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Hot Rolled Plate Steel Local Thick 10 mm with Quench and Temper Process

[1, 2]Achmad Taufika, [1]Pratiktoa, [1]Agus Supraptoa and [1]Ahmad As'ad Soniefa
[1]Department of Mechanical Engineering, Faculty of Engineering, Universitas Brawijaya, Malang, Indonesia
[2]FTI National Institute of Technology, Department of Mechanical Engineering,, Malang, Indonesia

Abstract: Hardness is a phenomenon observed in the steel of HRPS. This study, conducted by heat treatment of quench and temper by analyzing the hardness of a material, using hardness test tester. Violence is identified from the nature of the changes indicated by the hardness test data. The results show that there is increasing violence which influence due to heating rate. The quench-temper heat treatment process on the HRPS steel has a clear effect on structural changes and mechanical properties of the HRPS armor.

Key words: Hardness, heat treatment, quench, tester, hardness, structural change, HRPS

INTRODUCTION

Steel globally accepted as the material used mainly for the construction of military vehicles and non-military. This is due to the features associated with steel, such as high energy absorption properties, high strength, toughness greater notch and high hardness (Krauss and Hadar, 1999; Lee and Su, 1999; Mohandas and Reddy, 1996). Selection of the appropriate armor materials for defense applications is very important in relation to the increased mobility of the system as well as maintaining safety.

Stainless armor steel protectiveis used to prevent damage to an object, individual or vehicles with direct contact or projectile weapons, usually during combat or of damage caused by potentially dangerous environments or actions outside the control [https://en, wikipedia.org/wiki/Armor]. In other words that the steel armor is steel that can protect an object (or another person) to attack projectile (bullet) because the steel is widely used in military purposes (such as combat vehicles and others). In order to withstand the impact of projectiles then the steel armor must have toughness (which is a combination of strength, plasticity and hardness) were good. One of the steel has good toughness is Quenched and Tempered steel or Q&T steel, the steel is obtained by treating thermal quenching and tempering in heat treatable steel.

Q&T steel is a steel produced from hot rolled steel plate (HRP steel)which diaustenisasi then quench with water to rise right media violence and followed by tempering to obtain plasticity (ductility). The results of that process is steel that has high hardness and strength and then is later called steel armor steel (steel armor).

HRP steel is a heat treatable steel which can be made by the son of Indonesia (PT Krakatau steel). To obtain a high hardness and strength then steel HRP heat treated quenching (by heating until the temperature austenitic and detained for a few moments and then cooled with water media), the result is called the high hardness steel Quenched steel HRP (QHRP steel). Then QHRP steel is heat treated tempering (by heating until certain temperature below the line eutectoid and arrested some time later cooled with medium atmospheric air) to improve Plasticity (ductility), the result is a steel high hardness clay called Q&T HRP Steel or Q&T steel but the Q&T steel still has the violence not optimal because their structure austenitic that is not transformed into martensite completely. Besides the process quenching large objects much experience problems temperature decrease austenitic when entering the quencher water, so that, violence is not the maximum.

The novelty of this study is the violence caused by changes in temperature austenite grains through the line closest to the transformation Ar_3. The problems that arise in this research is how to increase the hardness and impact toughness of hot roll steel plate reached ≥500 BHN?

MATERIALS AND METHODS

Ballistic performance steel armor is based on the hardness, the higher the hardness, the better ballistic performance. The main consideration is the use of steel in the military is the resistance to penetration and light (Mohandas and Reddy, 1996). While the optimum properties steel armor are determined by the toughness and yield strength. Armor steel types of quenched and

Corresponding Author: Achmad Taufika, Department of Mechanical Engineering, Faculty of Engineering, Universitas Brawijaya, Malang, Indonesia

