The effect of coffee powder as a carburizing agent and preventing corrosion

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Abstract. Low carbon steel has a carbon content between 0.01% - 0.2% C, has properties of malleability and machining, usually used for machines, machinery and mild steel. The disadvantages of this low carbon steel are its relatively low mechanical strength and poor corrosion resistance. By using coffee powder as a carburizing agent and as an inhibitor corrosion, it is expected that the mechanical strength and corrosion resistance can be increased. This study aims to determine the effect of using coffee grounds in increasing wear resistance, and its hardness and corrosion resistance using coffee powder media. The process is carried out by carburizing at a temperature of 915^0C and held for 30 minutes with coffee powder media as charcoal and tempering at a temperature of 325^0C to increase its mechanical strength. The next process is testing its corrosion resistance using a coffee powder inhibitor with a percentage of 10 Ppm, 20 Ppm, and 30 Ppm. The results showed an increase in the mechanical strength of low carbon steel by carburizing the process using coffee grounds. There was an increase in the hardness value of the hardness test specimen from 180 HB in raw material to 395.3 HB. In the wear test, there was a decrease in the value of the wear volume from 0.079 mm^3 to 0.041 mm^3. In testing the corrosion rate using coffee grounds as a corrosion inhibitor medium, it was found that the corrosion rate of the raw material decreased with a value of 2.153 mm / yr to 1.495 mm / yr when using coffee inhibitors with a level of 30 Ppm.

1. Introduction

ST 41 Steel Specification Carbon is an alloy where iron is a basic element with several other elements, including carbon. The carbon in steel ranges from 0.08% to 0.20% by weight according to the grade, so this includes in the low carbon group. Its low carbon content and its microstructure consisting of ferrite and pearlite phases make low carbon steel soft and weak in strength but excellent in ductility and toughness[1]. To be able to improve its mechanical properties it is necessary to do heat treatment on the metal. Structural changes in heat treatment Iron and steel are expected to have static and dynamic strength, be ductile, easy to process, corrosion resistant and have electromagnetic properties so that they can be used as materials for construction and machinery [2]

The addition of carbon to a given heat treatment called Pack carburizing or carburizing, carried out by heating at a temperature high enough at a temperature of austenite in an environment containing active carbon atoms, so that the activated carbon atoms will diffuse into the steel surface and reaches a certain depth. After the diffusion process, followed by rapid cooling, the combination of these two processes results in a harder surface, but tough and tough in the middle [3]. Based on the given carbon media, there are three carburizing process methods that can be done, namely: 1) solid carburizing, 2)

liquid carburizing, and 3) gas carburizing. Solid carburizing is done by heating the metal above the austenite temperature for the desired holding time [4].

As well as being used as a source of carbon in carburizing, coffee grounds will also be used as an inhibitor to reduce the corrosion rate of the steel metal. The reason for choosing coffee beans as a carbon source and corrosion inhibitor is that there are many coffee plants in Indonesia, so it is very easy and cheap to get coffee beans, besides that it is safe to use in corrosion prevention because it is more natural [5]. The objectives to be achieved in this study were to determine the benefits of coffee beans in the process heat treatment on the mechanical properties of St 41 steel, to determine the effect of corrosion inhibitors from coffee bean powder to reduce the corrosion rate that occurs in ST.41 steel.

2. Research

A way to improve the mechanical properties of iron is by doing heat treatment is a heating process to a certain temperature and during a certain time followed by cooling according to a certain cooling rate to change the physical and mechanical properties of the metal without changing its size [6]. During the process the heat treatment metal remains in a solid state and does not change the shape or size of the product.

Carburizing is a heat treatment process on the surface of a work piece by utilizing carbon as a hardening element. The addition of carbon is called Pack carburizing or carburizing. Pack carburizing is a thermochemical process or chemical heat treatment which is carried out by changing the chemical composition of the steel surface to enrich the carbon element on the steel surface at a temperature of 850– 950ºC [7]. There are several factors that affect the rate of carbon diffusion, namely, temperature, composition and time.
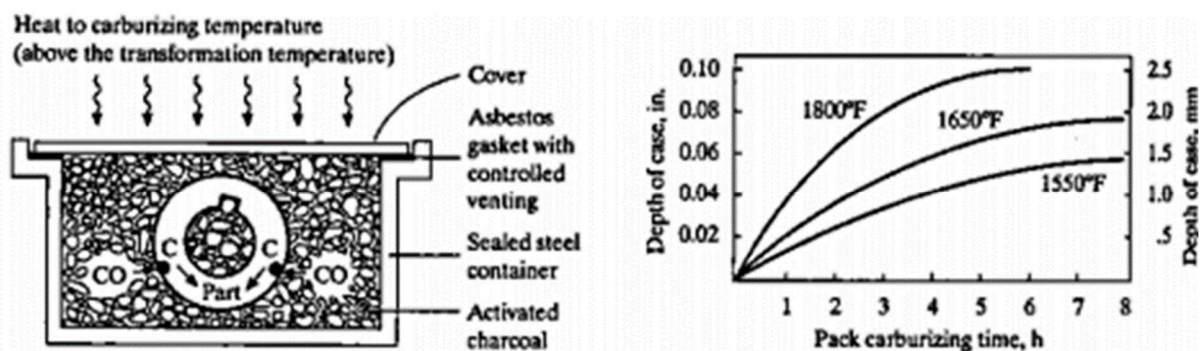

