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Theme : "Smart Engineering for Better Environment"

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FOREWORDS

Dear Authors, esteemed Readers

It is with great satisfaction that we write this foreword to the proceedings of the 2nd International Conference on Engineering and Environment (ICEE 2019) held in Padang, Indonesia, Octobre 30th 2019, organised by Faculty Engineering Universitas Negeri Padang, with partnerships are Kyoto University, Southern Taiwan University of Science and Technology, Ottawa University, Universiti Sains Malaysia and Kyoto Alumni Association Malaysia.

ICEE 2019 continues a tradition of bringing together researchers, academics and professionals from all over the world, and offers significant contributions to engineering and environmental science in theoretical and practical aspects. The conference particularly encouraged the interaction of research students and developing academics with the more established academic community in an informal setting to present and to discuss new and current work. Their contributions helped to make the Conference as outstanding as it has been.

In addition to the contributed papers, four invited keynote presentations consists: Prof. Wolfgong Bruestle is formerly head of the Seismological Service Baden-Wuerttemberg, German, Prof. Dr. Mohd Hasbullah from Universiti Teknologi Malaysia, Riki Mukhaiyar, Ph.D. from Universitas Negeri Padang and Fadzli Mohd. Nazri, Ph.D. from Universiti Sains Malaysia, parallel sessions presenters from Indonesia and abroad too.

This Proceeding will furnish the scientists of the world with an excellent reference book. I trust also that this will be an impetus to stimulate further study and research in all these areas.

Finally, we would like to you for the support from various parties, which is keynote speakers, authors, participants, universities, and leaders who have participated in this conference, and special thanks for committee member who have given their help and energy for this event. We hope that through this preceeding, we could expand your multidisciplinary studies relationship network and develop the joint research in the future.

Rusnardi Rahmat Putra
Conference Chair

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CONTENT PROCEEDINGS
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COMPARISON OF HARDNESS OF ASSAB 705 STEEL AND AISI 4140 STEEL THAT GIVES HEAT HARDENING TREATMENT WITH OIL COOLING MEDIA

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Abstract

The purpose of this study was to determine the comparison of the hardness value of assab 705 steel and AISI 4140 steel. Steel assab 705 and AISI 4140 steel were two medium carbon steels whose carbon content was 0.38% -0.43% C. With its carbon content the same, allowing these two steels to be hardened by a hardening heat treatment process using oil cooling media. The experimental method was used in this study, with 6 specimens of test specimens and cooled with oil cooling media. The results of the hardness test showed that there was a difference in the value of hardness between steel assab 705 with steel AISI 4140. In assab 705 steel, the average value of steel hardness of the three test specimens obtained a value of 378.33 BHN. Whereas for AISI 4140 steel, the average value of steel hardness from the three test specimens obtained a value of 489 BHN. It can be concluded that Steel AISI 4140 has a higher hardness value than steel assab 705.

Keywords: Hardening, Hardness, Oil Cooling Media, Steel Assab 705, Steel AISI 4140.

1. INTRODUCTION

Metal as the main operational material or as a raw material for its production is widely used by industry. Carbon steel is widely used mainly for making tools, agricultural equipment, automotive components, household needs. Application of its use, all metal structures will be affected by the influence of the external force in the form of frictional stresses resulting in deformation or deformation. The effort to make metal more friction resistant or pressure is by heat treatment on steel, this plays an important role in increasing the hardness of steel according to needs [3]. In many cases the tenacity or toughness of a material is often needed in addition to the wear-resistant nature of the surface. It is necessary to harden the surface, which is one way to obtain hard, wear-resistant surface parts and tough and tough parts to get this purpose requires a hardening heat treatment. On the surface hardening will also result in the surface layer of the workpiece becoming wear-resistant and the fatigue limit rises [7]. Hardness in the hardening process is influenced by several factors such as: composition of carbon contained in steel before hardening, hardening process, type and cooling material used in the hardening process.

