

PREHEAT TEMPERATURE ANALYSIS OF CUTTING KNIFE COATING VIOLENCE IN THE HARD FACING PROCESS OF AISI A35 CARBON

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Abstract. The hard facing process is the welding process of SMAW by using a hard facing DIN 888 electrode as a hard facing to replace conventional cutting tool material. Research method is designed using factorial experiment design with 2 factors, 3 levels, and 4 iterations. The purpose of this analysis is to determine the effect of preheating temperature on the welding of hard coatings on AISI A35 low carbon steel. The results of this study are expected to obtain optimum hardness on coated steel, from variations in the temperature of the preheating, there will be a change in the hardness of the welding deposit, the deposit will be used as cutting tools. The results of this study can be used as guidelines for making cutting tools.

Keywords: temperature, ampere, deposition

1. INTRODUCTION

Wear and crack often happen on cutting edge of cutting tool that is used on high impact load e.g plastic, wood, or composite waste crusher which is used in industrial applications. These wear and crack are unavoidable thus maintenance of the cutting tool in form of resharpening process is needed. Resharpening process is generally done by grinding. Problems will usually arise if the cutting tool suffers some fatal problems like chipping on the edge of the tool due to an impact with a hard surface. Repair procedure for a chipped cutting tool will take a considerable amount of time, and more cutting material will be wasted therefore reducing its lifetime

There are several approaches in making a cutting tool [1]-[4] i.e (1) insert method, which is inserting a hard material as the cutting edge into a softer material which act as the holder. The bonding between the two material uses Brushing and Silvering process. If damage occurs on the cutting tool, the cutting edge can be disassembled and replaced with the new cutting edge. Materials that are generally used are HSS, Cemented Carbide and Tungsten Carbide. (2) Hard layering method, this method is easier to do if SMAW welding is applied, using hard facing electrode to add layer to a soft material as a holder for the hard material which act as the cutting edge. The sharpening of the edge usually done by grinding.

2. METHODS

2.1 Research Design

Research is designed using factorial experiment design with 2 factors, 3 levels, and 4 iterations. Two of the influencing factors are (1) magnitude of the hardness level, (2) magnitude of electrical current and geometrical structure of the test subject (Figure 3.1). Both of the treatments are assumed to affect the hardness of the deposit within two categories of experiments.

First experiment is determining significant factors from altering cutting parameters, or the setting of parameters in EDWC, whether cutting process duration (ANOVA) is affected significantly by type of material being cut. The second experiment is conducted to analyze the optimization of the resulting cutting process duration (Factorial Experiment Design).

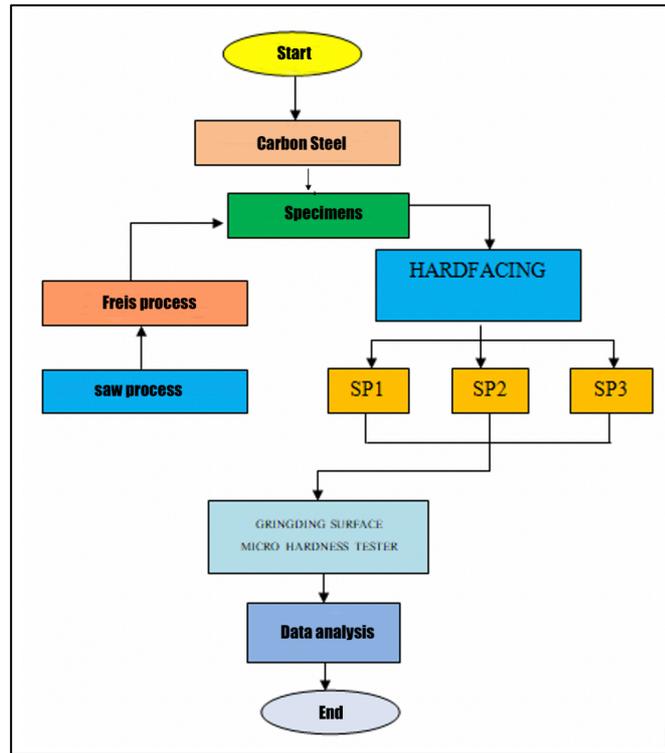


Figure 1. Research Flowchart

Note: Hard facing process (1, 2 dan 3) with SMAW welding

2.2 Testing specimen

Testing specimen with size according to Figure 2 with AISI A 36 as the material, which is made using milling machine in the amount of requires sample needed for data sampling .