Figure 1. Pack Carburizing Process Effect of Carburizing Time on Hardness Depth [8]

The type of material used in this study is ST-41 with a temperature in the process of Carburizing 950ºC [9][10] and holding time for 30 minutes using coffee powder media and cooling it. with sea water, then carried out the process tempering 325^{0}C with a holding time for 60 minutes then cooled with air. Tests conducted to determine the effect of pack carburizing using coffee grounds are hardness testing and wear testing. The wear test itself is defined as the loss of the surface part of the metal due to friction which can cause material damage.[11]

In addition to good mechanical properties, corrosion resistance is also an important concern for metal. In addition to changing the mechanical properties of the metal, the heat treatment process will also cause a change in the corrosion rate of the metal [12][13]. Corrosion itself is a very serious problem in the material world and is very detrimental because it can reduce a construction's ability to bear loads. As a result of corrosion, the age of a construction is reduced from the planned time [14]. Corrosion itself cannot be eliminated, only the rate at which it attacks a metal is reduced. Corrosion is a redox reaction between a metal and other compounds in its environment (for example, water and air) and produces undesirable compounds. Corrosion events are known as rusting. This corrosion has resulted in losses every year. Usually the metal that experiences the most corrosion is iron. In the event of corrosion there

are anodes, cathodes, electrolytes and conductors, which are basically the same as electrochemical cells. The process of corrosion is an oxidation process, in which metal is corroded there will be a process of releasing electrons [15].

To reduce the rate of corrosion, there are many ways that can be used which are adapted to the metal used and the existing environmental conditions, one of which is by using a corrosion inhibitor [16]. The inhibitor itself is a substance when added to an environment, it can reduce the corrosion attack rate of that environment to a metal. The inhibitor itself can be divided into organic inhibitors and inorganic inhibitors. A number of inhibitors inhibit corrosion by means of adsorption to form an invisible thin layer with a thickness of only a few molecules, some are due to environmental influences to form visible deposits and protect the metal from attack which corrode the metal and produce a product that forms a passive layer, and some are which eliminates aggressive constituents [16].

Determination of the current density of corrosion is very necessary, because the current density of corrosion is proportional to the corrosion rate of a metal in its environment. This is in accordance with corrosion rate equation [17]in mils (0.001) in) per *year* (mpy) as below:

$$r = 0{,}129 \frac{i_{kor}\ (EW)}{D} \tag{1}$$

With:
r　　= corrosion rate (mpy)
i　　= corrosion flow density (uA / cm2)
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The corrosion rate is in mile units per year or may be converted into another unit shown in the following formula;

$$1\ mpy = 0{,}0254 \frac{mm}{yr} = \frac{25{,}4\ \mu m}{yr} = \frac{2{,}9\ nm}{yr} = \frac{0{,}805\ \rho m}{yr} \tag{2}$$

Meanwhile, to determine the ability of the inhibitor in reducing the corrosion rate, it can be found by the following equation; [18]

$$E = \frac{R_0 - R_i}{R_0} \times 100\% \tag{3}$$

Where:
E　= Inhibitor Efficiency
Ro = Corrosion rate without inhibitor
Ri = Corrosion rate with inhibitors

In this research, the inhibitor used is to use coffee powder with a concentration of 10 Ppm, 20 Ppm, and 30 Ppm.

3. Results and Discussion

The first test we do is testing the metal composition of the material used. We do this test to find out the composition of the metal and ensure that the metal has a low carbon content.

Table 1. Compositions of ST-41

Unsure	Test Result %	Unsure	Test Result %
C	0.20	Co	0.01
Si	0.21	Cu	0.01
Mn	0.35	Ti	0.01
P	0.02	W	0.03
S	0.01	Pb	0.01
Cr	0.33	Ce	0.01
Ni	0.33	Fe	9.87
Al	0.01		

From the testing results, it shows that the material composition used is carbon steel with a carbon composition of 0.20%.

3.1. Corrosion Test Results

Corrosion rate testing was carried out using the tafel extrapolation method with three electrode cells. The concentrations tested were: Coffee inhibitors: 10 Ppm, 20 Ppm, 30 Ppm.

