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Enhancing Mechanical Properties of Low Carbon Steel through Carburizing with Holding Time and Quenching Media Variation According to ASTM Standard Testing

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***Abstract*-- Steel is a material widely use in engineering, especially in industrial world. Because its wide application, usually we need to tailor its mechanical properties so it suit our needs. Sometimes we need to perform heat treatment to changes its mechanical properties. Principally heat treatment process is we heating up the material above its recrystallize temperature. The change in its microstructure then will depend on the length of holding temperature and the cooling rate. With specific length of holding temperature and specific cooling rate, heat treatment can tailoring the mechanical properties of steel to suit the needs. (Hari Amanto. Daryanto, tt : 82).**

Carburizing is heat treatment which aim is to increasing the hardness of material surface. In this study we varying the holding time and quenching media to increase steel hardness. Our longtime goal are to find a way to enhance the mechanical properties of steel to accommodate industrial needs.

The research methodology are experiment method with holding time variation of 1 hour, 2 hours, 3 hours, 4 hours and 5 hours, and quenching media variation of water, lubricating oil, and air. The material used are low carbon steel. The data is analyze with ANOVA and T test. Resulting data showed increase in hardness in specimen with longer holding time and quenching media of lubricating oil, with hardness value are 61.33 HRc, 67.33 HRc, 70 HRc, 74.33 HRc, 76.33 HRc, quenching media of water, the hardness value are 55 HRc, 62.67 HRc, 64.33 HRc, 67.67 HRc, 71,33 HRc and quenching media of air, the hardness value are 31 HRc, 42.67 HRc, 45 HRc, 47.33 HRc, 52.67 HRc.

***Keywords*-- Mechanical properties of steel, Hardness, Carburizing, Holding Time, Quenching.**

I. INTRODUCTION

The using of ferrous metal, in steel or casting iron has its own characteristic, it will need specific treatment for each cases.

The development in technology has caused the need in increasing material quality. Higher efficiency need higher working temperature, thus it need higher material quality like hardness and strength.

Mechanical properties of steel is the ability to endure all kind of load, static or dynamic. The usual mechanical properties are strength, ductility, hardness and toughness.

Many times the needs are higher hardness so the steel can endure frictional loads better. In this case we need to apply heat treatment to it. With heat treatment we can alter the micro structure of metal, thus tailoring the mechanical properties to suit our need. (Hari Amanto, Daryanto, tt : 82)

II. METHODOLOGY

In this study we use experimental method, the goal is to find specific time for holding time and type of quenching media that can yields steel with highest hardness value in carburizing low carbon steel material.

The variable are the length of holding time in 1 hour, 2 hours, 3 hours, 4 hours and 5 hours, and the type of quenching media like water, lubricating oil and air.

The testing procedures are Hardness Test, EDAX for its carbon contain and SEM for its micro structures.

We used 30 specimen, with 5 different treatment, the data collected are analyze with ANOVA and T test.

The experiment was conducted at Mechanical Engineering Laboratory of Brawijaya University.

Table 1
Hardness Value Before Carburizing

Specimen	Hardness Value (HRc)
1	19
2	20
3	21

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Table 2
Hardness Value After Carburizing With Water Quenching and Holding Time Variasion

Specimen	Hardness Value (HRc)				
	1 hours	2 hours	3 hours	4 hours	5 hours
1	59	68	69	73	76
2	63	68	70	75	75
3	62	66	71	75	78
Σ	**184**	**202**	**210**	**223**	**229**
$\overline{X}_j$	**61,33**	**67,33**	**70**	**74,33**	**76,33**
$\overline{X}$	**69,89**				

Table 3
Hardness Value After Carburizing With Lubricant Oil Cooling and Holding Time Variasion

Specimen	Hardness Value (HRc)				
	1 hours	2 hours	3 hours	4 hours	5 hours
1	56	62	63	67	70
2	55	63	64	67	73
3	54	63	66	69	71
Σ	**165**	**188**	**193**	**203**	**214**
$\overline{X}_j$	**55**	**62,67**	**64,33**	**67,67**	**71,33**
$\overline{X}$	**64,2**				

Table 4
Hardness Value After Carburizing With Air Cooling and Holding Time Variasion

Specimen	Hardness Value (HRc)				
	1 hours	2 hours	3 hours	4 hours	5 hours
1	32	42	45	48	50
2	31	43	47	47	55
3	30	43	43	47	53
Σ	**93**	**128**	**135**	**142**	**158**
$\overline{X}_j$	**31**	**42,67**	**45**	**47,33**	**52,67**
$\overline{X}$	**43,73**				