During this time often encountered components that experience continuous friction in the function of work, so that quickly experience wear and tear. The components include sprocket, gears, piston and shaft. These components work in contact with other components so that they will experience wear and tear and cause these components to be easily damaged. To overcome this problem it is necessary to do a hardening heat treatment process that is useful for hardening the components so that they are resistant to friction, and also often encountered by people who only use water cooling media to cool the specimens after undergoing a heat treatment process.

Hardening is the process of heat treatment to harden steel by heating until the phase changes are homogeneous then followed by rapid cooling until a structure called martensite occurs [7]. This treatment consists of heating the steel to its hardening temperature and holding it at that temperature for a certain period of time and then cooled to a very high cooling rate or quenched to obtain the desired hardness. The reason for heating and holding it to austenisation temperatue is to dissolve sememitite in austenite then proceed with the quenching process. At this stage, trapped carbon will cause displacement of atoms so that a centralized tetragonal structure is formed. This structure is called martensite which is very hard and brittle. Usually hardened steel is followed by tempering processes which reduce the stress caused by quenching due to the presence of martensite formation.

2. LITERATURE REVIEW

2.1 Steel

Steel is an alloy of iron and carbon, with carbon content up to a maximum of 1.5%. The carbon occurs in the form of iron carbide, because of its ability to increase the hardness and strength of the steel [6]. Steel is a mixture of iron and carbon, with a maximum carbon content of 1.5%. Carbon occurs in the form of iron carbides, increasing the hardness of steel. Steel is an alloy of iron and carbon which can contain concentrations of other mixed elements. There are thousands of other mixtures of metals that have different compositions. The mechanical properties of steel are very sensitive to carbon content, which is normally less than 1.5%. some of the steel is classified according to carbon concentration, which is in low carbon steel, medium and high carbon types, whereas based on its carbon content, steel is divided into three types, namely low carbon steel containing less than 0.3%, medium carbon steel which containing carbon 0.3% - 0.6%, and high carbon steel containing carbon 0.6% - 1.5%.

2.1.1 Carbon Steel

Carbon steel is an alloy of carbon iron where the carbon element determines its properties, while other alloy elements commonly contained in it occur due to the manufacturing process [7]. The nature of carbon steel is determined by the percentage of carbon and microstructure. Besides that steel also contains other elements such as sulpur (S), phosphorus (P), silicon (Si), manganese (Mn), etc. which are limited in number. The nature of steel is generally strongly influenced by carbon percentages and microstructure. The microstructure of carbon steel is influenced by heat treatment and steel composition. Carbon with other mixed elements in steel forms carbides which can add hardness, scratch resistance and temperature resistance to steel. The difference in the percentage of carbon in a mixture of carbon steel metals is one way to classify steel. Based on carbon content, steel is divided into three types, namely Low Carbon Steel, Medium Carbon Steel, High Carbon Steel.

Table 1. Classification of Carbon Steel

Jenis dan Kelas	Kadar karbon (%)	Kekuatan luluh (kg/mm²)	Kekuatan tarik (kg/ mm²)	Perpanjangan	Kekerasan Brinell	Penggunaan
Baja karbon rendah	0,05 – 0,30	18 – 36	32 – 55	40 –22	80 – 145	Pelat tipis
Baja karbon sedang	0,30 – 0,60	30 – 40	50 – 60	30 –17	140 – 170	Alat mesin
Baja karbon tinggi	0,60 – 1,50	30 – 47	58 – 100	30 –11	160 – 235	Perkakas

Sumber: [5]

The mechanical properties of steel are also influenced by the way carbon bonds are made with iron, there are 2 main forms of crystals when carbon holds an iron bond, that is:

1. Ferrite, which is pure iron (Fe), is located close to each other irregularly, both in shape and size. Ferrite is the most soft part of steel, pure ferrite will not be suitable to be used as a material to work with which it holds a load because of its small strength.
2. Perlite, is a mixture of ferrite and cementite with a carbon content of 0.8%. The structure of perlitis has its own ferrite crystals of the most adjoining fine cementite flakes in a thin layer.

