required. If however a lower tensile deposit is required on low carbon steel the E6013 electrode could be used.

Keywords: E6013 and E7018 Electrodes; Low Carbon Steel; Shielded Metal Arc Welding; Tensile Test; Weld Deposits.

INTRODUCTION

Low carbon steel (LCS) is the most common form of material found and used in the steel industry; it has a carbon percentage between 0.25% and 0.30%, and for that matter not responsive to heat treatment because of the low carbon content. Obviously plain carbon steel of this kind does not form martensite when heat is applied and quenched; its microstructure is chiefly of ferrite and pearlite constituents [1] [2]. As a result, the LCS is relatively soft with superior mechanical properties such as tensile strength, ductility and toughness. Further, LCS is less expensive as compared to other steels, and can easily be welded and machined [2]. In the welding industry, low carbon steel is extensively used for fabrication works, construction and maintenance. It is interesting to note that steel is produced in various forms with different mechanical and physical properties. The properties are due to varying chemical compositions as well as the quantities in which they are found in the steel in question. The AISI 1018 is a Standard grade Low Carbon Steel which is composed of 0.15-0.20% Carbon (C), 0.60-0.90% Manganese (Mn), 0.04%(max) Phosphorus (P), 0.05%(max) Sulfur (S), and the base metal being Iron (Fe), and is responsive to many engineering applications. Clearly, the choice of electrode in welding LCS to achieve a high quality and strong weld is of paramount importance

to the welding engineer. The commonly used electrodes for welding LCS are the E60 and E70 groups [3]. The E60 and E70 electrodes are very popular for welding applications such as vehicles, sheet metal works, shipbuilding, fabrication, construction and maintenance [3]. While both electrodes are mild steel based, they differ in yield and tensile strength where the E7018 has higher specifications in both. Precisely, the coating on the E6013 is high Titania potassium whereas that of the E7018 is low hydrogen potassium coating. Two separate samples welded with these electrodes can be subjected to a tensile pull to examine the extent to which they can resist a permanent deformation or fracture. The effects of welding current on tensile strength have not been considered in this study. The empirical results of Rohit and Jha [4] on the effect of process parameter such as welding current on tensile strength of mild steel weld metal is quite impressive. The study revealed that welding current of 120A with Shielded Metal Arc Welding (SMAW) produces a maximum tensile strength. With this current value the ultimate tensile strength (UTS) of 515.185 MPa was recorded. Evidently, it can be concluded that with increase in welding current the UTS will increase proportionately until an optimum value is achieved. However, increasing the current beyond this optimum value will result in decreased UTS [4].

A tensile test is one of the most basic types of mechanical testing carried out in a laboratory with a tensile machine [5]. The tensile test is a commonly used method in industry and in research to characterize the various steels manufactured in the steel industry. With tensile test, properties such as yield point, ultimate tensile strength (UTS) and elongation are most commonly used to determine the applicability of steel for various purposes [6]. The yield point is an important tensile property, it is at this point it manifests whether or not the structure has the capability to function where and when yielding occurs. However, the material deformation becomes plastic or permanent beyond the yield point (thus, plastic region) and the stress is no longer proportional to the strain [7]. Tensile test involves applying a pulling force to a prepared steel, referred to as specimen and measuring its response to the stress. This test is carried out by applying longitudinal or axial load at a specific extension rate to a standard tensile specimen with known dimensions (gauge length and cross sectional area perpendicular to the load direction) till failure. The applied tensile load and extension are recorded during the test for the calculation of stress and strain [8]. These two parameters were then used for the calculation of stress and strain to give a relationship as illustrated in equations 1 and 2.

$$\boldsymbol{\sigma} = \frac{P}{Ao} \qquad \text{.....(1)}$$

$$\boldsymbol{\varepsilon} = \frac{Lf - Lo}{Lo} = \frac{\Delta L}{Lo} \qquad \text{.....(2)}$$

Where; σ is stress, ε is the strain, *P* is the external axial tensile load, *Ao* is the original cross-sectional area of the specimen, *Lo* is the original length of the specimen, *Lf* is the final length of the specimen and *ΔL* is change in length. The unit of the stress is Pascal (Pa) or N/m^2 according to the SI Metric Unit whereas the unit of psi (pound per square inch) can also be used. A stress-strain relationship had been established between two specimens; they had been prepared with equal lengths, one welded with E6013 electrode and the other welded with E7018 electrodes. The yield stress, σy, was obtained by dividing the load at yielding (*Py*) by the original cross-sectional area of the specimen (*Ao*) as shown in equation 3.

