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9 Oktober 2020 02.21

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**ANALYSIS OF COIL DIMENSIONAL ON INDUCTION HEATING MACHINE AGAINST MICROSTRUCTURE AND HARDNESS DISTRIBUTION AS NEW CANDIDATE OF PROJECTILE RESISTANT STEEL PLATES MATERIALS.docx**

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10 Oktober 2020 11.06

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Dear Editors!

Please find enclosed for your review an original research article, "Analysis of coil dimensional on induction heating machine against microstructure and hardness distribution as new candidate of projectile resistant steel plates materials" by Helmy Purwanto, Mohammad Tauviqirrahman, Muhammad Dzulfikar, Rifky Ismail, Purnomo and Ahnas Syifauddin, All authors have read and approved this version of the article. No part of this paper was published or submitted elsewhere. No conflict of interest exists in the submission of this manuscript. We appreciate your consideration of our manuscript for possible publication in the "Eastern-European Journal of Enterprise Technologies", and we look forward to receiving comments from the reviewers

On behalf of all authors of this manuscript,

Helmy Purwanto

[Kutipan teks disembunyikan]

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5 November 2020 11.01

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Helmy Purwanto <helmypurwanto@unwahas.ac.id>

10 November 2020 12.05

Kepada: Oksana Nikitina <0661966nauka@gmail.com>

Dear Ms. Oksana Nikitina

Greetings healthy,

In the following, we include the articles that we have revised according to the reviewers' suggestions and input.

I hope you get good news soon.

Best regards

Helmy Purwanto

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18 November 2020 16.58

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Greetings healthy,

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Best regards

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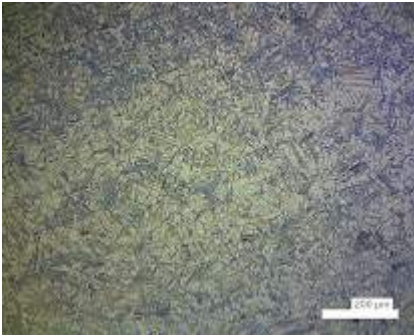


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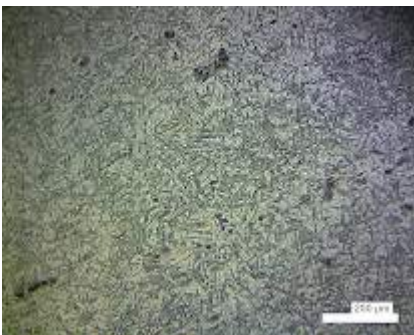


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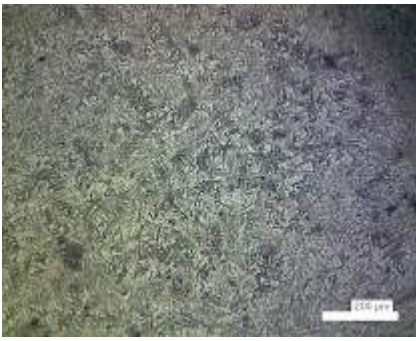


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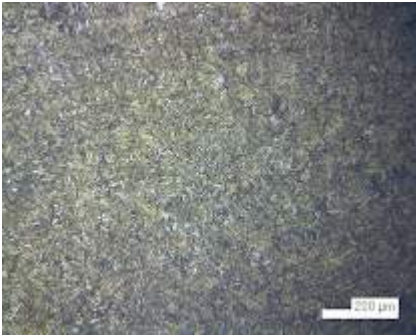
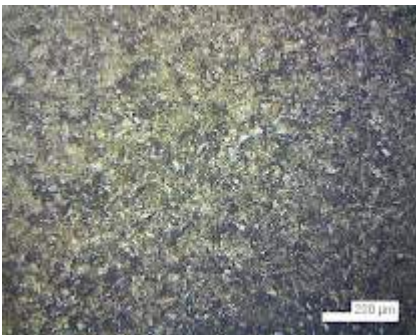


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19 November 2020 12.14

Received, thank you.

чт, 19 нояб. 2020 г., 6:27 Helmy Purwanto <helmypurwanto@unwahas.ac.id>:
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16 November 2020 02.38

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Oksana Nikitina

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17 November 2020 02.16

Kepada: Oksana Nikitina <0661966nauka@gmail.com>

Good morning, Dear Oksana Nikitina

We send the revised results according to the comments of the reviewers.

I hope we have some good news soon.

always healthy greetings from Indonesia.

Best regards

Helmy Purwanto

[Kutipan teks disembunyikan]



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Oksana Nikitina <0661966nauka@gmail.com>

17 November 2020 18.13

Kepada: Helmy Purwanto <helmypurwanto@unwahas.ac.id>

Thank you very much.