Figure 3.2 Testing specimen

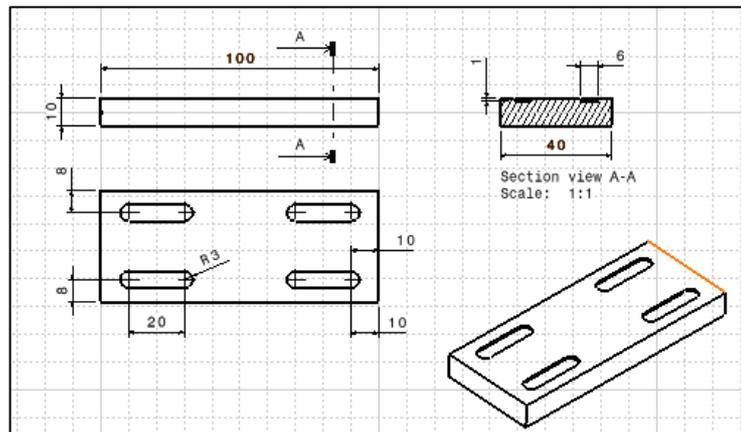


Figure 2. Testing specimen

3. RESULTS AND DISCUSSION

3.1 Heating and Welding Process

Heating process which is used is pre-heated specimen with varied temperature ranging from: no preheat, 100°C, 200°C, and 300°C. Welding process that is used is hard deposit forming with SMAW welding using hard-facing electrode DIN 8555. Electric current magnitude used in this experiment ranges from 80A, 90A, and 100A. Deposit forming with SMAW welding is done after the specimen temperature reaches 100°C, 200°C, and 300°C, respectively



Figure 3. Preheat and SMAW Welding

3.2 Deposit Hardness Measurement

Measurement is done by using micro hardness toward each specimen with each treatment i.e preheat process and electric current used during the welding process



Figure 4. Micro hardness test

The result data of micro hardness test toward hard-layering specimens is listed in Table 1.

Table 1. Micro hardness test

Temp.	Electric Current		
	80 A	90 A	100 A
Preheating	54	53,5	49,2
	55	56	48,5
	53	55	49,4
	53,5	56	49,1
100°	51,2	51,2	51,6
	51,6	53,6	51,5
	51,2	52,2	54
	50,2	53,2	52,2
200°	57,4	57,4	47,3
	52,2	44,2	55,6
	53,2	56,2	56,2
	54,5	56,6	57,2
300°	46,2	48,5	47,9
	49,2	56,5	59,1
	47,6	52,2	58,2
	48,1	52,1	58,6

3.3 Factorial Design Analysis

Minitab software simplifies the creation of factorial design, using Table 1 as a reference. The data from Table 3 are used for factorial analysis, factorial design output interpretation, and ANOVA interpretation.

3.3.1 Factorial Analysis, Factorial Design Output Interpretation

Figure 5 shows factorial design output analysis, started with notes regarding factors, each with 3 levels of treatments. The temperature levels are: 100°C, 200°C, and 300°C, while welding current levels are 80A, 90A, and 100A. ANOVA table is depicted below. ANOVA table can be used to observe the effect of each factors or interaction between factors and response variable (deposit hardness)

General Linear Model: Kekerasan versus Temp, Preheating; Ampere						
Factor	Type	Levels	Values			
Temp, Preheating	fixed	3	1; 2; 3			
Ampere	fixed	3	80; 90; 100			
Analysis of Variance for Kekerasan, using Adjusted SS for Tests						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
Temp, Preheating	2	5,029	5,029	2,514	0,49	0,617
Ampere	2	38,617	38,617	19,309	3,77	0,036
Temp, Preheating*Ampere	4	183,599	183,599	45,900	8,96	0,000
Error	27	138,238	138,238	5,120		
Total	35	365,483				
S = 2,26272 R-Sq = 62,18% R-Sq(adj) = 50,97%						