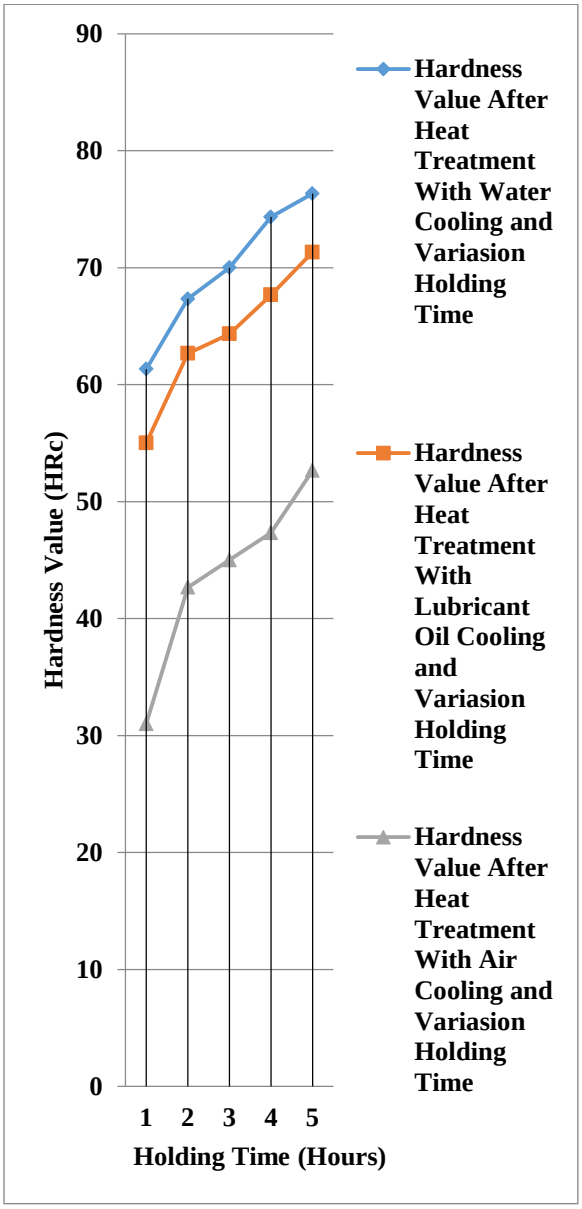

Figure 1. Hardness Value After Carburizing With Quenching Media and Holding Time Variasion

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Table 5
Carbon Contain Before Heat Treatment

Specimen	Carbon Contain (%)
1	0.460
2	0.535
3	0.438

Table 6
Carbon Contain After Carburizing With Water Quenching

Specimen	Carbon Contain (%)				
	1 hours	2 hours	3 hours	4 hours	5 hours
1	13.55	16.17	21.80	28.22	27.22
2	14.17	12.69	25.63	20.22	24.06
3	16.27	17.98	25.97	25.89	25.70
Σ	**43,99**	**46,84**	**73,4**	**74,33**	**76,98**
$\overline{X}_j$	**14,66**	**15,61**	**24,47**	**24,78**	**25,66**
$\overline{X}$	**21,04**				

Table 7
Carbon Contain After Carburizing With Lubricant Oil Quenching

Specimen	Carbon Contain (%)				
	1 hours	2 hours	3 hours	4 hours	5 hours
1	8.10	9.85	10.18	9.83	12.56
2	8.08	11.00	8.95	7.92	12.36
3	9.66	7.83	9.99	11.65	7.92
Σ	**25,84**	**28,68**	**29,12**	**29,4**	**32,84**
$\overline{X}_j$	**8,61**	**9,56**	**9,71**	**9,8**	**10,95**
$\overline{X}$	**9,73**				

Table 8
Carbon Contain After Carburizing With Air Quenching

Specimen	Carbon Contain (%)				
	1 hours	2 hours	3 hours	4 hours	5 hours
1	6.57	7.06	6.66	7.34	8.18
2	6.05	6.77	8.66	8.44	7.86
3	5.90	7.16	6.32	7.83	9.99
Σ	**18,52**	**20,99**	**21,64**	**23,61**	**26,03**
$\overline{X}_j$	**6,173**	**6,997**	**7,213**	**7,87**	**8,677**
$\overline{X}$	**7,386**				