2.1.2 Alloy Steel

Alloy steel is steel that contains another or more elements with levels that are more than usual levels in carbon steel [7]. The elements usually contained in carbon steel are C, Mn, Si, P and S. to obtain better properties then the levels of Mn or Si are added, or other elements such as Cr, Ni, Mo, Co, Ti , W and so on. Thus in addition to improving the mechanical properties also improve corrosion-resistant properties, high temperature resistance, wear-resistant and electrical and magnetic properties.

Levels of alloy elements, alloy steel can be divided into two groups, namely low alloy steel and high alloy steel or special alloy steel [7]. Low alloy steel is steel that contains a little alloy element below 10%, while high alloy steel can contain alloy elements above 10%. Low alloy steel can be classified as follows:

1. High strength low alloy steel

High strength low alloy steel has better mechanical properties and corrosion resistance than ordinary low alloy steel. Low alloy steel is made through a process of management, both softened and normalized. Because of its low carbon content this steel is relatively soft and tough, making it easier to form and weld. Silisium, manganese, nickel, chromium are added in this steel as alloying elements with a total amount not exceeding 5%. These elements form a solid solution with ferrite which increases the strength of the steel.

2. Ordinary low alloy steel

Ordinary low alloy steels generally contain at least 0.3% carbon which can be easily hardened. Because of the elements of nickel, chrom, manganese and molybdenum, this steel has good hardening properties. When hardened and tempered until certain hardness or if all of them have a martensitic structure, then these steels have symptoms that show the same mechanical properties as ordinary carbon steel with the same carbon content.

2.1.3 AISI 4140 Steel

AISI 4140 steel is medium carbon steel which is very widely used in the industrial world which contains carbon of 0.38% -0.43% C, and with its carbon content it allows steel to be hardened by working on appropriate heat treatment such as . In addition, AISI 4140 steel is also very suitable given hardening heat treatment when compared to other steels such as low carbon steel and high carbon steel.

2.1.4 ASSAB 705Steel

Steel assab 705 is medium carbon steel which is very widely used in the industrial world containing carbon in the amount of 0.38% -0.43% C, and with its carbon content allowing steel to be hardened with the appropriate heat treatment such as hardening . In addition steel asssab 705 is also very suitable given hardening heat treatment when compared to other steels such as low carbon steel and high carbon steel.

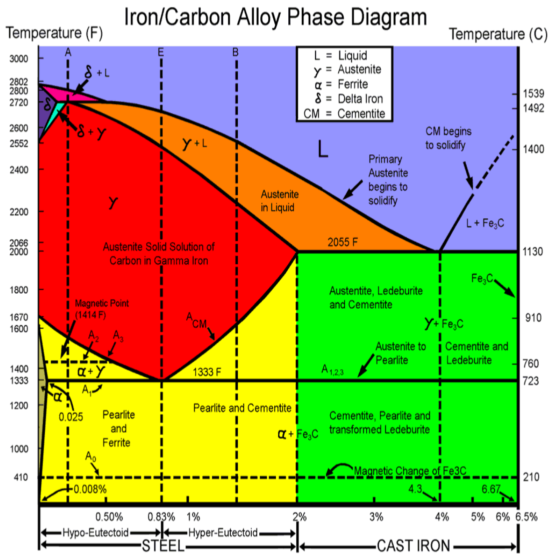

Figure 1. Diagram of Iron-Carbon Balance

2.1.4. Microstructure of Steel

1. Diagram of Iron-Carbon Balance

The Iron-carbon (Fe-C) diagram is a map that can be used to chart the proper sequence of operations for a given heat treatment [3]. The iron-carbon equilibrium diagram is a picture that should be used as a basis for carrying out heat treatment. The use of this diagram is relatively limited because some heat treatment methods are used to produce unbalanced structures. However, knowledge of phase changes in balanced conditions gives basic knowledge to heat treatment. In the Fe-C diagram material containing carboms below 2% is a major concern in the heat treatment of steel. Carbon content of more than 2% is classified as cast steel. The steel heat treatment method is based on austenite phase changes in the Fe-C system. The austenite transformation during heat treatment to other phases will determine the microstructure and properties obtained in steel [4].