пн, 16 нояб. 2020 г. в 21:16, Helmy Purwanto <helmypurwanto@unwahas.ac.id>:

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21 Desember 2020 16.38

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Kepada: Oksana Nikitina <0661966nauka@gmail.com>

Dear Ms. Oksana Nikitina

Thank you, we think it is correct and can be published. but if you wish to improve Figure 2. Specimens for microstructure and microhardness tests (attached)

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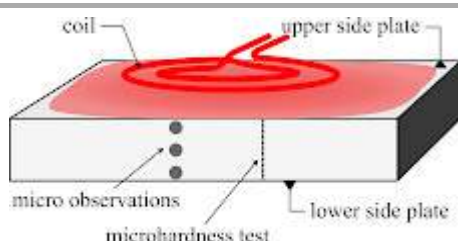


Figure 2. Sample.jpg

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21 Desember 2020 20.29

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Salam hangat,



M. Dzulfikar

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Дата подачи: 09.10.2020

Дата принятия:

UDC 621

ANALYSIS OF COIL DIMENSIONAL ON INDUCTION HEATING MACHINE AGAINST MICROSTRUCTURE AND HARDNESS DISTRIBUTION AS NEW CANDIDATE OF PROJECTILE RESISTANT STEEL PLATES MATERIALS

Helmy Purwanto, Mohammad Tauviquirrahman, Muhammad Dzulfikar, Rifky Ismail Purnomo, Ahnas Syifauddin

The field of defense and security required ballistic resistant materials for self-protection. Ballistic resistant materials must be able to withstand projectile spin rate and absorb impact energy. A combination of hardness on the surface and ductility on the other side is required to make the projectile resistance plate. Hardness is required to withstand the projectile rate, while ductility is required to reduce cracking, brittle fracture and absorption of impact energy. The objective of this study is to find the effect of the coil shape on microstructure and hardness distribution on the steel plate that is carried out by surface hardening using an induction machine. Medium carbon steel plate with the thickness 8 mm austenitized by using induction heating machine with coil dimension and shape variations. austenitized on the surface and rapid quenching in oil media are up to 900 °C. A micro-observation was conducted on quench plates and the hardness distribution on their cross-section. The results of microstructure observation and micro vickers hardness test of coil variation at diameter 5 mm and with the number of turns is 2 and 3 is microstructures on all sides formed martensite structure and equal hardness on the entire cross section, so that no surface hardening formed. Micro-observations showed martensite structure on the surface side and the ferrite and perlite structures are still visible on the middle and lower sides using 8 mm diameter coils and 2 turns. The maximum hardness is 497 HVN on the upper side surface and 257 HVN on the lower side surface using an 8 mm diameter coil and 2 turns. An increased hardness on one of the plate surfaces while maintaining the ductile on the opposite side can be proposed as a candidate for ballistic-resistant plate through further research

Keywords: heating coil, induction heating machine, surface hardening, hardness distribution, ballistic material

1. Introduction

Ballistic resistant material is really needed in the field of defense and security. Ballistic resistant material is used to protect ourselves from the enemy attacks, whether it is in the form of projectiles or other weapons with a very high velocity impact. Steel plate is one of the materials used as ballistic resistant material (armor). Armor steel plate is used to build military vehicles including tanks and other military tactical vehicles. The demand and need for armor plates is still very high until now. Ballistic resistance is continuously improved through material engineering and construction design.

In materials engineering, ballistic resistance is a complex combination of hardness, toughness and tensile strength [1]. The harder the steel, the more its ballistic resistance is, but the less impact energy absorption ability is target hardness is required to hold the projectile tip, while ductility is used to absorb impact energy. With the simulation, the maximum absorption of impact energy is able to withstand the projectile's rate when an impact occurs with the target [2]. Installing a hard material on one side and a ductile material on the other side is done to increase its ballistic resistance. Therefore, there have been many studies which have combined different types of materials in the form of layers or sandwich [3–5].

Improving the ballistic resistance through heating treatment has also been carried out. One of the materials is medium carbon steel whose hardness can be increased through quench heat treatment. Quenching is the hardening of steel by heating the material until it reaches austenite temperature and then followed by rapid cooling using cooling medium. As the hardness increases, the strength of the steel also becomes higher. Steel with high hardness has a weakness, which is decreased ductility so that it has brittle characteristics. Therefore, after conducting quenching process, it is followed by a tempering process to decrease the residual stress and increase ductility. Quenching process which is followed by tempering process has been widely used to improve ballistic performance in steel [1, 6–8].

2. Literature review and problem statement

Layered or sandwich panels manufacturing is done to increase the ballistic resistance and decrease the density. The paper [9] reported that to increase the ballistic resistance of steel plates, polyurea coating needs to be done. The addition of polyuria on the front side of the target plate indicates better ballistic performance compared to steel plates with low hardness. Polyurea also has capacity to absorb high energy, therefore it is considered a very good material for structural protection. The report [10] also added polyurea to the core of the sandwich plate and compared it to the rubber core. The results of ballistic testing with various levels of projectile velocity in a simulation show that the addition of polyurea cores can significantly improve ballistic performance compared to rubber cores. The best ballistic resistance performance was attained with metal – fabric layered structures [11]. A high strength steel plate is positioned on the front and lightweight, good impact absorbing aluminum was tested using a 7.62 mm projectile at a velocity of 800-850 m/s. Ballistic performance increases by 50%, while the density decreases by 25%

compared to single plate [12].

Layered or sandwich ballistic resistant plates have weakness in their manufacturing. Different types of materials cause difficulties in construction, especially in the manufacture of military vehicles. Damage to the first layer can lead to decreased resistance towards projectiles. The use of a layer material also causes an increase in thickness, so that the volume effectiveness decreases, even the density calculated also decreases.