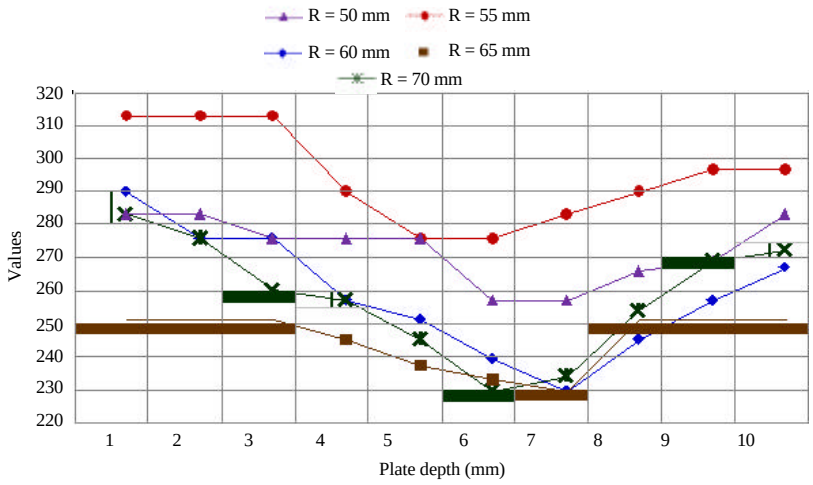

Fig. 1: Hardness vs. HRP bending radius steel

tempered steels widely used in highly stressed structures such as hull and turret combat vehicles (Mohandas *et al*., 1999). Quenched stainless limits the strength and the highest hardness but lower ductility. Distortion occurs during the formation of martensite platelets which leads to an increase in strength and hardness (Lee and Su, 1999). To maintain the strength of quenched martensite (hard), industrially performed tempering at temperatures between 150-200°C (Krauss and Hadar, 1999).

Steel is a polycrystalline substance containing various microstructure as austenitic before, martensite and the grain boundary feritic (Ooki, 2004). Martensite can be formed if the steel in austenitasi and cooled at a rate high enough to avoid the formation of ferrite, pearlite and bainite as stated in diagram line continuous cooling transformation (Silva *et al*., 2004). Due to the high hardness, strength and weight ratios are high and good toughness, Q&T steel is widely used in the military (Magudeeswaran *et al*., 2008). In addition, the steel must have ballistic properties and good mechanical (by a combination of strength, plasticity and hardness (Magudeeswaran *et al*., 2009). The increase in violence due to the structure martensite full which is only determined by the content of carbon (low-carbonsteel) and is equal to the maximum hardness of steel (Nishibata and Kojima, 2013).

The microstructure is a major factor affecting the hardness when fully austenitizing with increased speed and reduced temperature cooling phase transitions, micro hardness increases gradually (Xiao-Nan *et al*., 2012). Refining the microstructure in the quenched and tempered martensitic steel is expected to increase its strengthm (Fig. 1).

This research method using a quench-tempering temperature variation. Factors that affect the mechanical properties of medium carbon steel such as:

Table 1: Chemical composition of sheet material (mass %)

Variables	Values
Al	0.03780
C	0.29340
Cr	0.55030
Cu	0.08330
Fe	96.7625
Mn	1.41210
Mo	0.19300
Ni	0.27870
P	0.01420
Pb	0.00820
S	0.00810
Si	0.32980
Sn	0.00340
Ti	0.00440
V	0.01470
W	0.00950

Table 2: Hardness values seel hot rolled plate

The test object code	VHN_1	VHN_2	VHN_3	-
HN_{HRC}	248.60	278.33	298.73	275.220

- Material
- Heating temperature
- Holding time
- The cooling medium

Variable response:

- Medium carbon
- Steel hardness

The independent variable/controllable factors:

- HRPS steel material
- Quench temperature of 700, 750, 800, 850, 900°C
- Holding time 30 min

Materials research:

- Hot rolled plate steel
- Chemical composition of hot rolled plate steel (Table 1 and 2)

RESULTS AND DISCUSSION

From the test results HRPS thick steel plate bending 10 mm, the size of the specimen 120×15 mm and the bending process is shown Table 3.

Figure 2 shows the difference in the hardness value of each bending region. Hardness testing before getting a quench-tempering treatment of 315 HV depth of 3 mm on the sample bending radius of 55 mm and the lowest in the sample bending radius of 70 mm to 251 HV hardness at the same depth that is 3 mm from the curved surface.