By using groundwater in the city of Tegal, the results of the corrosion rate test can be seen in the following table:

Table 2. Corrosion Rate Test Results

	No Inhibitors	Coffee Inhibitors		
		10 Ppm	20 Ppm	30 Ppm
I_{cor} ($\mu A/cm^2$)	182,210	155,060	146,750	129,770
	189,350	154,330	152,800	130,680
	184,250	156,810	148,440	125,490
Corrosion Rate (mm/yr)	2,152	1,805	1,735	1,494

From the above test results it can be seen that the I_{cor} produced by groundwater is quite high. With this current will produce a corrosion rate of 2.152 mmpy, the corrosion rate is large enough so that treatment is needed to reduce the corrosion rate.

With the addition of coffee inhibitors with various concentrations of 10 Ppm, 20 Ppm, 30 Ppm, there was a decrease in the I_{core} value where the lowest value was obtained by the coffee inhibitor with a concentration of 30 Ppm with an average corrosion rate of 1.494 mmpy. For more details, see the following graphic figure. 1.
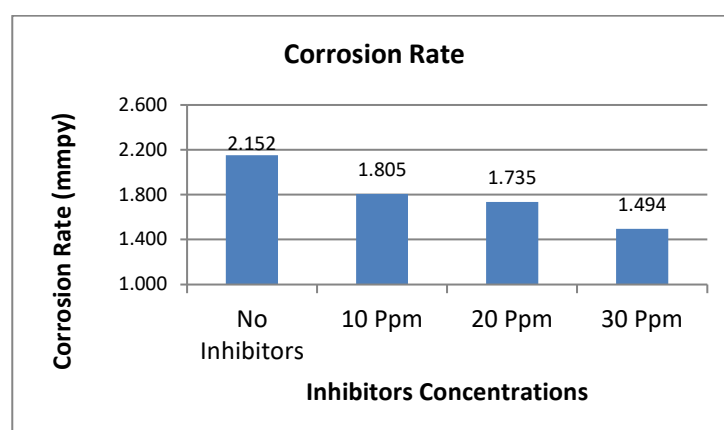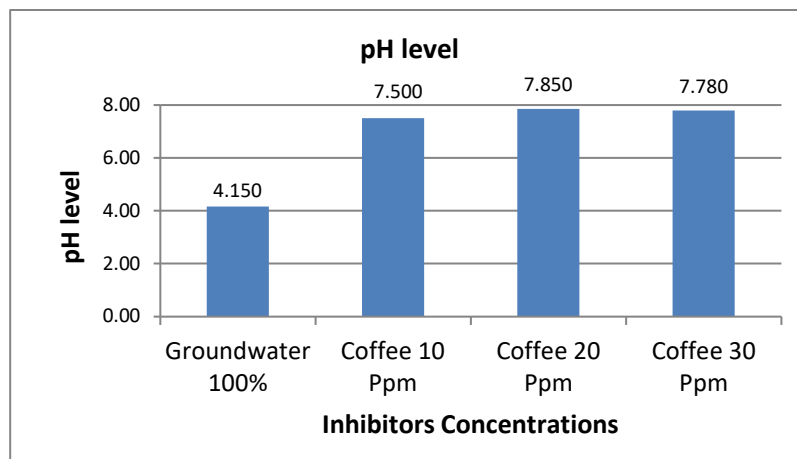

Figure 2. Graph of Corrosion Inhibitor Effect on Corrosion Rate

This decrease in the rate of corrosion is due to the presence of an inhibitor that changes the condition of the groundwater used so that it becomes more neutral. This can be seen in the results of testing the pH level of the water used which can be seen in the following table:

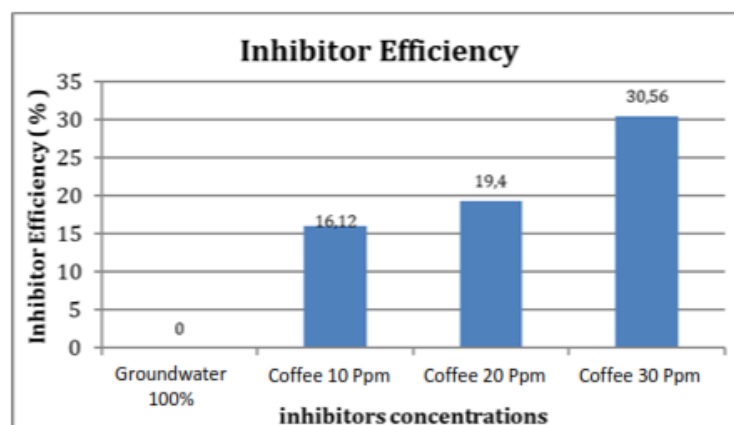**Table 3**. The results of the pH level test of water