Another reported ballistic-resistant material manufacturing is through quench heat treatment. The stability between the hardness and brittleness of the steel is affected by the austenizing temperature and the tempering temperature [13]. Quenching through oil media can increase the hardness and the hardness slightly decreases after the tempering process. The higher the temper temperature, the greater the decrease in hardness and increase the ductility [6]. The higher the temper temperature, the higher the projectile depth of penetration on the steel [14]. Austempered steels are more resistant to the Adiabatic Shear Band (ASB) formation during high velocity impact deformation, consequently slowing the cracks initiation and propagation of ASBs [7]. High hardness has an effect on increasing vulnerability. This will also affect the decrease in ballistic resistance.

Single plate with both high hardness and high ductility at the same time continues to be studied to further improve its ballistic resistance. One of the methods is surface hardening. The plate was hardened on one side, while the other side is left to remain soft and ductile. Such surface hardening method is usually applied to wear-resistant components.

There are not many report on the manufacture of ballistic-resistant plates by surface hardening with quench heat treatment, one of them which has been done is through surface strengthening. Surface hardening through surface strengthening by carburizing and boronizing the medium carbon steel can improve the ballistic resistance and is able to exceed the ability of wear-resistant steel [15]. Case hardening increases perforation resistance by more than 20%, and is able to reduce the capacity compared to layered plate manufacturing [16].

Surface hardening can also be done by heating using induction heating machine. This machine is able to heat the steel until it reaches austenite temperatures in a very short time. Many studies have been conducted to improve heating efficiency using coil wire shapes and styles for wear-resistant steel applications. The use of induction heating machine with certain coil shapes and sizes is able to heat up to austenite temperatures in a very short time. The efficiency of induction can be maximized by the number of turns multiplied by the number of strands [17]. The multi-layered coil provides a high heating speed and better heat distribution than conventional single-layered coils [18]. The coil design must be adapted to the heated shape and object. The electromagnetic induction power is affected by the amount of current and resistance in the coil. The greater the current and the smaller the resistance, the greater the induction power. Furthermore, other than the shape and size of the coil, the shape of the work piece also affects the heating speed, in which the thicker work pieces, the slower the heating process which results in rapid heat dissipation after the induction heating [19].

The manufacture of ballistic-resistant materials using layered or sandwich method is inhibited on the manufacturing and volume, while the hardening process decreases the toughness and increases the brittleness. The potential for making ballistic-resistant materials by surface hardening is still open and needs to be studied further.

To increase ballistic resistance on steel plates is surface hardening. Surface hardening on steel plate through surface heat treatment process. The front surface of the plate with high hardness is able to hold and break the tip of the projectile. Meanwhile, the middle and back sides need high ductility to prevent the growth of cracks and brittle fractures and to be able to absorb impact energy.

Surface hardening with is generally applied to wear-resistant materials. Plate surface hardening for ballistic-resistant materials has not been much found. Due to the surface hardening on the relatively thin and wide as on a plate media, it is difficult to obtain. Austenizing speed is required on the thin and wide surface, while on the other side it is maintained. The shape and dimensions of the coil affect the amount of current resistance and the resulting frequency. This will affect the speed of heating time to the desired temperature. Shorter time is needed to reach the austenizing temperature on the surface, while the other parts and sides have not yet reached the austenizing temperature. In such condition, if a rapid quench process is done, then the microstructure changes and the hardness can vary. The shape of the sample in the form of a relatively thin plate requires the right parameters, so that the hardening of one surface can be maximized, while the ductility on other parts and surfaces can be maintained.

3. The aim and objective of the study

To get the surface hardening of thin plates, proper austenization is required. It requires a surface heating rate and resists thermal conductivity to propagate on the other side of the surface. This needs to be moved to the previous section. This study aims to determine and analyze the effect of coil shape and size on the formation of martensite structures and the distribution of hardness in the cross-section of the plate with a thickness of 8 mm on commercial medium carbon steel. To accomplish the aim, we solved the following:

- Austenizing the medium carbon steel plate to temperatures of 900 °C by induction machine and rapid quench in oil medium
- Cross-sectional characterization using an optical microscope and a micro-hardness vikers tester and analyze it on each variable

4. Material and Methods

Commercial medium carbon steel plates with chemical composition as shown in Table 1 are cut with dimensions 130 x 130 x 8 mm. The steel plate is heated to austenitizing temperature (900 °C) by using an induction heating machine as shown in Fig. 1. Temperature change is monitored using a thermocouple and infrared thermometer on the surface. The induction machine is set at a maximum current of 1424 A. Install the heating coil on the induction machine. Vary the shape and size of the coil to get the heating rate and frequency on the machine display. Coil dimensions

and shapes used in this study are shown in table 2. If the austenitizing temperature obtained, then the sample is rapid quenching in oil media as much as 15 liters of oil in room temperature (30 °C).