2. Changes in the Iron Carbon Phase

Changes in the Fe-C phase that occur can be seen in the Fe-C phase diagram, some phase changes are ferrite (α-Fe), austenite (γ-Fe), cementite, pearlite and martensite phase changes.

2.2. Heat Treatment

Heat treatment of steel is the process of heating steel to a certain temperature and for a certain period of time followed by a cooling process according to a certain cooling rate to obtain the desired properties within the limits of the steel capability which are different from the original properties [7]. Heat treatment is the process of heating or cooling a metal or metal alloy to change the desired mechanical properties of the steel. Steel can be hardened so that it is resistant to wear and the cutting ability increases or can be softened to facilitate further machining. From the explanation above, it can be defined as heat treatment is the process of heating or cooling an alloy metal to change its mechanical properties in a solid state. The following are some types of heat treatment in steel, i.e:

1. Anealing
2. Normalizing
3. Hardening
4. Tempering

2.3. Cooling Media

Cooling media is a medium used to cool test specimens after undergoing a heat treatment process. To cool the material known for a variety of materials to obtain even cooling, the coolant is almost all circulated. Some cooling media used to cool the test specimens in this study are as follows:

1. Water

Water is a medium that is very widely used for quenching, because of its low cost, easy to use and fast cooling. Water is especially used in low carbon steel which requires a rapid decrease in temperature in order to obtain good hardness and strength.

2. Oil

Oil as a cooling medium is softer when compared to water. Used in critical materials, including materials that have thin parts or sharp edges.

3. Salt solution

Salt water is a medium that is often used in quenching processes especially for tools made of steel. Some of the advantages of using salt water as a medium are :

a. The temperature is evenly distributed in salt water.
b. The cooling process is evenly distributed on all metal parts.
c. There is no danger of oxidation, carburizing or decarburization during the cooling process.

2.4. Metal Mechanical Properties

The mechanical properties of a metal are the ability or behavior of a metal to withstand the loads imposed on it, either static or dynamic loading at ordinary temperatures, high temperatures or temperatures below 0^0 [7]." The mechanical properties of metals include stiffness, strength, elasticity, tenacity, brittleness, softness, toughness, and flexibility [1]. To find out the mechanical properties of a material it is necessary to do mechanical tests, as for mechanical testing commonly carried out including; Hardness testing, tensile testing, impact testing.

2.5. Test of Violence

Hardness is a measure of the resistance of a material to localized plastic deformation (eg "small indentation" or scratch) [2]. The previous hardness test was Mohs hardness test, based on the scale of the material's ability to scratch other materials (from 1 = talk to 10 = diamond).

a. Brinell Hardness Testing
b. Vickers Hardness Testing
c. Rockwell Hardness Testing

The following table converts the price of the hardness of a material.

Table 1. Violence Value Conversion Table

Hardness Conversion Table				
Tensile Strength (N/mm^2)	Brinell Hardness (BHN)	Vickers Hardness (HV)	Rockwell Hardness (HRB)	Rockwell Hardness (HRC)
285	86	90		
320	95	100	56,2	
350	105	110	62,3	
385	114	120	66,7	
415	124	130	71,2	
450	133	140	75,0	
480	143	150	78,7	
510	152	160	81,7	
545	162	170	85,0	
610	181	190	89,5	
640	190	200	91,5	
675	199	210	93,5	
705	209	220	95,0	
740	219	230	96,7	
770	228	240	98,1	
800	238	250	99,5	
820	242	255		23,1
850	252	265		24,8
880	261	275		26,4
900	266	280		27,1
930	276	290		28,5
950	280	295		29,2
995	295	310		31,0
1030	304	320		32,2
1060	314	330		33,3
1095	323	340		34,4
1125	333	350		35,5
1155	342	360		36,6
1190	352	370		37,7
1220	361	380		38,8
1255	371	390		39,8
1290	380	400		40,8
1320	390	410		41,8
1350	399	420		42,7
1385	409	430		43,6

