Effects of Martempering Heat Treatment on Corrosion Rate in 1.5Ni Laterite Steel

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Abstract. Laterite steel is commonly used for applications in the industrial worldwide. The behavior of this characteristics of laterite steel can be repaired in various ways, one of them by special heat treatment. This research aims to determine the value of corrosion rates, hardness, and transformation in microstructure that occur in laterite steel contain 1.564% Ni after heat treatment. Heat treatment carried out is austenizing at 950 ºC and then quenching water; oil and normalizing in the air. And also tempering temperature variations 100 ºC, 200 ºC, and 300 ºC. Tests carried out were CMS 100 corrosion test which is 3.5% NaCl solution media, hardness testing with Vickers scale, and metallographic testing using an optical microscope. The results obtained showed that a microstructure transformation in 1.564% Ni laterite steel after HT consisted of martensite, ferrite, pearlite, residual austenite, and bainite. The lowest value of corrosion rate obtained in the sample normalizing 300 ºC tempering air and the highest in raw material. Whereas the highest hardness value was obtained 459.7 HV in the non-tempered water quenching sample.

1. Introduction

The development of laterite steel is currently being discussed by various research institutions, one of which is the Indonesian Institute of Sciences Center for Metallurgy and Materials Research for its potential to become national steel. According to Barkas in Hasbi et al 2016 study, in general, laterite ore is used as an alloy in the manufacture of stainless steel, superalloys and metal alloys applications to increase the corrosion resistance. With 35-45 % iron content and 0.8-1.5 % nickel, after being processed into steel, laterite nickel ore in the form of Nickel Pig Iron (NPI) will produce steel with a nickel content of 2-3 %[1].

In addition to Fe and Ni content, laterite steel also contains Chromium and Manganese elements, where both elements will have an impact on the properties of steel surface hardness, and corrosion resistance[2]. Low alloys steel is widely used as the main material in construction steel and railway steel because of its long service life, corrosion resistance, easy coating treatment, and economical[3].

Annisa et. al. explained that the optimum hardness value was found in martensitic stainless steel 13Cr which experienced austenitization at 1050 ºC with tempering temperature 600 ºC. The high tempering temperature rise in stainless steel 13Cr does not have a linear negative effect on the wear resistance of the steel. So in this study using low tempering temperature[4]. The purpose of this study...
was to determine the effect of quench media variations and tempering temperature to characterize hard properties, corrosion rates and metallography of laterite nickel steel.

2. Experimental
Research experiments began with the preparation of plate cast raw materials with cutting and milling based on the standards of hard testing, corrosion and metallography. Then heating austenization at 950 °C with 60 minutes holding time and cooled with 3 different media such as air, water and oil which then heated tempered at a temperature of 100; 200; 300 °C see the effect of the steel characteristics.

Characteristics of mechanical properties using hardness Vickers using loading 5kgf methods, for corrosion testing with Corrosion Measurement System 100 instrument and metallographic testing with grinding, polishing preparation and special etching solutions for Fe alloys with optical microscope analysis tools magnification 500x.

3. Results and Discussions
Chemical composition testing is carried out to determine the content of chemical elements contained in laterite-based alloy cast steel resulting from the casting process with material balance and integration calculations.

| Type   | Chemical Element |
|--------|------------------|
|        | C    | Si    | Mn   | P    | S      | Cr   | Ni  | Mo  | Fe  |
| As-Cast| 0.203 | 0.24  | 0.3088 | 0.01 | 0.0075 | 0.4520 | 1.564 | 0.001 | Bal. |

From the the chemical composition testing of alloy steel, it can be seen that the main chemical composition contained in the laterite steel samples of As-Cast is (Ni) = 1.564 %, Ni is the main constituent element. From the results of this test the carbon content (C) = 0.203 % with this carbon content can be concluded that this steel is categorized in medium carbon steel and low alloy steel, medium carbon steel that is steel containing carbon elements from 0.10% - 0.30% approached the modified steel standard AISI 4140.[5], [6]

Corrosion measurement testing aims to determine the effect of variations of quench media in laterite steel and variations on tempering temperature.

![Figure 1. Corrosion rate test result for variety of treatment](image)
From Figure 1, it can be concluded that the cooling medium affects the corrosion rate. Because with a very rapid decrease in temperature, in the dyeing medium, it also provides a high residual stress on the material of the test material. Therefore, the material dipped in water has a higher corrosion rate than that dipped in oil and allowed to stand in the air. Tempering treatment also affects the corrosion rate, because given tempering treatment, the residual stress after the heat treatment process is reduced.

![Figure 2. Hardness Vickers test result](image)

In Figure 2 showed that the cooling medium affects the material's hardness. Due to immersion into water, the microstructure of the material is transformed into hard martensite. While the moderate temperature reduction (dipping into the oil), the microstructure of the material turns into a pretty hard bainite. And in the air normalizing grain refinement only occurs without a change of phase, i.e. the combination of pearlite and ferrite phase which makes the material is soft [7]. Besides the tempering process also affects the hardness of the material. The higher the tempering temperature is given, then the material hardness obtained will be lower.
Figure 3. The microstructure of lateritic steel a) normalizing non-temper b) normalizing temper 300°C; c) oil quench non-temper d) oil quench temper 300°C; e) water quench non-temper; f) water quench temper 300°C

Figure 3 show The microstructure formed in the normalizing samples is ferrite and pearlite. The grain size still looks great because in this sample is still in effect casting product with a percentage of pearlite phase 20.03% - 29.56%. The percentage of the pearlite phase affects the hardness of samples, the higher the percentage of perlite the hardness will increase[8].

Grain structure formed has a smaller form factor and dense compared to the grain structure of the as-cast sample. Microstructure formed in the test sample is the oil quenching bainite structure, the bainite percentage of 45.36% - 50.49%. Microstructure formed in the test sample is a water quenching martensitic structure, with martensite percentage of 42.36% - 56.90%. The percentage of bainite and
martensite phase affects the hardness value of the sample, the higher the percentage of the phase, the higher the hardness value of the sample [9,10].

4. Conclusion
The higher the tempering temperature, affecting the decrease in residual energy that occurs. So that it affects the value of the corrosion rate. The percentage of test material hardness values tend to increase, and the increase that occurred in the test material is different when compared to the as-cast. In the air normalizing test material an increase of 13.36% - 31.22%. In the oil quenching test material by 110.97% - 161.96%. And on the water quenching test material by 166.53% - 213.36%. Variations of the most influential in this test is the result of quenching medium cooling rate different test objects.

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