Figure 5. Factorial design output analysis

In this case there are 2 factors and 1 interaction, therefore 3 hypotheses are to be formulated, that is hypothesis testing in order to determine the influence from the preheat temperature, the influence of the magnitude of electrical current used in welding (ampere), and the influence of interaction between the preheat temperature and the magnitude of electrical current for welding. Usually there is the influence of the preheat temperature [5][6], the influence of the electric current used in welding (amperes) [7][8], and the influence of the interaction between the preheat temperature and the amount of electric current for welding [9]. Observing the influence of the preheat temperature on the magnitude of the hardness value of the deposit. Conducting hypothesis testing to observe the influence of preheat treatment on the magnitude of electrical current for welding.

Hypothesis

H0: $\tau_1 = \tau_2 = \tau_3 = 0$

(preheat temperature does not impact the hardness value of the deposit)

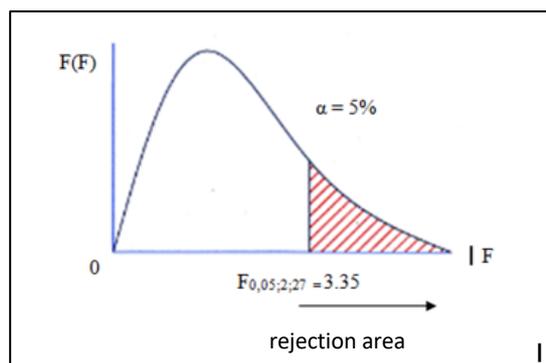


Figure 6 Rejection area for F distribution on 5% tolerance levels [10]

Rejection Area

As long as statistic of F exceeds $F_{0,05; 2; 36} = 3.35$, then reject H_0 or if p value is less than α , then reject H_0 . The area of rejection could be found on Figure 3.4

3.3.2 Interpretation of ANOVA Output for Testing the Influence of Preheat Temperature

From output it is known that statistic of F for preheat temperature from Figure 4.4 is 0.49 and p value is 0.0617 and it is concluded that the original hypothesis, which states that the average of all levels on preheating temperature factor is the same, is rejected; in other words, the alternative hypothesis is accepted. This means there

is a significant difference amongst the levels in preheating temperature factor or there is a significant impact from preheating temperature on the value of hardness of the welds deposit.

Determining The Influence from Electrical Current of Welding (Ampere) on Preheat Temperature

Hypothesis

Hypothesis for this test states

$$H_0 : \beta_1 = \beta_2 = \beta_3 = 0$$

(The magnitude of electrical current of welding does not impact the hardness of the deposit)

Ho : At least one $\beta_j \neq 0$

the magnitude of electrical current of welding impacts the hardness of the deposit.

Where $j = 1,2,3$

Rejection Area

As long as F statistic exceeds $F_{0,00;2;36}$ (3,35) or p-value is less than α it is concluded that H_0 is rejected.

Interpretation

From output it is determined that F statistic for the magnitude of electrical current is 3.77 and the p-value is 0.036. The conclusion is the original hypothesis, which states that electrical current of welding does not impact the hardness of deposit, is rejected. It is then accepted that the factor of electrical current of welding possesses a significant influence on the value of hardness.

Determining the Influence of Interaction Between Factors on Hardness Value of Deposit

Hypothesis

The Hypothesis states:

$$H_0: (\tau\beta)_{ij} = 0 \text{ for all } ij$$

(Iteration between factors doesn't impact the hardness value of deposit)

$$H_1: (\tau\beta)_{ij} \neq 0 \text{ deposit layer}$$

(interaction between factors affects the time of deposit hardness value)

Rejection Area

If F statistic exceeds $F_{0,05;4;36}$ (2,73) and p-value is less than α then H_0 is rejected.

Interpreting the Result

From output it is known that F statistic amounts 8.96 and p-value is 0.00. The conclusion is, a significant impact from iteration between material type and magnitude of electrical current is present.