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$$\sigma_y = \frac{Py}{Ao} \quad \text{.....(3)}$$

The purpose of this study was to examine the influence of two different mild steel electrodes, the E6013 and the E7018 on the tensile characteristics of welded low carbon steel of grade, AISI 1018 under a tensile test using the shielded metal arc welding (SMAW) process. The study examined the difference in yield strengths and tensile strengths of the two specimens. By subjecting them to an external tensile loading they underwent elastic and plastic deformation. Initially, the metals elastically deformed giving a linear relationship of load and extension. These two parameters were then used for the calculation of stress and strain to give a relationship.

MATERIALS AND METHODS

An experimental procedure had been designed to produce samples from AISI 1018 low carbon steel for the tensile test. The AISI 1018 is a Standard grade Carbon Steel. It is composed of (in weight percentage) 0.15-0.20% Carbon (C), 0.60-0.90% Manganese (Mn), 0.04%(max) Phosphorus (P), 0.05%(max) Sulfur (S), and the base metal being Iron (Fe). Two samples had been produced by lathing into a dog-bone format, one being welded with E6013 electrode and the other by E7018. This move was to compare the tensile values of the two specimens when weld deposits are made with these electrodes. This test was conducted at Akenten Appiah-Menka-University of skills training and entrepreneurial development (AAM-USTED) with a universal tensile testing machine as specified in table 1.

Table 1: Tensile Test Machine Specification

UNIVERSAL TENSILE TESTING MACHINE			
Voltage	380V/3Phs	**Model**	WAW-1000H
Power	5KW	**Serial No.**	011206
Frequency	50Hz	**Date**	2017 08
Capacity	1000KN		

A geometrical presentation of the sample had been showed in figure 1 with various designations of the component.

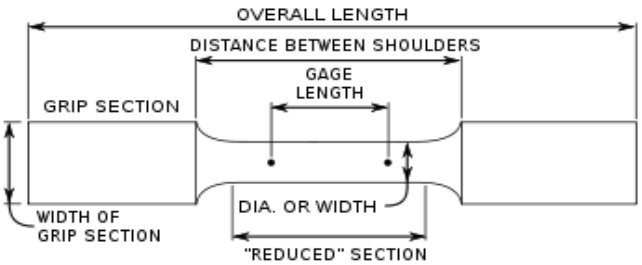

Figure 1: Structure of the Specimens

The overall length of the specimens was 200mm with grip sections of 80mm and distance between shoulders being 40mm as shown in figure 2.



Figure 2: Specimens Lathed in a Cylindrical Form (dog-bone format)

Weld deposit on specimen using the shielded metal arc welding process with multirun as shown in figure 3.



Figure 3: Specimens Welded with 6013 and 7018 Electrodes

During the tensile test it reached a point at which the material failed and fracture occurred as seen in figure 4.



Figure 4: Fracture of Specimens after Tensile Pull

RESULTS AND DISCUSSION

By subjecting the two specimens to an external tensile loading they underwent elastic and plastic deformation. Initially, the metals elastically deformed giving a linear relationship of load and extension. These two parameters were then used for the calculation of stress and strain to give a relationship as illustrated in figure 5.