Table 1

Commercial medium carbon steel plate chemical composition

Unsure	C	Mn	Cr	Ni	Si	Nb	Al	V	S
wt%	0.4667	0.5584	0.0556	0.0411	0.2441	0.0002	0.0163	0.001	0.0106
	Mo	W	P	Cu	Ti	N	B	Sb	Ca
	0.0013	0.0016	0.0195	0.0577	0.0044	0.0078	0.0002	0.0064	0.0003
	Mg	Zn	Co	Fe					
	0.0009	0.0004	0.0108	balance					

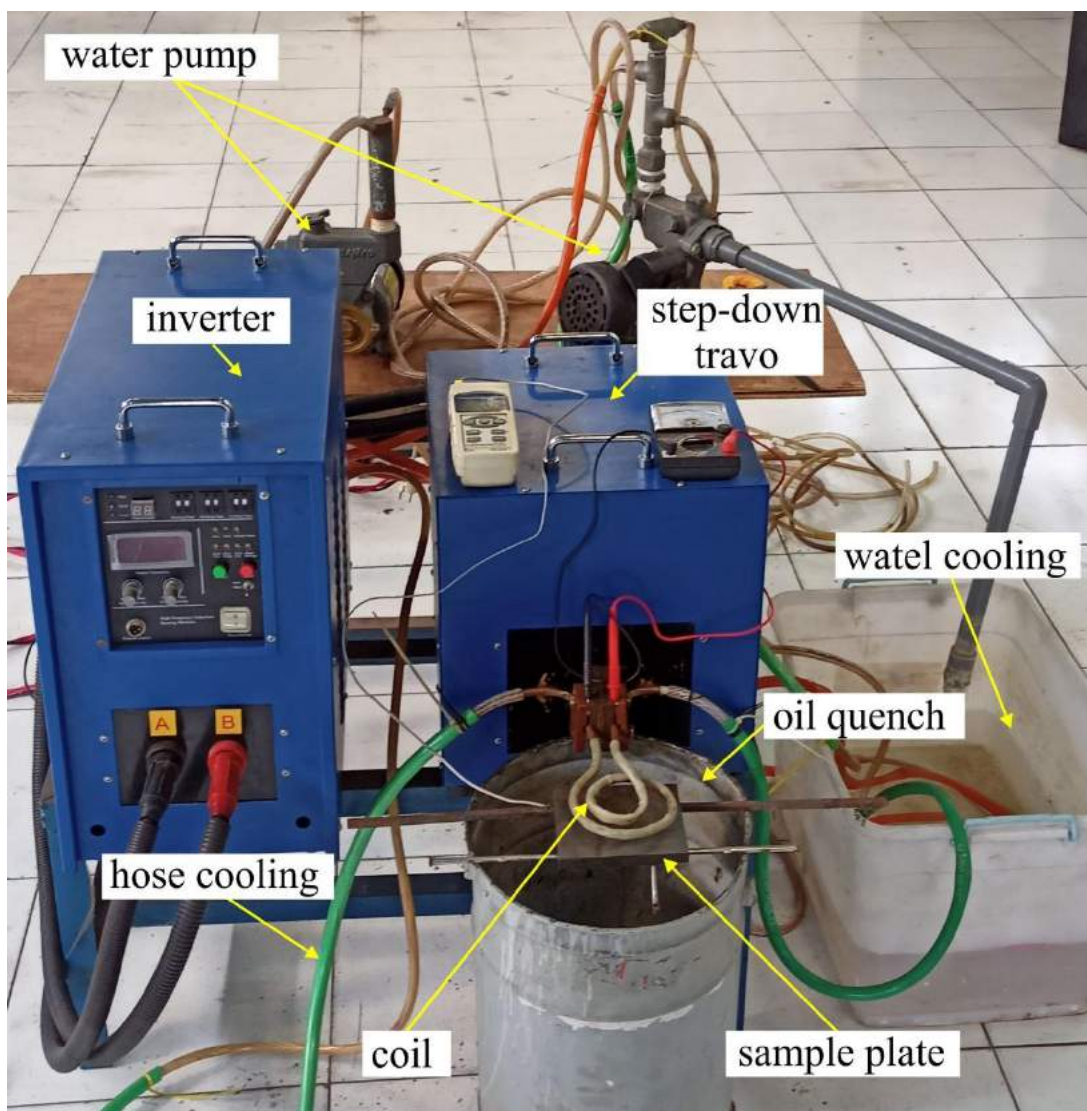





Fig. 1. Induction heating machine

Table 2

Variations in shape, size, and coil coding

Coil	Configuration Coil	Pipe	Coil	Number of
------	--------------------	------	------	-----------

Code		Diameter (mm)	Length (mm)	Turns
A		8	930	2
B		5	930	3
C		5	1120	2

To obtain the microstructure transformation and hardness distribution, observation and testing are done on the cross-section of the sample as shown in Fig. 2. The upper side is defined as the plate surface which is heated using an induction coil machine, while the lower side is defined as the plate surface which is not directly exposed to heat by the induction coil. To avoid damage to the sample during the cutting process, cut using a wire cutting machine. Each specimen was taken three different places. Each variation of the shape of the coil is repeated three repetition times.