4.1.3 Graphs for Factorial Design

In order to evaluate the levels of each factor, a plot is drawn with the following results

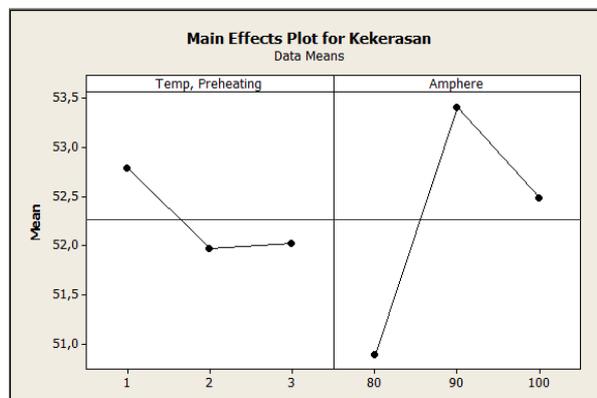


Figure 7. Main effects plot for hardness

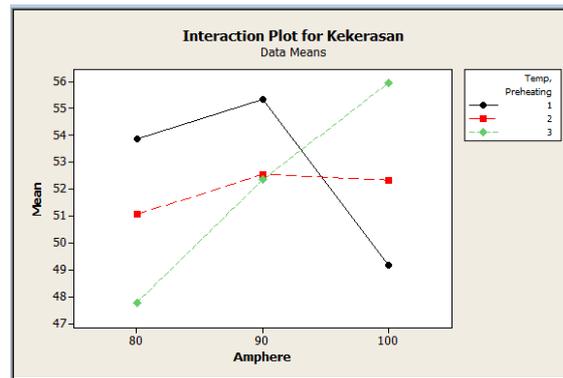


Figure 8. Iteration plot for hardness

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

The result of the study of The Impact of Preheat Temperature on The Layer Hardness of Cutting Knife during Hard facing Process of Carbon Steel AISI A36 is as follows:

- 1) From hypothesis testing in order to determine the impact of preheat temperature on the welds deposit hardness time

$$H_0: \tau_1 = \tau_2 = \tau_3 = 0$$

(preheat temperature doesn't affect the hardness value of welds deposit)

$$H_0 : \text{minimum of one } \tau \neq 0 \quad i = 1, 2, 3$$

(Material type affects the time of cutting process for wire cut)

- 2) From output it is determined that F statistic of preheat temperature is 0.49 and p-value is 0.0617 and the conclusion is that the original hypothesis, which states that the average of all levels on the factor of preheating temperature is the same, is rejected. In other words, the alternative hypothesis is accepted. This means, that a significant difference between levels in factor of preheating temperature is present, or there exists a significant impact from preheating temperature upon hardness value of welds deposit.
- 3) Determining the Influence Between Factors on Value of Deposit Hardness
From output, it is determined F statistic with the amount of 8.96 and p-value is 0.00, which leads to the conclusion that there is an impact of interaction between material type with the magnitude of electrical current in significant amount.
- 4) The plot of the graphs for main factors Figure 4.16 shows that preheat temperature and electrical current of 90 ampere inflicts a large influence upon the hardness value of deposit. Both types of factor have contradicting values; the increase of the level of material type also increases its influence on the process time; on the other hand increasing the electrical current will give bigger influence towards the hardness of the deposit which means the optimal electrical current for welding ranges from 90 A up to 100 A.
- 5) In the table of research data Table 4.1 it is shown that the magnitude of electrical current and preheat treatment results in high mean hardness value.

4.2 Suggestions

After conducting the study Analysis of Preheat Temperature's Influence on Layer Hardness of Cutting Knife during Hard facing Process of Carbon Steel AISI A36, the following are suggested:

- 1) Further studies regarding the impact of microstructure on HAZ hard facing process on low carbon steel is needed.
- 2) The hardness analysis of deposit after flat grinding process during implementation on cutting knife is required.
- 3) Analysis for effects from heat treatment of deposit upon deposit hardness is needed.

6. REFERENCES

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