EFFECT OF HEAT TREATMENT ON THE MECHANICAL PROPERTIES OF STEEL S45C WELDING PROCESS WITH SMAW (SHIELDED METAL ARC WELDING)

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ABSTRACT

Steel is used mainly to make tooling, automotive components, household goods, to frame buildings and bridges. Hardening is a heat treatment process applied to produce hard workpieces. This treatment consists of heating the steel to a temperature hardening (austenisasi temperature) and held at that temperature (holding time) for a certain period of time and then cooled by the cooling rate is very high (Quench), in order to obtain the desired hardness. The purpose of this study was to gain an overview of the mechanical properties of steel S45C with heat treatment and without heat treatment, and analyze temperature heat treatment that can provide maximum strength at S45C steel after welding. The results showed in the heating process 150^{0}C, 250^{0}C and 300^{0}C produces changes in the mechanical properties in which the tensile strength will continue to rise to a temperature of 300^{0}C at 42 kgf / mm2, while its toughness will decrease the maximum temperature of 300^{0}C at the Hi = 0.836 J / m2 and its violent nature increase reaching 300^{0}C = 40.83. The maximum strength values achieved at the heating temperature of 3000C for tensile strength and hardness at a temperature of 300^{0}C impact value decreases.

Keywords: Medium Carbon Steel (S45C), Heat Treatment, SMAW.

INTRODUCTION

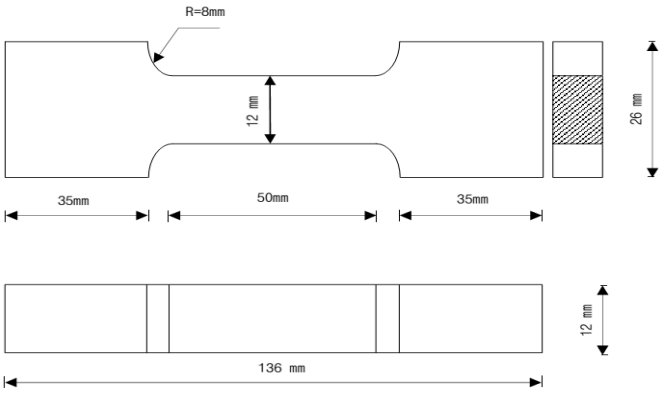
Steel has been used mainly for making tooling, automotive components, household goods, power generators to frame buildings and bridges. According Anrinal (2013: 82), hardening is a heat treatment process applied to produce hard workpieces. This treatment consists of heating the steel to a temperature hardening (austenisasi temperature) and held at that temperature (holding time) for a certain period of time and then cooled by the cooling rate is very high (Quench), in order to obtain the desired hardness.

METHODOLOGY

The method used is the method Research Laboratory test S45C steel samples, to determine the characteristics S45C steel by doing some kind of test is a tensile test and hardness test, impact test and microstructure.

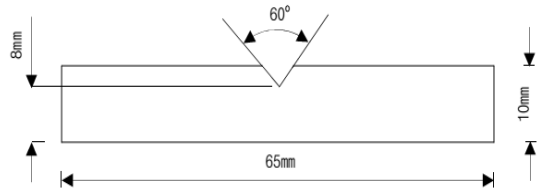
a. Tensile Test

Dimensions of tensile test sampled follow testing standard ASTM E8. Dimensions of the sample specimen is described as follows:



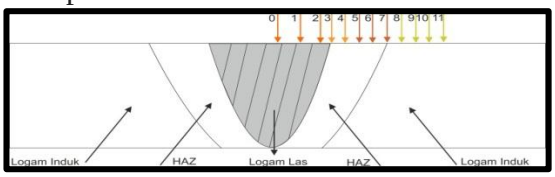
b. Impact Test

Impact test sample dimensions follow the standard ASTM E 23-96 using point load and constant load for each loading.



c. Hardness test

Materials for hardness testing in accordance with ASTM E18. In Brinell hardness testing method with a steel ball indenter emphasis. Test of the violence done to determine the hardness distribution in each region of the parent metal, HAZ and weld metal of the weld and heat treatment, as in the picture:



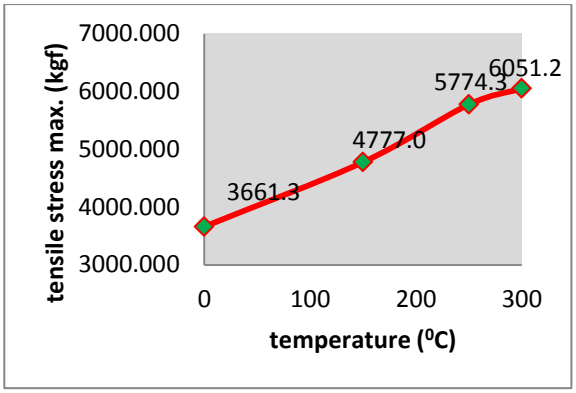
d. Test Microstructure

To observe the microstructure formed on the metal used an optical microscope. Before the test specimen was observed in optical microscopy, the specimen must pass through the stages of preparation. The aim is that at the time of the observed specimen can be seen clearly, because it is essential metallographic image results. The more perfect the preparation of the specimen, the clearer the image the structure obtained.

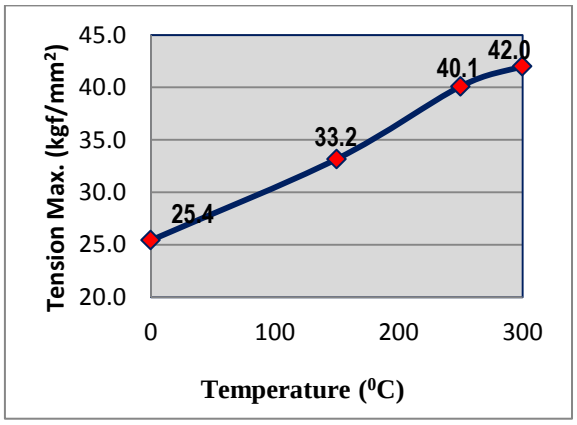
RESULTS AND DISCUSSION

Results of tensile test

Based on the calculation note that on heating the material in the heat treatment process the higher the tempering temperature (0^0C-300^0C) tensile load on average up to the maximum condition increases, in the material by welding without the tempering process (0^0C) Pmaks = 3661.3 kgf, an increase in the average temperature of 150^0C maximum tensile load of Pmaks = 4777.0 kgf, further increased and at a temperature of 300^0C tensile load is at 6051.2 kgf as the following graph:



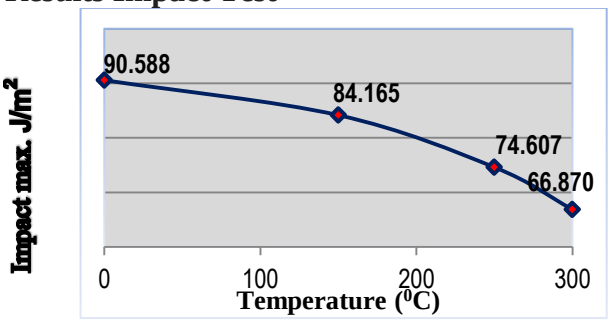
Graph of the relationship between the heat treatment temperature and tensile load of the average maximum



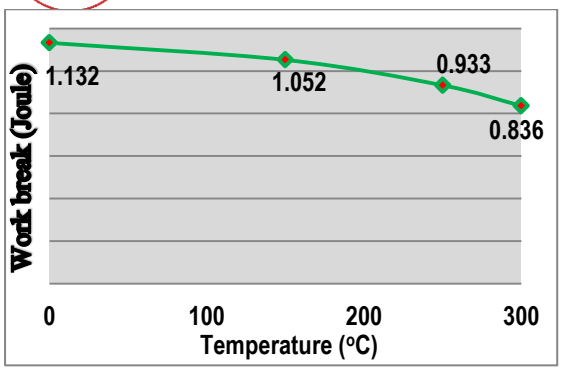
Graph of the relationship between the heat treatment temperature and tensile strength material

The graph known heat treatment temperature 0^0C σ_{maks} = 25.4 kgf / mm2, at 150^0C σ_{maks} = 32.3 kgf / mm^2, 250^0C σ_{maks} = 40.1 kgf / mm^2 and at 300^0C σ_{maks} = 42.0 kgf / mm^2.