Addition of an Inhibitor	Corrosion rate mm/y	Ph
Ground water 100%	2.152	4.150
Coffee 10 Ppm	1.805	7.500
Coffee 20 Ppm	1.735	7.850
Coffee 30 Ppm	1.494	7.780

From the table above it can be seen that without inhibitors, The groundwater used has a Ph content of 4,150. Where at that level the solution is acidic and has a high corrosion rate capability of 2.152 mmpy. With the addition of an inhibitor it is able to change the pH of the groundwater used so that it is closer to neutral Ph, where at neutral Ph the solution will decrease its corrosion rate [17], and reduce the corrosion rate to 1.494 mmpy at a coffee inhibitor concentration of 30 Ppm. More details can be seen in the following graph:

Figure 3. Graph of Ph Levels Solution

3.2. Efficiency Inhibitor

Inhibitors Corrosion Usually measured by their efficiency, namely by comparing the corrosion rate of the system being reviewed. The results of the corrosion rate test indicate an inhibitor's effect on decreasing the corrosion rate.

Figure 4. Inhibitor Efficiency Graph

In the graph above we can see that the efficiency inhibitor increases with increasing concentration inhibitors. This is because the higher the inhibitor concentration, the Ph level is getting closer to neutral conditions where the corrosion rate also decreases.

3.3. The Results of Hardness and Wear Tests

In the process, carburizing temperature of 950 ° C and tempering temperature of 325 ° with holding time of 30 minutes with coffee powder gave a good enough effect on the hardness value of ST 41 steel, namely the hardness value of 395.3 HB increased from raw material. 180 HB.

Table 4. Material Hardness Test Results

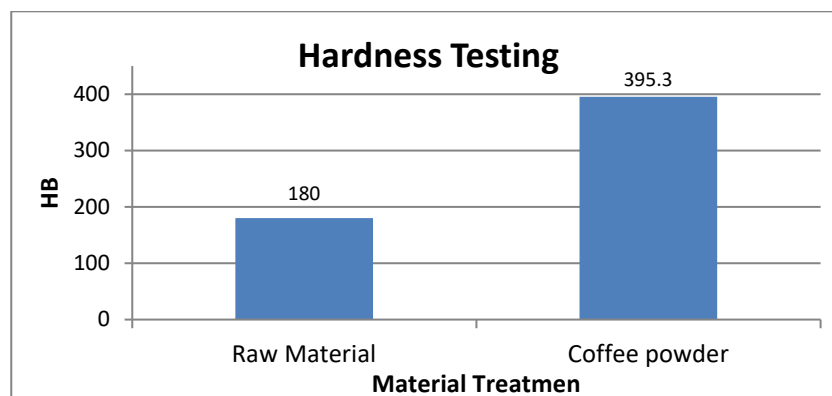| No	Test Area	Specimen	D (mm)	d (mm)	F (N)	Hardness Testing Results
	Point 1		2,5	1,13	1840	179
1	Point 2	Raw Material	2,5	1,13	1840	182
	Point 3		2,5	1.13	1840	179
Average Value						180
	Point 1		2,5	0,8	1840	382
2	Point 2	carburizing with coffee powder	2,5	0,8	1840	395
	Point 3		2,5	0,76	1840	409
Average Value						395,3

Figure 5. Graph of Hardness Testing Results

Coffee Powder Charcoal Has a fairly good effect on the wear value of ST 41 steel, namely the value of the wear volume of raw material 0.079 mm^3/ kg, being 0,041 mm^3/ kg, against raw material ST 41.

Table 5. Wear of materials test Results

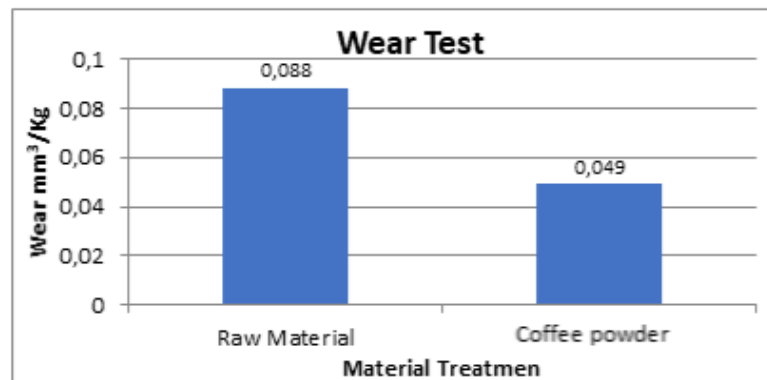| Specimens	Test point			Width disc (B) mm	Disc (r) mm	b^3	$W = \dfrac{B.b^3}{12.r}$ mm^3/kg
	1	2	3				
Raw material	14	15	16	25	12,5	0,475	0,079
Average Value		15					
carburizing with coffee powder	10	12	14	25	12,5	0,251	0,041
Average Value		12					

Figure 6. Graph of Wear Test Results

4. Conclusion

From the test results above, it can be seen that coffee powder has good benefits for metal materials and can be used both as an inhibitor for reducing the rate of corrosion and as an additional material in the carburizing process to increase the hardness and wear resistance of ST41 steel.