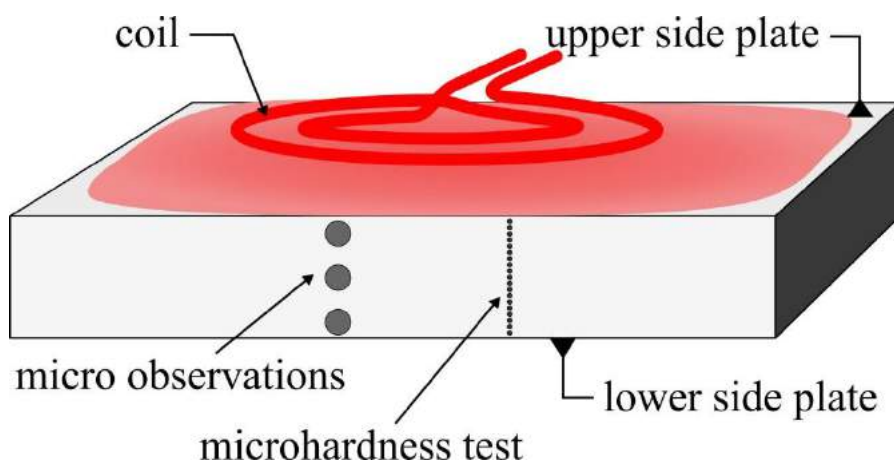


Fig. 2. Specimens for microstructure and micro hardness

The cross section was smoothed using sandpaper and etched using 2% nital for microstructure observation. The microstructure is observed at three points; those are on the upper, middle and lower side of the cross-section. The hardness distribution is carried out using micro vickers hardness as many as 20 points of the cross-section from the upper side to the underside or with the distance between points is 0.4 mm with load 0.5 N.

5. Result

This section should be divided into subsections – for each task set in section 3,

its own separate subsection. That is, if 2 tasks are set, there should be 2 subsections: 5.1, 5.2.

5.1. Frequency and heating rate

The results of using variations in the shape and size of the coil in an induction heating machine are shown in Fig. 3. The frequency generated by the engine is affected by the current resistance on the coil. While the resistance is influenced by the size and number of coil turns.

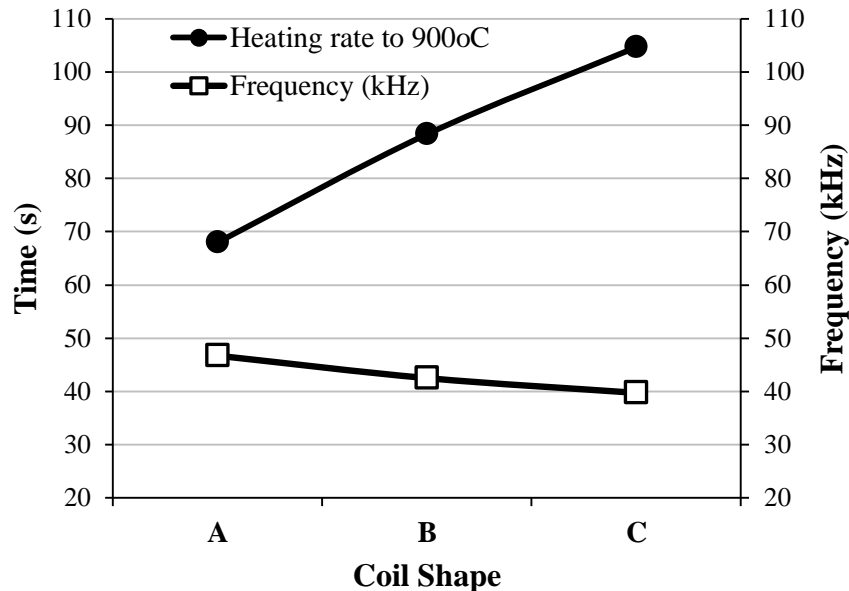


Fig. 3. The effect of the shape and size of the coil on the resulting frequency of the coil and the heating time up to 900 °C of the austenitizing temperature

The number of turns and coil dimensions that affect the resulting frequency. The measurement result on the coil A Have the highest frequency value which is 46.67 kHz. While coil B and C are 42.33 kHz and 39.67 kHz, respectively. The frequency produced by each coil is different, so the time to reach the temperature of the austenite in the sample is also different. Time to reach austenite temperature (900 °C) in coils A, B and C respectively: 68.00 s, 88.33 s and 104.67 s. From the measurement data of frequency and time measurements can be seen, the lower the frequency produced by the coil, the longer it takes to heat the sample to the temperature of the austenite.

5. 2. Micro Structure

The microstructure of the plate cross-section on the upper side, middle side and lower sides of each coil shape variable is shown in Fig. 5–7. Microstructural observations were made to see the transformation in each part and each sample variable. Microstructural changes due to rapid quench of the austenite phase can serve as the basis for mechanical changes.