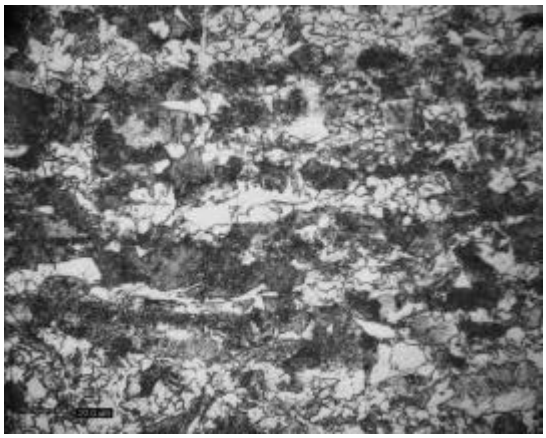

Fig. 2: Micro structure hot rolled steel plate

Table 3: Hardness vs. radius bending HRP steel

	Hot Rolled Plate steel (HRP steel) (mm)				
Distance (mm)	50	55	60	65	70
1	290	313	283	283	251
2	276	313	276	283	251
3	276	313	260	276	251
4	257	290	257	276	245
5	251	276	245	276	237
6	239	276	229	257	233
7	229	283	234	257	229
8	245	290	254	266	251
9	257	297	269	269	251
10	267	297	272	283	251

Table 4: Hardness vs. radius bending THRP steel

	Tempered Hot Rolled Plate steel (THRP steel) (mm)				
Distance (mm)	50	55	60	65	70
1	272	348	297	313	290
2	272	348	290	305	276
3	274	339	283	309	263
4	274	330	276	297	257
5	257	276	257	305	234
6	239	321	245	269	221
7	239	321	229	269	221
8	248	313	251	279	237
9	266	317	263	313	257
10	276	317	283	313	290

From the test results of bending steel plate HRPS 10 mm thick, the size of the specimen 120×15 mm and process tempering is shown as in following Table 4.

Tempering results showed the highest hardness value of 348 HV on a bending radius of 55 mm at a depth of 2 mm from the curved surface. And the lowest in the sample bending radius of 70 mm to 276 HV hardness (Fig. 3).

From ^^ the test results of bending steel plate HRPS 10 mm thick, the size of the specimen 120×15 mm and the quench is shown as in the following Table 5.

It is the result of hardness test after quench process showed the hardness of steel armor thickness of 10 mm, the sample bending radius of 60 mm at a depth of 9 mm from the curved surface hardness reaches 498 HV (Fig. 4).

From the test results of bending steel plate HRPS 10 mm thick, the size of the specimen 120×15 mm and the quench and tempering is shown as in the following Table 6.

The curve of the changes the temperature of the workpiece when it is cooled or quench of temperature hardening. To obtain the desired hardness quenching process is carried out. The result shows the behavior of the material after quench and tempering process changes significant violence on the bending radius of 70 mm reaches 498 HV at a depth of 8-10 mm (Fig. 5).

Table 5: Hardness vs. radius bending QHRP steel

	Quenched Hot Rolled Plate steel (QHRP steel) (mm)				
Distance (mm)	50	55	60	65	70
1	389	384	413	413	413
2	385	384	413	389	419
3	413	358	413	401	419
4	413	358	439	389	419
5	413	389	446	403	403
6	413	413	453	395	395
7	413	419	453	407	389
8	413	419	482	419	413
9	413	413	498	439	426
10	413	401	482	439	419

Table 6: Hardness vs. radius bending Q&THRP steel

	Quenched Hot Rolled Plate steel (QHRP steel) (mm)				
Jarak (mm)	50	55	60	65	70
1	450	453	426	4398	498
2	450	453	444	439	498
3	453	453	444	439	495
4	453	453	453	439	495
5	453	450	453	453	489
6	453	463	467	446	495
7	453	467	475	482	475
8	467	464	490	482	498
9	467	464	498	482	498
10	460	460	490	482	498