Based on the results of research from testing and evaluating data, the following conclusions can be drawn:

1. Analysis of the material used shows that the material used is ST-41 steel where the composition test results show the carbon content of 0.20% which is included in the type low carbon steel.

2. Testing of the corrosion rate on ST-41 steel material with inhibitors coffee shows that the trend of protection against corrosion and efficiency inhibitor will increase along with the increase in concentration inhibitor, where at the highest concentration at 30 Ppm with coffee inhibitor the corrosion rate is obtained to be 1.494 mmpy from 2,152 mmpy in raw material with inhibitor efficiency reaching 30.56%.

3. Process Carburizing with a temperature of 950^0C and a holding time of 30 minutes, with coffee powder obtained an average hardness of 395.3 HB, increased from 180 HB in raw material and a wear volume of 0.041 mm^3/ kg from 0.088 mm^3/ kg.

References

[1]   W. D. Callister, *Materials Science*. John Wiley & Sons, Inc., 2007.

[2]   T. Surdia and S. Saito, *Pengetahuan Bahan Teknik*. PT. Pradnya Paramita, 1999.

[3]   H. S. Hariningsih, Sumpena, "The effectivity of used-oil as Quenching Medium of 42CrMo4 Steel for Automotive Material," *Appl. Res. Smart Technol.*, vol. 1, pp. 28–34, 2020.

[4]   A. N. S. Darmo and S. Widodo, "Pengaruh Proses Pack Carburising Terhadap Kekerasan Baja Karbon Rendah," *Jur. Tek. Mesin Fak. Tek. Univ. Tidar*, no. 2, pp. 73–78, 2019.

[5]   F. A. Az Zahra Bariyah; Nurhadi, Luki Oktavian, "Ekstrak Kafein Ampas Kopi Sebagai Inhibitor Korosi Baja Murni Dalam Media H2SO4," *Pros. Semnastek*, no. PROSIDING SEMNASTEK 2019, pp. 1–9, 2019.

[6]   I. Ropi'i and M. Fajar Sidiq, "Analisis Sifat Mekanik Material Shaft Mata Pisau Pada Mesin Penghancur Plastik Menggunakan Baja ST 41," in *2nd Mechanical Engineering National Converence*, 2019, vol. 2, pp. 1–7.

[7]   M. Hamzah, M.S., Iqbal, "Improvement of Low Carbon Steel Wear with Carburizing Methods," *SMARTek*, vol. 6, no. 3, pp. 169–175, 1999.

[8]   M. A. S. Sidiq, M. Fajar , Soebyakto, "Peningkatan Kekerasan Baja Karbon Rendah dengan Menggunakan Cangkang Telur," in *Seminar Nasional Metalurgi dan Material (SENAMM) X*, 2017, no. November, pp. 418–426.

[9]   E. Gunawan, "Analisa Pengaruh Temperatur Terhadap Sifat Mekanis Dan Struktur Mikro Pada Baja Karbon Rendah (St41) Dengan Metode Pack Carbirizing," *Tek. Eng. Sains J.*, vol. 1, no.

2, pp. 117–124, 2017.

[10]   A. Darmawan, Mustaqim, and Mf. Sidiq, "Pengaruh Temperatur Carburizing Pada Proses Pack Carburizing Terhadap Sifat – Sifat Mekanis Baja S 21 C," *ENGINEERING*, vol. 14, no. 1, Apr. 2017.

[11]   A. Bahrami, S. H. M. Anijdan, M. A. Golozar, M. Shamanian, and N. Varahram, "Effects of conventional heat treatment on wear resistance of AISI H13 tool steel," *Wear*, vol. 258, no. 5–6, pp. 846–851, 2005.

[12]   M. F. Sidiq, M. A. Shidiq, and Soebyakto, "Pengaruh Suhu Heat Treatment Terhadap Laju Korosi Material Pagar," 2016, no. November, pp. 1–5.

[13]   M. A. Lucio-Garcia *et al.*, "Effect of heat treatment on H2S corrosion of a micro-alloyed C-Mn steel," *Corros. Sci.*, vol. 51, no. 10, pp. 2380–2386, 2009.

[14]   Y. Ludiana and S. Handani, "Pengaruh Konsentrasi Inhibitor Ekstrak Daun Teh (C Amelia Sinensis) Terhadap Laju Korosi Baja Karbon Schedule 40 Grade B ERW," *J. Fis. Unand*, vol. 1, no. 1, pp. 12–18, 2012.