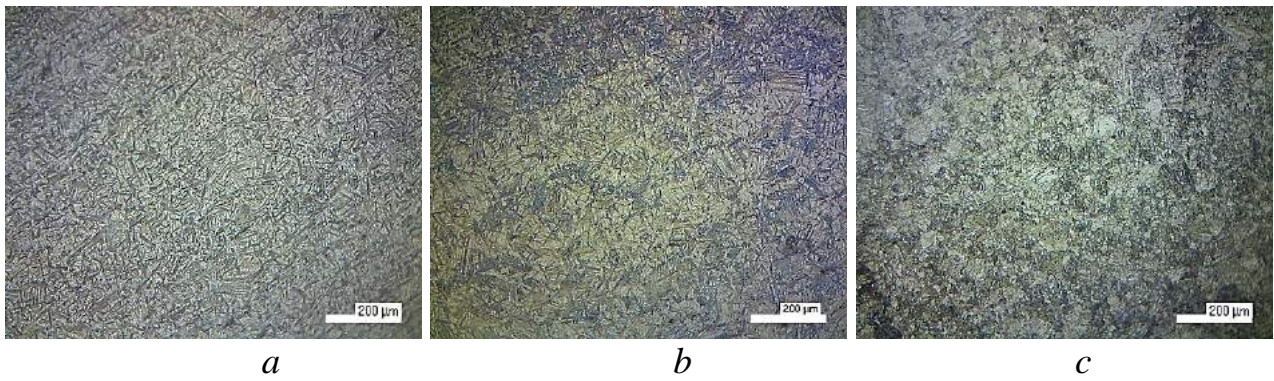


Fig. 5. The cross-sectional microstructure of the specimen using coil code A:
a – fine martensite structure on upper side; *b* – coarse martensite structure on middle side; *c* – coarse martensite and some of the remaining perlite and ferrite structure on lower side

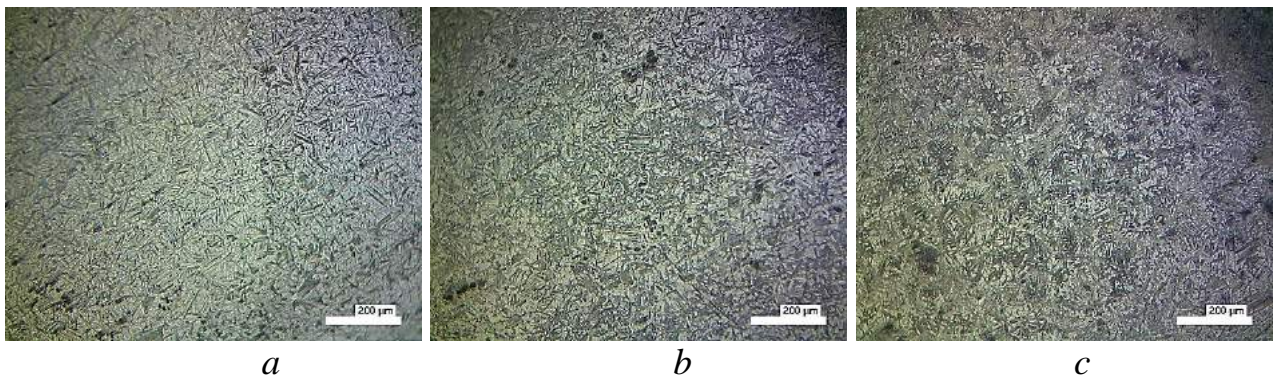


Fig. 6. The cross-sectional microstructure of the specimen using coil code B:
a – fine martensite structure on upper side; *b* – fine tends to be coarser martensite structure on middle side; *c* – coarse martensite structure on lower side

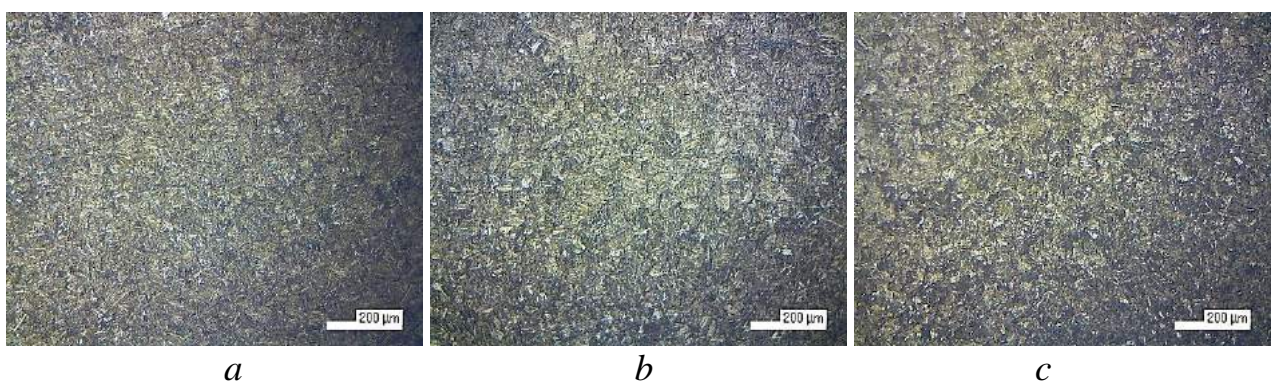


Fig. 7. The cross-sectional microstructure of the specimen using coil code C:
a – fine martensite structure on upper side; *b* – fine martensite structure on middle side; *c* – fine martensite structure on lower side

In specimens using coil code A, the microstructure formed on the upper side plate is a fine martensite structure (Fig. 5, *a*), while the middle side (Fig. 5, *b*) show coarse martensite structure and lower side (Fig. 5, *c*) tend to still be visible ferrite and

perlite structures. The use of coils with codes B and C, on all sides of the microstructure is a fine martensite structure.

5. 3. Hardness Distribution

The micro vickers hardness distribution on the plate cross-section of each variable coil is as shown in Fig. 8.