Hardness Conversion Table				
Tensile Strength (N/mm^2)	Brinell Hardness (BHN)	Vickers Hardness (HV)	Rockwell Hardness (HRB)	Rockwell Hardness (HRC)
1420	418	440		44,5
1455	428	450		45,3
1485	437	460		46,1
1520	447	470		46,9
1555	456	480		47,7
1595	466	490		48,4
1630	475	500		49,1
1665	485	510		49,8
1700	494	520		50,5
1740	504	530		51,1
1775	513	540		51,7
1810	523	550		52,3
1845	532	560		53,0
1880	542	570		53,6
1920	551	580		54,1
1955	561	590		54,7
1995	570	600		55,2
2030	580	610		55,7
2070	589	620		56,3
2105	599	630		56,8
2145	608	640		57,3
2180	618	650		57,8

3. METHODOLOGY

The research method that I use in this study is a descriptive comparative method using a quantitative approach. Research using a comparative study method is done by comparing equations and differences as a phenomenon to find out what factors / situations that can cause a particular event to arise. This study begins by holding a collection of facts about the factors that cause a particular symptom to arise, then compared. After knowing the similarities and differences in causes, then it is determined that something that causes the appearance of a symptom in the object under study, that is what actually causes the appearance of these symptoms. The other way is to compare the factors or variables which most influence the changes that occur in the results of the research being carried out. So the researchers wanted to analyze the hardness ratio of ASSAB 705 steel and AISI 4140 steel with hardening heat treatment using oil cooling media.

The object of the research is steel ASSAB 705 and steel AISI 4140 with the size as in figure 2.

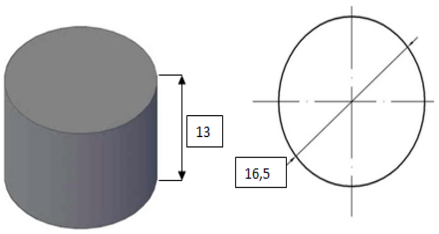

Figure 2. Test specimens

4. RESULTS AND DISCUSSION

4.1. Research result

Based on the results of research using Universal Hardnes Tester with Brinell method for steel assab 705 and Rockwell C hardness testing methods for AISI 4140 steel (Use of Rockwell C method because the hardness value of the material tested is more than 400 BHN (Brinell Hardness Number)), and has been analyzed, the data illustrated in the form of Table 2 and Figure 3 are obtained.

Table 2. Value of Assab Steel Hardness 705

Material	Specimen 1	Specimen 2	Specimen 3
Steel assab 705 (in Brinell)	370	382	370
	382	382	395
	359	395	370
	370,3	386,3	378,3

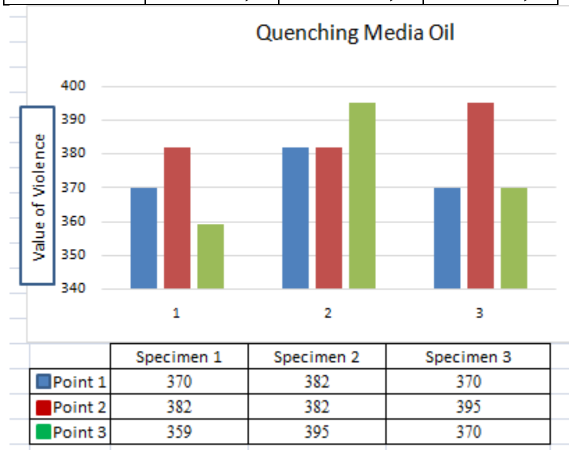

Figure 3. Graph of hardness values of Brinell steel specimens asssab 705 with quenching media oil.

For AISI 4140 Steel Material obtained the value of hardness in Rockwell C.