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Table 2: yield strength (N/mm²)

Sample Name	Area mm²	Lower Yield Force KN	Upper Yield Force KN	Lower Yield Strength N/mm²	Upper Yield Strength N/mm²
E6013	415.48	162.8	163.2	391.84	392.8
E7018	415.48	183.8	183.9	442	443

Table 2 illustrates the yield strength, a point at which plastic deformation starts to occur. More so, at a point the linear behavior of the graph stops. The yield point marks the beginning of stress in steel at which an increase in strain occurs [9]. The table exhibits the lower and the upper yield points. the maximum yield point for the E6013 deposit is 392.8N/mm² and that of E7018 deposit is 443 at a force of 183.9. Implying E7018 electrode has the highest yield point as compared with the E6013 electrode.

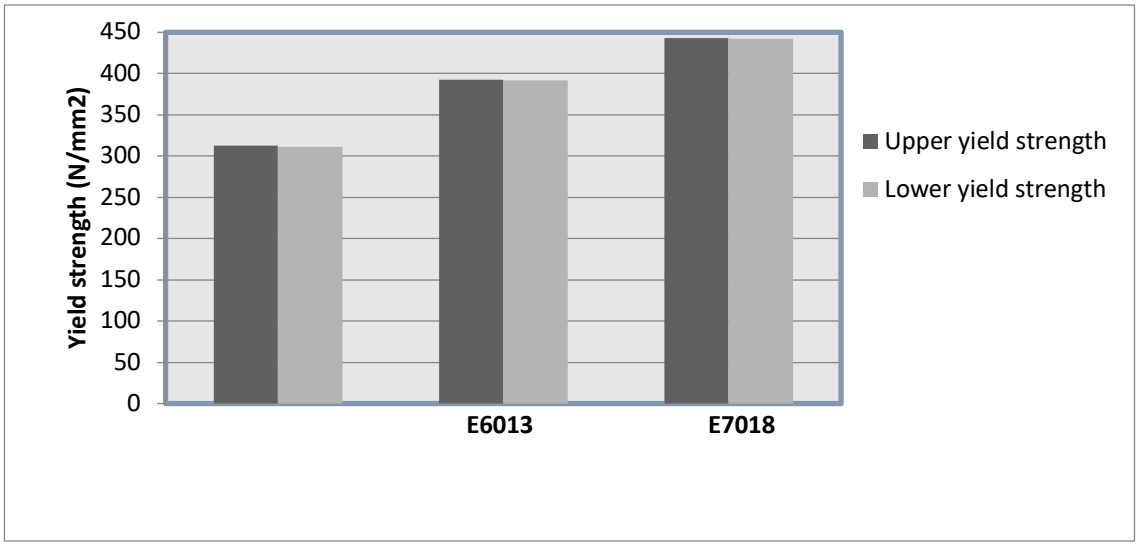

Figure 5: lower and upper yield strengths

Table 3: Average Tensile Strength (N/mm²)

Sample Name	Area mm²	Force KN	Tensile Strength N/mm²
E6013	415.48	173.6	418
E7018	415.48	187.5	451

Table 3 illustrates the ultimate tensile strength which is the maximum stress that the specimens sustained during the test. In this context, the UTS is equated to the specimen's strength at a breakage point. The ultimate tensile strength of low-carbon steel is between 400 – 550 MPa, and it is the maximum on the engineering stress-strain curve. However, the results revealed UTS of the two specimens as 418Nmm² for the E6013 electrode with a force of 173.6KN and 451Nmm² for the E7018 electrode with a force of 187.5KN. This clearly manifests the fact that the E7018 electrode has higher tensile deposit more than the E6013 deposit. Evidently, the magnitude of a force applied largely depends on the degree of tensile strength. A higher tensile

characteristic of a material requires a higher force to subdue it. Conversely the lower the tensile strength the lower the force that is required to overcome it.