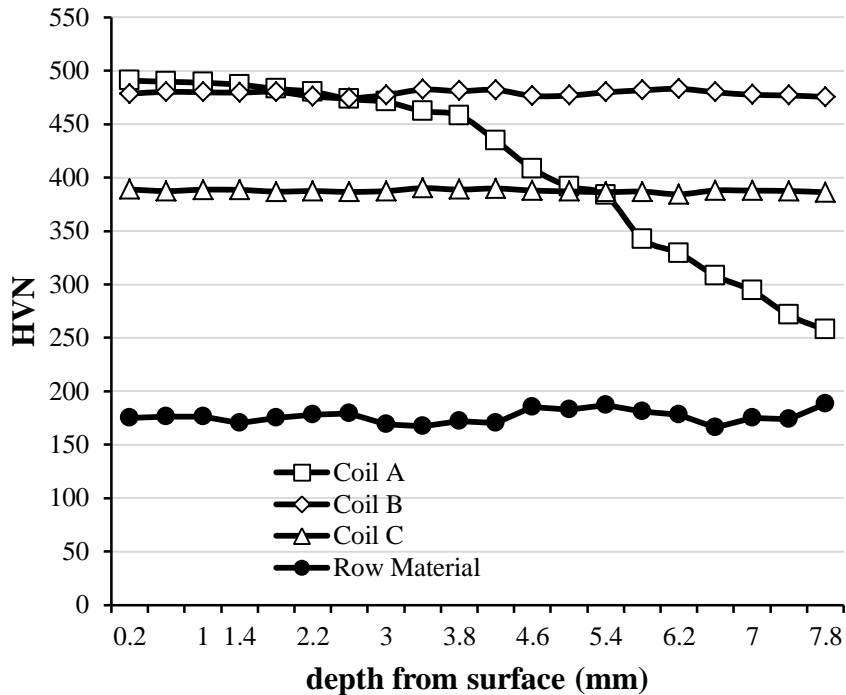


Fig. 8. The cross-sectional hardness distribution of the sample using variations in the shape and size of the coil.

The microstructure transformation of the sample that has been carried out by rapid quenching affects the hardness. After the rapid quenching process on the steel plate from the austenite temperature, there was an increase in the hardness of both the variable coil code A, B and coil code C. The increase in hardness was caused by the change in structure to martensite structure due to rapid cooling. In coils B and C, the distribution of roughness is relatively even from the upper side to the lower side. In coil A, the maximum hardness increases on the upper surface and the minimum hardness increases on the lower side.

6. Discussion of result

6. 1. Discusion of frequency and heating rate

The length of time to reach the austenite temperature is influenced by the frequency of the coil. The coil code A with a higher frequency value compared to coils code B and C. This is due to the shape and diameter of coil A are larger than coil code B and C so that the current resistance is the lowest [17]. Frequency affects the heating rate, the greater the frequency, the greater the heating rate. It takes 68

seconds to reach the austenitizing steel temperature of 900 °C for coil A. As for coil code B and coil code C, each 88 seconds and 104 seconds. The lower the current resistance, the higher the resulting frequency, and the greater the eddy current generated so that the heating is faster. The speed of temperature increases until it reaches the austenitizing temperature will greatly affect the hardness distribution and the microstructure that is formed. The velocity of reaching the austenitizing temperature at the plate surface is necessary to prevent the thermal conductivity from moving to the plate. The faster the austenitization occurs on the plate surface and the austenitizing temperature has not yet been conducted to the inner side and lower surface of the plate, then the sooner the plate quenching process. So that the austenitizing temperature only occurs on the surface of the upper side plate which near the coil, while on the inner or middle side and the lower of the plate surface there is no austenitizing temperature.

The frequency of induced current is influenced by the size of the current resistance in the coil. The lower the current resistance in the coil, the higher the working frequency of the induced current. When the working frequency of the induction is high, the concentration of eddy currents on the surface of the sample that is heated will not go deeper [21]. In other words, the heating will only occur on the surface. With a large frequency, the austenization of the sample only occurs on the surface close to the coil. This shows that the high frequency will give a high power density effect only on the edge or surface of a sample. And otherwise with low frequencies, will give the effect of power density that goes to the inside of a sample [22]. This is what causes surface hardening if the austenizing temperature has been reached on the surface and before heat conduction propagates into the core of the sample, a rapid quench process is carried out.

6. 2. Discussion of micro structure

The martensite structure that is formed tends to be needle-shaped martensite. The martensite structure formed tends to needle martensite, this is due to the medium carbon content in the sample [23]. This martensite is formed on steel with a carbon content of 0.4% C which is cooled by rapid quenching after austenitizing it. This martensite structure tends to be hard and brittle. Meanwhile, the middle and lower sides of the martensite are less visible. The structures seen on the middle and lower sides tend to be ferrite and perlite. These structures tend to be softer and more ductile. This is due to the fact that the austenite phase on the middle and lower sides has not yet been reached, so that when the rapid quenching of the martensite phase is not formed completely. The sample structure using coil code B and C on the upper, middle and lower sides (Fig. 6 and Fig. 7) tends to be martensite. This structure is formed because the austenitization process occurs completely in all parts of the sample and is carried out by rapid quenching. This can prove that the heating rate affects the distribution of the phase structure formation due to the uneven austenitization process.