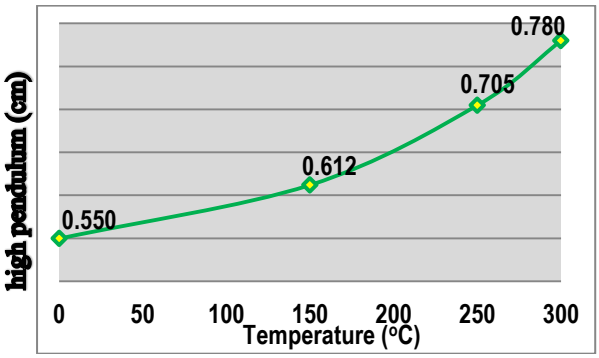
Results Impact Test



Graph of the relationship between temperature heat treatment and attempt to break the specimen.



Graph of the relationship between temperature heat treatment and material impact value



Graph relation to high temperature heat treatment of the pendulum after breaking the specimen

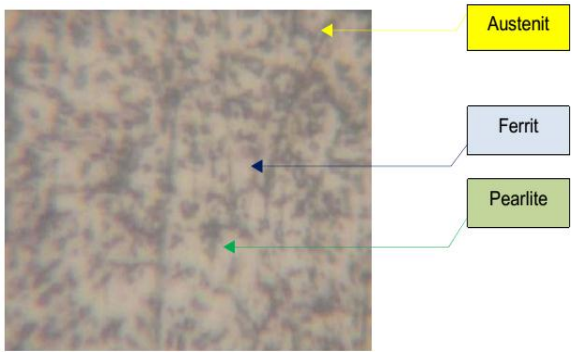
Results of Hardness Testing.

On the results of hardness testing, detected by the temperature change of the heat treatment, the hardness value of the test sample was also changed. The higher the heat treatment temperature, the higher the hardness value of the test sample. From some points of emphasis, the parent metal test samples also increased but not significant violence in which the value of minimum force on the specimen without heat treatment at 35.01 and the highest heat treatment temperature of 300^0C at 35.52.

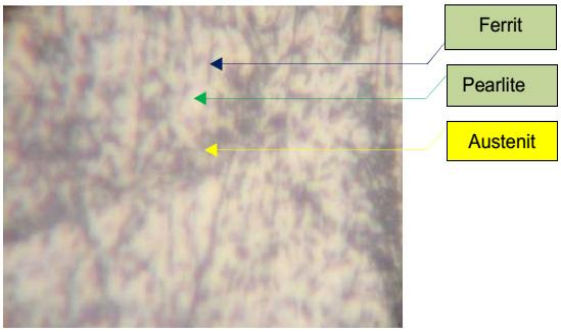
In the weld metal also experienced an increase in hardness due to changes in the temperature of the heat treatment. In the test samples without heat treatment process, the value of the maximum hardness at 37.25, at a temperature of 150^0C = 38.80, at a temperature of 250^0C = 40.49, and at a temperature of 300^0C = 40.83. The increase in the value of ductile of the test sample showed decreased and increased hardness properties.

Micro Structure Analysis

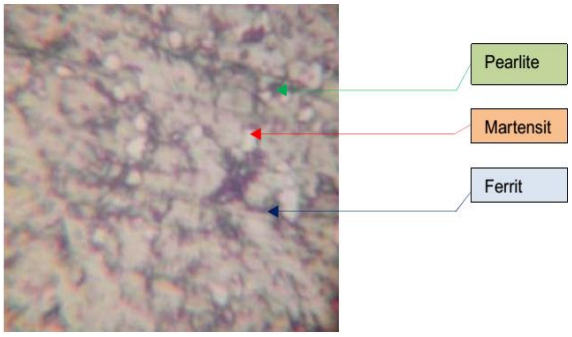
Based on observations and documentation of known photo micro structure is as follows:



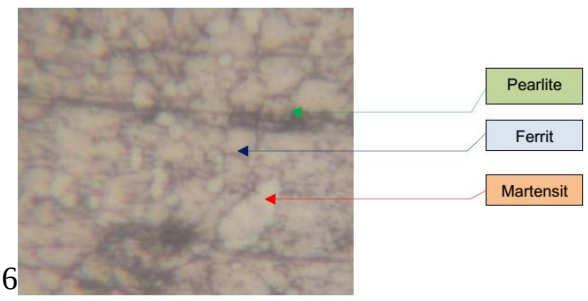
The microstructure of specimens without heat treatment



The microstructure of specimens heat treatment process 150^0C



The microstructure of specimens heat treatment process 250^0C



The microstructure of specimens heat treatment process 300^{0}C

Based on the micro structure photograph with magnification of 500 times, known to begin the process without heat treatment, heat treatment temperature of 150^{0}C, 250^{0}C and 300^{0}C on the microstructure there is a change.