[15]   F. Ali, D. Saputri, and R. F. Nugroho, "Pengaruh Waktu Perendaman Dan Konsentrasi Ekstrak Daun Jambu Biji (Psidium Guajava , Linn) Sebagai Inhibitor Terhadap Laju Terhadap Laju Korosi Baja SS 304 Dalam Larutan Garam Dan Asam," *Tek. Kim.*, vol. 20, no. 1, pp. 28–37, 2014.

[16]   S. Papavinasam, "Corrosion Inhibitors," in *UHLIG`S CORROSION HANDBOOK*, 2000, p. 1089.

[17]   D. A. Jones and R. Walker, *Principles and Prevention of Corrosion: Pearson New International Edition*, vol. 14, no. 3. 1996.

[18]   S. Widharto, *Karat dan Pencegahannya*, vol. 1. 1999.

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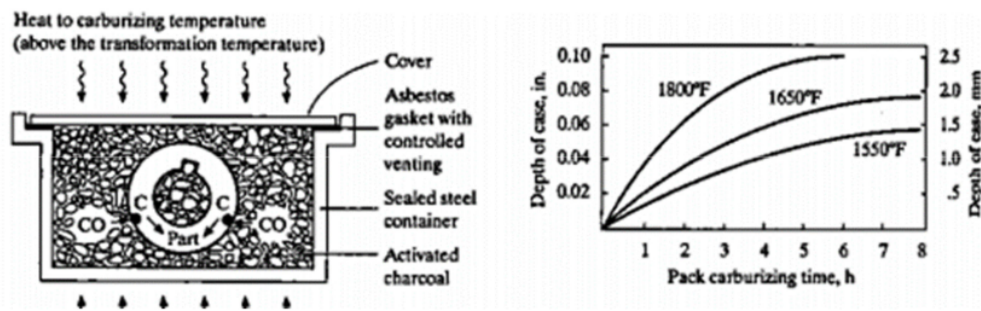

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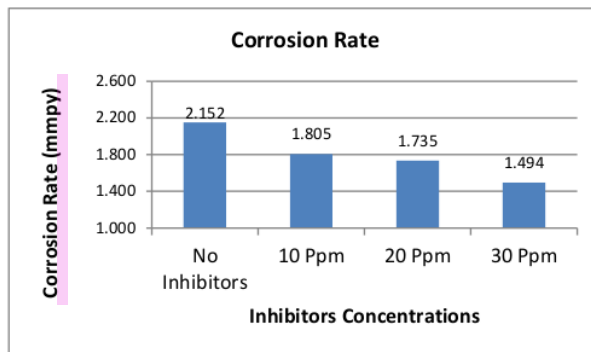

Figure 2. Graph of Corrosion Inhibitor Effect on Corrosion Rate

This decrease in the rate of corrosion is due to the presence of an inhibitor that changes the condition of the groundwater used so that it becomes more neutral. This can be seen in the results of testing the pH level of the water used which can be seen in the following table:

Table 3. The results of the pH level test of water

Addition of an Inhibitor	Corrosion rate mm/y	Ph
Ground water 100%	2.152	4.150
Coffee 10 Ppm	1.805	7.500
Coffee 20 Ppm	1.735	7.850
Coffee 30 Ppm	1.494	7.780

From the table above it can be seen that without inhibitors, The groundwater used has a Ph content of 4,150. Where at that level the solution is acidic and has a high corrosion rate capability of 2.152 mmpy. With the addition of an inhibitor it is able to change the pH of the groundwater used so that it is closer to neutral Ph, where at neutral Ph the solution will decrease its corrosion rate [17], and reduce the corrosion rate to 1.494 mmpy at a coffee inhibitor concentration of 30 Ppm. More details can be seen in the following graph:
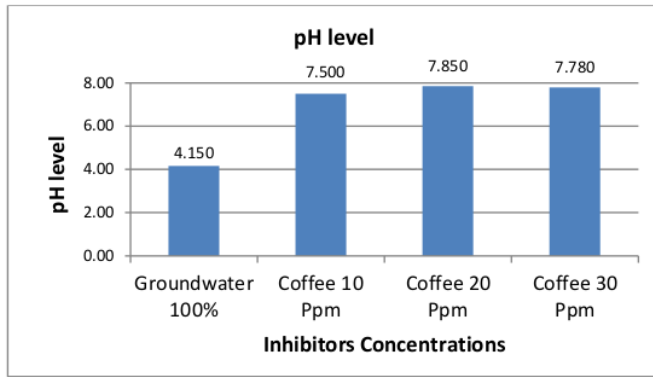