Due to the higher frequency of the coil with code A, the density effect on the sample does not enter too deep from the sample surface. The concentration of eddy currents does not to depth the sample, so the austenizing temperature only occurs on

the upper side, so that the martensite transformation occurs perfectly when the immersion process is carried out in the oil medium. On the lower side, the austenizing temperature has not been reached, the heat conduction from the upper side has not propagated, so the martensite transformation is not sufficient. So that on the lower side the ferrite and pearlite structures are still visible which are generally in medium carbon steel.

6. 3. Discussion of hardness distribution

The distribution of raw material hardness was 172.60 HVN. The increase in hardness occurs in all samples using coil code A, B, and C. As seen from the graph in Fig. 8, it can be seen that the distribution of hardness of coil B and coil C tends to be even from the upper to the lower side. The increase in the hardness of the C coil from the raw material is up 120% or becomes an of 387.64 HVN. The average increase in the hardness of coil B was up 171.83% or increased to 478.96 VHN. The hardness of the coil B and C samples' cross-sectional values did not result in the hardening surface. On all sides, hardness tends to be the same. It occurs because the sample structure is martensite on all cross-sides (Fig. 6 and Fig. 7). It differs from the distribution of hardness in the cross-section of the sample using coil A. The hardness on the upper side increased 178.54% or became 490.80 HVN, while on the lower side, it only increased by 46.14% or only 257.50 HVN. High hardness up to the test point of 10 or a depth of 4 mm from the upper side plate's surface. For a depth of more than 4 mm, the hardness decreases until it reaches the lowest hardness on the lowermost side. It proves that the martensite phase which is formed on the upper side has high hardness, while on the middle and lower sides with the less perfect martensite phase are lower.

The martensite transformation occurs in carbon steel as a result of the austenization process and is followed by a rapid cooling process. The high frequency on the code A coil, accelerates the austenization process and the density effect on the sample does not go too deep from the sample surface. So that the hardness on the plate using the code A coil increased significantly at a depth of 0.2 to 3.8 mm from the surface. While the deeper the surface, the hardness did not increase significantly from the row material. This is because the depth of more than 3.8 mm of the sample does not reach the perfect austenite phase, so that when it is immersed, it transforms completely into martensite so that the hardness is not too high.

Different hardness distributions in the experiment using coil code A between the upper and lower sides can cause different properties as well. High hardness has high strength but tends to be brittle when exposed to the impact force. The high hardness is capable of breaking and crushing the tip of the projectile compared to soft materials. The higher the hardness, depth of penetration projectile into the plate decreased [1]. However, high hardness also tends to cause adiabatic shear band (ASB) formation, and ASB induced cracking when exposed under high-velocity impact loads such as projectiles [14]. This ASB will lead to crack growth and failure. Very high hardness can also reduce ballistic resistance due to the failure process caused by shifting and cracking to holes due to projectile impacts [20]. Soft material will not be able to withstand the projectile rate, but soft material has ductile

properties and can prevent cracks and crack propagation.

7. Conclusions

1. The shape and size of the coil affect the frequency produced by an induction heating machine. This frequency will affect the heating speed. The faster the austenitizing temperature on the plate surface and the rapid quenching process carried out, the plate's inner side and the underside that not directly exposed to the coil will not have time to form an austenite phase. This condition will result in the formation of the microstructure and the level of hardness.

2. Higher hardness on one side of the plate surface and lower hardness on the reverse side theoretically and literary can improve ballistic resistance. The high hardness on the front cover of the target plate can withstand ballistic rates while preventing cracks and perforation due to ductility on the target plate's back. The use of a coil with a diameter of 8 mm and the number of turns 2 can increase the hardness on the upper side to 497 HVN while on the lower side it is 257 HVN. The plates processed by this method can be proposed as a ballistic resistant plate candidate. Further studies are needed both in simulation and experiment on ballistic impacts.

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6.4. In the case that, after the publication of the Work, a fact of violation of clause 2.1 of this Agreement is revealed by the Licensor, regardless of who discovered this fact, and in the case of a claim for copyright infringement by third parties, the Licensor is responsible. The Licensee may introduce sanctions within the institutions to the Licensee of material and moral damage and compensation for the expended economic benefits.

6.5. The Licensee shall not be liable for any illegal, unfair or fraudulent acts committed by the Licensor under this Agreement, the result of which is a violation of the copyrights and intellectual property rights of others.

6.6. A Party that improperly performed or failed to fulfill its obligations under this Agreement shall be obliged to compensate the losses caused to the other Party, including lost profits.

6.7. In all that is not provided for by this Agreement, the Licensor and Licensee are guided by the norms of the current legislation of Ukraine.

6.8. This Agreement is made in duplicate, having the same content and equal legal force, one for each of the Parties.

7. Other conditions

7.1. To ensure timely interaction under the present Agreement, the Party "Licensors" shall appoint from among themselves a representative under the present Agreement. Such person is **Helmy Purwanto** contact tel.+62 081390089207

7.2. The postal address for sending the Journal **Teknik Mesin Universitas Wahid Hasyim, Jl. Menoreh Tengah X/22 Sampangan Semarang 50236 Indonesia** and its recipient **Helmy Purwanto** (name)

8. Details and signatures of the parties

Licensee

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