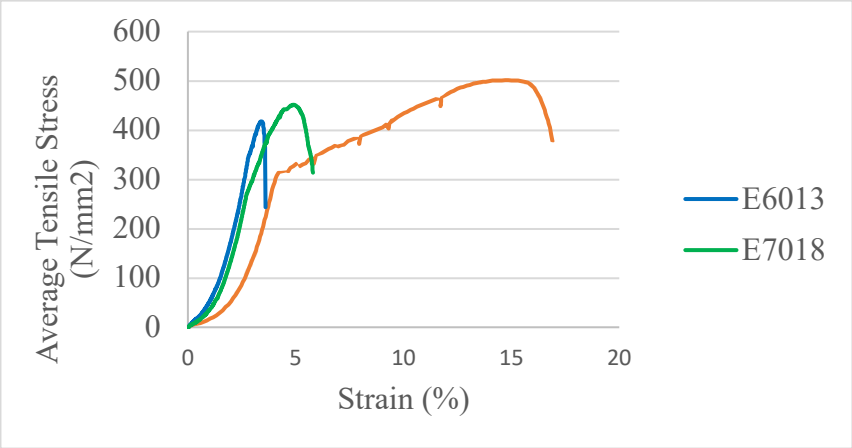

Figure 6: Stress-Strain Curve of E60 and E70 Electrodes

When plotted on a graph, this data results in a Stress-strain curve which shows how the material reacted to the forces being applied; the point of break or failure is of much interest. The curve shows that the steel welded with E7018 has higher UTS; the E6013 deposit has lower UTS. There is the likelihood that the E6013 deposit will fracture before the E7018 deposit.

CONCLUSION

In conclusion, the results revealed that the maximum yield point for E6013 and E7018 deposits are 392.8N/mm^2 and 443N/mm^2 respectively. Implying E7018 deposit is relatively higher in terms of yield point as compared with the E6013 deposit. The yield point is described as the beginning of stress in steel at which an increase in strain occurs. The results also revealed that the E7018 electrode has higher tensile deposit relative to the E6013 electrode. Clearly, the E6013 deposit has lower UTS compared with E7018. The likelihood is that the E6013 deposit will fracture before the E7018 deposit when a tensile force is applied. Evidently, the magnitude of the force applied largely depends on the degree of tensile strength. The tensile pull is to examine the extent to which the steel can resist a permanent deformation or fracture. A high tensile characteristic requires a high force to draw it to fracture. Conversely a low tensile strength demands a low force to bring the steel to a fracture. It is therefore recommended that welding joints that require higher tensile deposit on low carbon steel the E7018 electrode should be used to achieve this quality. Conversely, the E6013 electrode is used if lower tensile deposit is required on low carbon steel.

References

[1] Leake K. and henthorne N.J. (1968). Welding Science and Metallurgy, Rockwell pub. American welding society.

[2] Totten, G.E. (2006). Steel heat treatment: metallurgy and technologies, taylor and francis, Oregon, USA.

[3] Ward, S. (2020). 6013 VS 7018 Welding Electrodes Compared, welderpick

[4] Rohit Jha, Jha, A k., 2014 "Investigating the Effect of Welding Current on the Tensile Properties of SMAW Welded Mild Steel Joints", International Journal of Engineering Research & Technology (IJERT), Vol: 3, p.1304.

URL: http://dx.doi.org/10.14738/aivp.95.10958

[5] Svensson, I.L.and Salomonsson, K. (2018). Mathematical Characterization of the Tensile Deformation Curve of Cast Iron Materials Materials Science Forum SSN: 1662-9752, Vol. 925, pp 444-450, Trans Tech Publications Ltd, Switzerland.

[6] Sulamet-Ariobimo, R.D., Soedarsono, J.W., Sukarnoto, T., Rustandi, A., Mujalis, Y., and Dody Prayitno, D. (2016). Tensile properties analysis of AA1100 aluminium and SS400 steel using different JIS tensile standard specimen. Journal of Applied Research and Technology 14 (2016) 148–153.

[7] Callister, D. W. (2007). Materials Science and Engineering-An Introduction. New York: John Wiley $ Sons, Inc.

[8] Hashemi, S. Foundations of materials science and engineering, 2006, 4th edition, McGraw- Hill.

[9] ASTM A370. (2014). Standard Test Methods and Definitions for Mechanical Testing of Steel Products. In Annual Book of ASTM Standards. West Conshohocken.