Figure 3. Graph of Ph Levels Solution

3.2. Efficiency Inhibitor

Inhibitors Corrosion Usually measured by their efficiency, namely by comparing the corrosion rate of the system being reviewed. The results of the corrosion rate test indicate an inhibitor's effect on decreasing the corrosion rate.
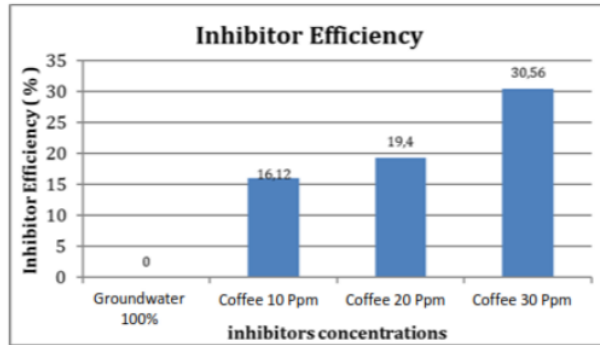

Figure 4. Inhibitor Efficiency Graph

In the graph above we can see that the efficiency inhibitor increases with increasing concentration inhibitors. This is because the higher the inhibitor concentration, the Ph level is getting closer to neutral conditions where the corrosion rate also decreases.

3.3. The Results of Hardness and Wear Tests

In the process, carburizing temperature of $950 °C$ and tempering temperature of $325 °$ with holding time of 30 minutes with coffee powder gave a good enough effect on the hardness value of ST 41 steel, namely the hardness value of 395.3 HB increased from raw material. 180 HB.

Table 4. Material Hardness Test Results

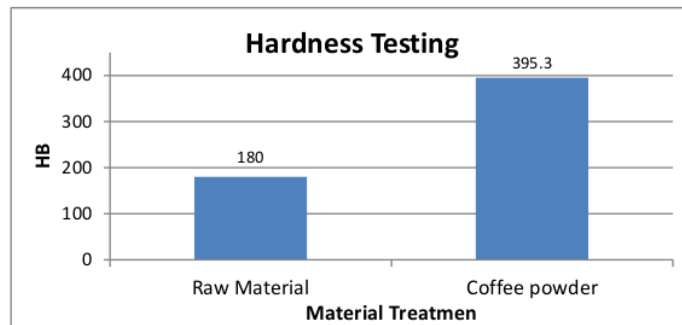| No	Test Area	Specimen	D (mm)	d (mm)	F (N)	Hardness Testing Results
1	Point 1	Raw Material	2,5	1,13	1840	179
	Point 2	Raw Material	2,5	1,13	1840	182
	Point 3		2,5	1.13	1840	179
Average Value						180
2	Point 1	carburizing with coffee powder	2,5	0,8	1840	382
	Point 2		2,5	0,8	1840	395
	Point 3		2,5	0,76	1840	409
Average Value						395,3

Figure 5. Graph of Hardness Testing Results

Coffee Powder Charcoal Has a fairly good effect on the wear value of ST 41 steel, namely the value of the wear volume of raw material 0.079 mm³/ kg, being 0,041 mm³/ kg, against raw material ST 41.

Table 5. Wear of materials test Results

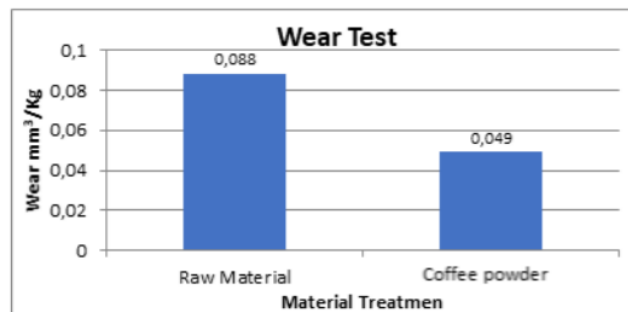| Specimens	Test point 1	Test point 2	Test point 3	Width disc (B) mm	Disc (r) mm	b^3	$W = \dfrac{B.b^3}{12.r}$ mm³/kg
Raw material	14	15	16	25	12,5	0,475	0,079
Average Value		15					
carburizing with coffee powder	10	12	14	25	12,5	0,251	0,041
Average Value		12					

Figure 6. Graph of Wear Test Results

4. Conclusion

From the test results above, it can be seen that coffee powder has good benefits for metal materials and can be used both as an inhibitor for reducing the rate of corrosion and as an additional material in the carburizing process to increase the hardness and wear resistance of ST41 steel.

Based on the results of research from testing and evaluating data, the following conclusions can be drawn:

1. Analysis of the material used shows that the material used is ST-41 steel where the composition test results show the carbon content of 0.20% which is included in the type low carbon steel.
2. Testing of the corrosion rate on ST-41 steel material with inhibitors coffee shows that the trend of protection against corrosion and efficiency inhibitor will increase along with the increase in concentration inhibitor, where at the highest concentration at 30 Ppm with coffee inhibitor the corrosion rate is obtained to be 1.494 mmpy from 2,152 mmpy in raw material with inhibitor efficiency reaching 30.56%.
3. Process Carburizing with a temperature of 950^0C and a holding time of 30 minutes, with coffee powder obtained an average hardness of 395.3 HB, increased from 180 HB in raw material and a wear volume of 0.041 mm^3/ kg from 0.088 mm^3/ kg.