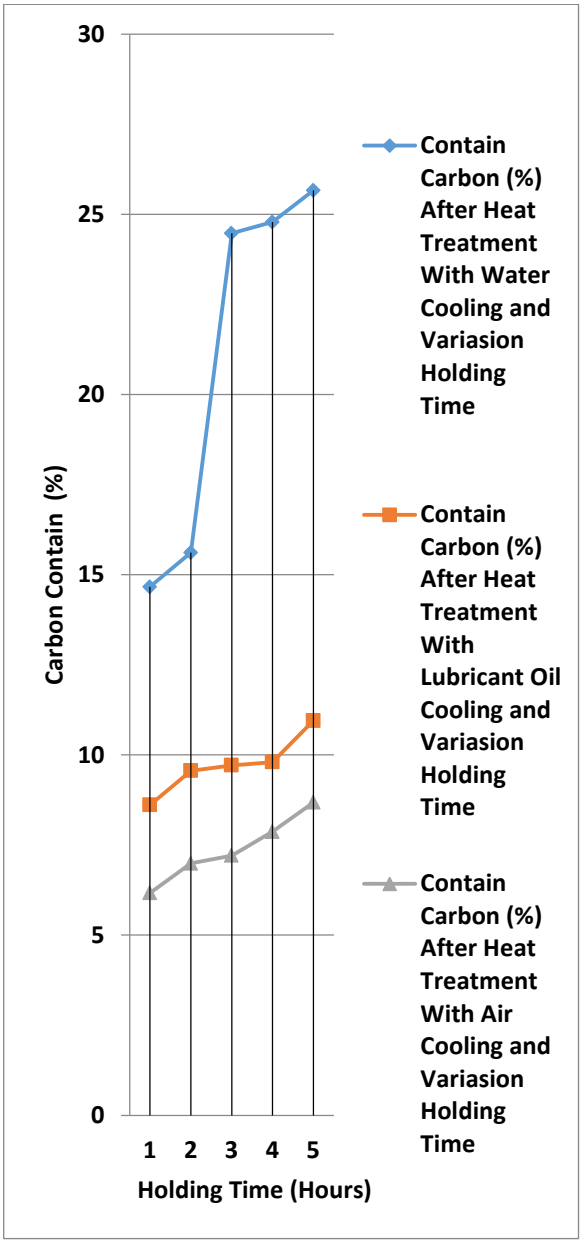

Figure 2. Carbon Contain (%) After Carburizing With Quenching Media and Holding Time Variasion

III. DISCUSSION

Our study shows in figure 1. That water as quenching media gives the highest hardness.

It is due to water as cooling media provides the fastest cooling rate, that will make the quenching process more effective, because the the faster the cooling rate will produce more martensit structure in its microstructure. And for all we know martensit is needle shape phase that has hard and brittle characteristic.

We can see that after more than 1 hour, holding time will produce small increase in material hardness. The hardness continually increasing as the holding time get longer, but the increasing rate is relative small. As the holding time getting longer the effectiveness of quenching process will getting lower, but the effect of solid diffusion from the carburizing process will be bigger. This is shown in figure 2. Where we can see that the longer the holding time, the carbon contain will grow higher.

IV. Conclusion

From our study and data experiment our conclusion are :

1. Water as cooling media producing higher hardness than lubricant oil and air as cooling media. The longer the holding time in carburizing process will yield higher hardness value in steel specimen. And our study shows and verify by Anova analysis and T test, that carburizing with some variation in holding time and quenching media at carbon steel ST 50 will significantly increase its hardness.
2. It shown that increasing holding time in carburizing from 1 hour, to 2, 3, 4 and 5 hours will increase the hardness in all cooling media of water, lubricant oil or air.
3. From EDAX testing, it shows that carburizing with water as cooling media produce carbon contain higher than carburizing with lubricant oil or air as cooling media.

REFERENCES

[1] Alois Schonmetz and Gruber K. “Pengetahuan Bahan dalam Pengerjaan Logam” Penerbit Angkasa, Bandung. 1994.

[2] Amstead B. H. et all, “Manufacturing Process, in Canada, Published Simultaneously, 7th ed. 1979.

[3] Asfarizal, “Peningkatan Kekerasan Dengan Metoda Karburasi Pada Baja Karbon Rendah Dengan Media Kokas”Jurnal Teknika No. 30 Vol. 1 Thn.XV November 2008, ISSN : 0854-8471.

[4] Bambang Kuswanto, “Peningkatan Kekuatan Tarik Maksimum Material BajaKarbon Rendah Menggunakan Proses Penambahan Karbon Padat,” Journal Teknis Vol. 5 No. 3 Desember 2010, hal. 117 – 120.

[5] Bhattacharya, Richard, “Statistical Concepts and Methods,” John Willey & Sons, New York. 1999.

[6] Dieter, George E. “Metalurgi Mekanik” Jilid 1, 4th ed. Erlangga, Jakarta. 1993.