Table 3. Value of Hardness of AISI 4140 Steel

Material	Specimen 1	Specimen 2	Specimen 3
AISI 4140 (in Rockwell C)	50	50	50
	50	49	51
	51	50	50
	50.3	49.7	50.3

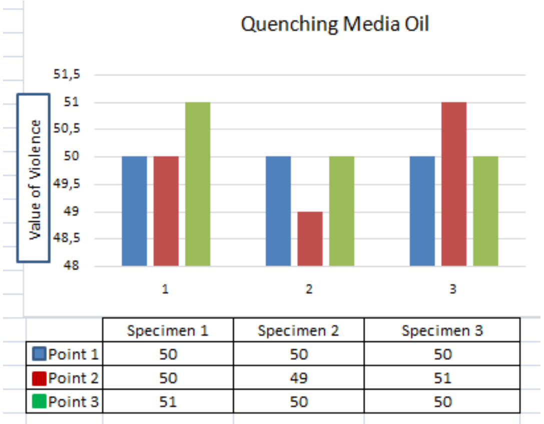

Figure 4. Graph of Rockwell C Hardness Value AISI 4140 steel specimen with Quenching Media Oil.

Based on Table 1 the value of hardness conversion, then the hardness value of AISI 4140 steel from Rockwell C to Brinell based on the closest value, is shown in Table 4.

Table 4. Value of Hardness of AISI 4140 Steel

Material	Specimen 1	Specimen 2	Specimen 3
AISI 4140 (in Brinell)	485	485	485
	485	475	504
	504	485	485
	491,3	481,7	491,3

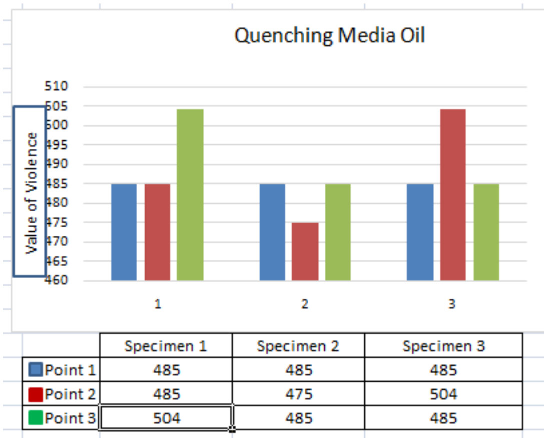

Figure 5. Graph of Brinell Hardness Value AISI 4140 steel specimen with Quenching Media Oil.

In Figures 3, 4 and 5 show that the hardness value of specimens that have been given hardening heat treatment and then quenched with oil media after the hardness test has a hardness value at each test point that is not much different between specimen 1, specimen 2, and specimens 3. For each specimen that has been given hardening heat treatment and quenched with oil media, each specimen is tested by three test points..

After that a comparison is made between Table 2 and Table 4. This comparison is a comparison of steel assab 705 and steel AISI 4140. The results obtained that steel AISI 4140 has a higher level of hardness. This is evident from the average hardness value of AISI 4140 Steel in specimen 1 amounted to 491.3, specimen 2 was 481.7, specimen 3 was 491.3. While Steel Assab 705 in sepesimen 1 has a hardness value of an average of 370.3, specimen 2 of 386.3, specimen 3 of 378.3.

4.2. Discussion

The test results showed that AISI 4140 steel had a higher hardness value than steel assab 705. This was seen from the average value of AISI 4140 steel hardness that was above 480 BHN - 492 BHN. Whereas steel assab 705 has an average strength value between 370 BHN-386 BHNs. AISI 4140 steel which experiences hardening heat treatment has good quality for medium carbon steel. For medium carbon steel hardening treatment is always increasing. The increase in the price of violence depends on the type of tool and the length of the heat treatment process.

5. CONCLUSION

The results of this study concluded that AISI 4140 steel has a higher hardness value than steel assab 705 which has been given hardening heat treatment using oil cooling media.

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