References

[1]   W. D. Callister, *Materials Science*. John Wiley & Sons, Inc., 2007.

[2]   T. Surdia and S. Saito, *Pengetahuan Bahan Teknik*. PT. Pradnya Paramita, 1999.

[3]   H. S. Hariningsih, Sumpena, "The effectivity of used-oil as Quenching Medium of 42CrMo4 Steel for Automotive Material," *Appl. Res. Smart Technol.*, vol. 1, pp. 28–34, 2020.

[4]   A. N. S. Darmo and S. Widodo, "Pengaruh Proses Pack Carburising Terhadap Kekerasan Baja Karbon Rendah," *Jur. Tek. Mesin Fak. Tek. Univ. Tidar*, no. 2, pp. 73–78, 2019.

[5]   F. A. Az Zahra Bariyah; Nurhadi, Luki Oktavian, "Ekstrak Kafein Ampas Kopi Sebagai Inhibitor Korosi Baja Murni Dalam Media H2SO4," *Pros. Semnastek*, no. PROSIDING SEMNASTEK 2019, pp. 1–9, 2019.

[6]   I. Ropi'i and M. Fajar Sidiq, "Analisis Sifat Mekanik Material Shaft Mata Pisau Pada Mesin Penghancur Plastik Menggunakan Baja ST 41," in *2nd Mechanical Engineering National Converence*, 2019, vol. 2, pp. 1–7.

[7]   M. Hamzah, M.S., Iqbal, "Improvement of Low Carbon Steel Wear with Carburizing Methods," *SMARTek*, vol. 6, no. 3, pp. 169–175, 1999.

[8]   M. A. S. Sidiq, M. Fajar , Soebyakto, "Peningkatan Kekerasan Baja Karbon Rendah dengan Menggunakan Cangkang Telur," in *Seminar Nasional Metalurgi dan Material (SENAMM) X*, 2017, no. November, pp. 418–426.

[9]   E. Gunawan, "Analisa Pengaruh Temperatur Terhadap Sifat Mekanis Dan Struktur Mikro Pada Baja Karbon Rendah (St41) Dengan Metode Pack Carbirizing," *Tek. Eng. Sains J.*, vol. 1, no.

2, pp. 117–124, 2017.

[10]   A. Darmawan, Mustaqim, and Mf. Sidiq, "Pengaruh Temperatur Carburizing Pada Proses Pack Carburizing Terhadap Sifat – Sifat Mekanis Baja S 21 C," *ENGINEERING*, vol. 14, no. 1, Apr. 2017.

[11]   A. Bahrami, S. H. M. Anijdan, M. A. Golozar, M. Shamanian, and N. Varahram, "Effects of conventional heat treatment on wear resistance of AISI H13 tool steel," *Wear*, vol. 258, no. 5–6, pp. 846–851, 2005.

[12]   M. F. Sidiq, M. A. Shidiq, and Soebyakto, "Pengaruh Suhu Heat Treatment Terhadap Laju Korosi Material Pagar," 2016, no. November, pp. 1–5.

[13]   M. A. Lucio-Garcia *et al.*, "Effect of heat treatment on H2S corrosion of a micro-alloyed C-Mn steel," *Corros. Sci.*, vol. 51, no. 10, pp. 2380–2386, 2009.

[14]   Y. Ludiana and S. Handani, "Pengaruh Konsentrasi Inhibitor Ekstrak Daun Teh (C Amellia Sinensis) Terhadap Laju Korosi Baja Karbon Schedule 40 Grade B ERW," *J. Fis. Unand*, vol. 1, no. 1, pp. 12–18, 2012.

[15]   F. Ali, D. Saputri, and R. F. Nugroho, "Pengaruh Waktu Perendaman Dan Konsentrasi Ekstrak Daun Jambu Biji (Psidium Guajava , Linn) Sebagai Inhibitor Terhadap Laju Terhadap Laju Korosi Baja SS 304 Dalam Larutan Garam Dan Asam," *Tek. Kim.*, vol. 20, no. 1, pp. 28–37, 2014.

[16]   S. Papavinasam, "Corrosion Inhibitors," in *UHLIG`S CORROSION HANDBOOK*, 2000, p. 1089.

[17]   D. A. Jones and R. Walker, *Principles and Prevention of Corrosion: Pearson New International Edition*, vol. 14, no. 3. 1996.

[18]   S. Widharto, *Karat dan Pencegahannya*, vol. 1. 1999.

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