The main composition microstructure consisting of ferrite, martensite and pearlite either change the percentage of the amount or distribution. The micro structure changes result in a change of tensile strength, impact and hardness. In the test samples without heat treatment process, the percentage composition of ferrite is more dominant than the heat treatment process to a temperature of 300^{0}C. The conditions resulted in decreased material hardness and toughness and increased strength tensile test at each temperature increase of heat treatment.

Statistical Analysis

Statistical analysis was performed using analysis of variance Annova on data from tensile test and hardness test. Based on data from the results of tensile testing, hardness and toughness test results of statistical analysis are shown in Table 1, 2 and 3 as follows:

Table 1. Output ANOVA variance calculation for the maximum value of Tensile stress as follows:

DATA VARIANCE

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	2	40.100	20.050	803.986
Row 2	2	175.426	87.713	7759.350
Row 3	2	283.174	141.587	23506.841
Row 4	2	342.022	171.011	33276.327
Column 1	4	700.000	175.000	17500.000
Column 2	4	140.721	35.180	56.727

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	26422.79	3	8807.5979	1.0067	0.4979	9.2766
Columns	39099.12	1	39099.1159	4.4689	0.1249	10.1280
Error	26247.39	3	8749.1295			
Total	91769.3	7				

Table 2. Out put ANOVA variance calculation for hardness value

DATA VARIANCE

SUMMARY	Count	Sum	Average	Variance
Row 1	2	36.77624	18.38812	676.2459
Row 2	2	189.8923	94.94615	6061.853
Row 3	2	288.5778	144.2889	22349.68
Row 4	2	340.5553	170.2777	33655.76
Column 1	4	700	175	17500
Column 2	4	155.8017	38.95041	2.776286

ANOVA

e of Vari	SS	df	MS	F	P-value	F crit
Rows	26783.77	3	8927.922	1.041175	0.487159	9.276628
Columns	37018.98	1	37018.98	4.317156	0.129277	10.12796
Error	25724.56	3	8574.854			
Total	89527.31	7				

Table 3. Out put ANOVA variance calculation for Impact test

DATA VARIANCE

SUMMARY	Count	Sum	Average	Variance
Row 1	2	1.132347	0.566173	0.641105
Row 2	2	151.0521	75.52603	11092.74
Row 3	2	250.9326	125.4663	31017.29
Row 4	2	300.8359	150.4179	44749.59
Column 1	4	700	175	17500
Column 2	4	3.952868	0.988217	0.017051

ANOVA

e of Vari	SS	df	MS	F	P-value	F crit
Rows	26199.99	3	8733.33	0.996195	0.501213	9.276628
Columns	60560.2	1	60560.2	6.907992	0.078439	10.12796
Error	26300.06	3	8766.687			
Total	113060.3	7				

The third table is based on analysis of variance Annova out put of the above, it is known that the heat treatment temperature greatly affects changes in properties such as tensile strength, hardness and impact materials. Statistical indicators identified through comparison of the value of F with Fcrit.

In table 4 the out put value variance analysis ANOVA results of tensile testing known the value of F = 1.0067 while the value Fcrit = 9.2766 in this condition is known values F <Fcrit by a margin of 8.2699 shows the effect of heat treatment temperature influence is 89, 14% increase in tensile strength. In table 4. an unknown value while the value of F = 1.041175 Fcrit = 9.276628 in this condition is known values F < Fcrit with a difference of 8.235453 shows the effect of heat treatment temperature influences the change of 88.77% for escalating violence. The same conditions occur in the value of toughness with i value while the value of F = 0.996195 Fcrit = 9.276628 in this condition is known values F < Fcrit by a margin of 8.2699 shows the

effect of heat treatment temperature influence on the decrease of 89.26% mashed force or impact.

CONCLUSION

From the research results can be concluded that: 1) The process of tempering 150^0C, 250^0C and 300^0C produces changes in the mechanical properties in which the tensile strength will continue to rise to a temperature of 300^0C at 42 kgf/mm^2, while its toughness will decrease the maximum temperature of 300^0C at the Hi = 0.836 J/m^2 and hardness increase reaching 300^0C = 40.83, 2) Rated maximum strength is achieved at a temperature of 300^0C heat treatment for tensile strength and hardness at a temperature of 300^0C impact value decreases.

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