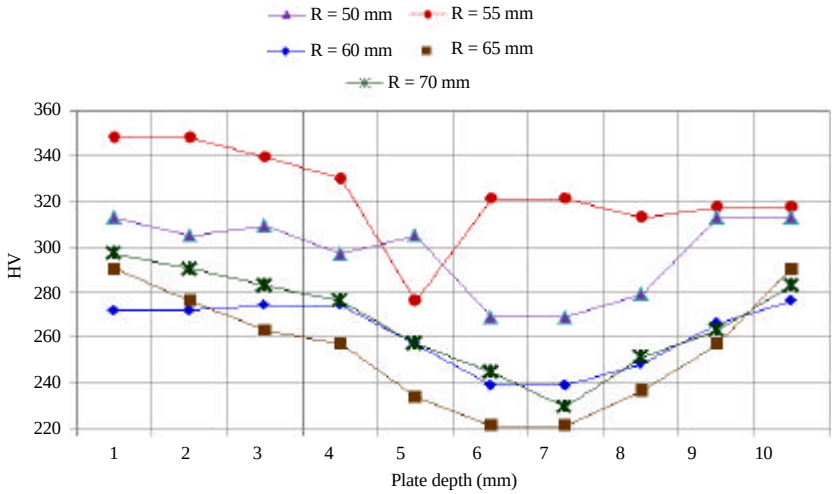

Fig. 3: Hardness vs. THRP bending radius steel

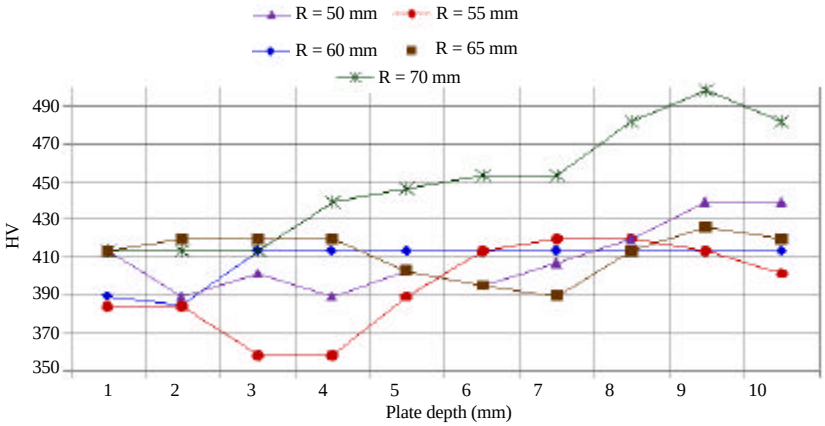

Fig. 4: Hardness vs. QHRP bending radius steel

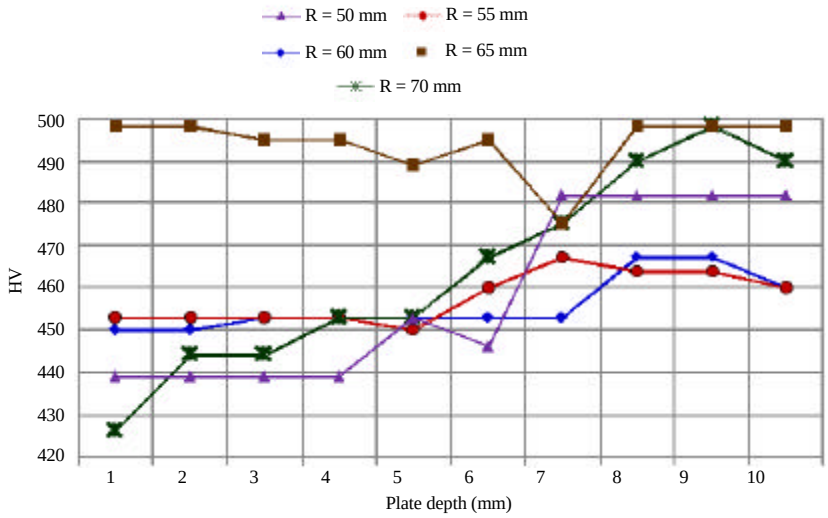

Fig. 5: Hardness vs. radius bending Q&T HRP steel

CONCLUSION

Bending test performed on specimens of steel armor with different treatment of quench and tempered of each specimen to get different results because of the warming caused damage to the microstructure of the metal material, so that, the process of making the walls of the tanks should minimize the heating process. Armor steel bending process will produce plastic deformation during bending is eliminated there will be changes in the shape and surface irregularities of the die used for suppression. This is because the plate has elastic properties, so that, some deformation will be a little bit back at a certain position. The heat treatment process always begins with the transformation of the austenite decomposition into other micro. Selection of media quench to harden the steel armor depending on the cooling rate is desirable in order to achieve a certain hardness, the behavior of the material after the quench and tempering undergo hardness changes significantly at the bending radius of 70 mm reaches 498 HV at a depth of 8, 9 and 10 mm.

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