Increased Corrosion Resistance On Cu35%Zn Surface By Shot Peening Process

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Abstract. Cu35Zn is a metal with a copper matrix that has the properties of forgings and has good corrosion resistance. Cu35Zn is commonly known as brass metal. Brass is widely used by industry to make various metal components. Brass for engine components must be able to withstand statistical and dynamic loads. One of these components is a ship propeller made of brass. These components must be able to withstand axial loads and have high corrosion resistance. To improve physical and mechanical properties, surface treatment needs to be done with the shot peening method. Shot peening is done with steel shot ball with a diameter of 0.5 mm with a hardness of 40-50 HRC. Shooting distance between nozzles and 100 mm specimens for 4, 6 and 8 minutes. The shot peening pressure varies 7, 8 and 9 bars. Corrosion tests according to the ASTM G5-94 standard are carried out in a 3.5% NaCl solution, instead of seawater. The results showed an increase in the best corrosion resistance of 0.028 mpy at 8 Bar shot pressure, which is 2.8 times compared to raw materials.

1. Introduction
Brass metal is an alloy between copper (Cu) and zinc (Zn) which is widely used for various industrial purposes. The advantage of this alloy is that the price is relatively cheap, easy to pour and forged, resilient and has good corrosion resistance. Brass has varying strength and hardness, depending on alloy composition and the cold working process. The brass alloy has a very high zinc content, so other alloys that makeup brass will decrease with increasing zinc content. Brass with copper matrix has advantages that are widely used in the electricity industry and household appliances. Brass is also used as material for making ship propellers and musical instruments [1]–[5]. Brass is also applied to the civil industry, arms industry, aircraft industry, engine body, motor car, electrical industry, body of the ship, chemical industry including the production of musical instruments.

The mechanical properties of the brass can be improved through a grain smoothing process. This method will produce better brass mechanical properties, especially yield strength and hardness. Refining grains through Thermomechanical Controlled Processed (TMCP) is used to smooth the grain in CuZn alloys. Metals with fine grains and relatively small grains will be harder and stronger than coarse grains because fine grains have a wider grain boundary area to block dislocation movement. The high hardness and strength values will have an impact on decreasing ductility and material toughness. Increased mechanical properties can be done by setting the cooling rate through metal casting techniques [6]–[10]. Increasing the composition of Cu, Pb and Sn followed by heat treatment at a temperature of 400°C was held for 1 hour and varied with cooling media can increase material hardness. The method for improving other mechanical properties is by shot peening process. Shot peening was done by shot steel ball with a
certain diameter and pressure settings are carried out to improve the mechanical properties of strength and resistance.

The process of increasing physical and mechanical properties by the shot peening process on metal surfaces is influenced by various parameters, including duration, shot pressure, shot distance, shot angle, and steel ball size. The effect of pressure and duration of shot peening on the Cu35Zn surface on corrosion rates and microstructure has been investigated in this study.

2. Materials and Methods

Cu35Zn used in this study was made using a sand casting process, with cylindrical molds with a diameter of 18 mm. The material is then machined to get a 14 mm diameter and 3 mm thick specimen. The surface of the specimen is smoothed using gradual grade 600, 1000 and 2000. The shot peening process in this study used three pressure variations and shot peening duration (7, 8, and 9) bars and (4, 6 and 8) minutes. The particles used for shooting were steel balls with a 0.5 mm diameter, 40-50 HRC hardness and 100 mm surface shot distance.

Corrosion testing is carried out by corrosion testing equipment with the Ametek Versastat 4 type in accordance with ASTM G5-94 standards [11]. Corrosive media used using 3.5% NaCl as a substitute for seawater. Corrosion testing is carried out on raw material and material specimens that have been carried out by the shot peening process. The corrosion rate value is determined with the \( I_{\text{corr}} \) value, where the corrosion rate value of metal will be worth the \( I_{\text{corr}} \). The \( I_{\text{corr}} \) data obtained is the relationship between the potential difference inputted with the magnitude of the current that [12].

| Material       | Chemical elements (%) |
|----------------|-----------------------|
| Cu-35wt.% Sn   | Cu  | Zn  | Pb | Sn  | Mn | Fe | Others |
|                | 59.00 | 34.80 | 2.15 | 1.17 | 0.09 | 0.06 | <2.73 |

3. Results and Discussion

Potentiodynamic Tafel from corrosion test results is shown in Figure 2-4. The raw Cu35Zn specimens and specimens that have been shot peening are seen to be different in the value of the potential for corrosion and the corrosion current. Changes in specimen surface due to the shot peening process due to increased Tafel. The material carried out by the shot peening process will be more anodic than the value of the corrosion potential of the non-treatment (raw) material. The Tafel curve that moves upward shows the direction of the noble potential, which means it is more corrosion resistant. Corrosion rate values can be determined by the size of the current density value. The value of the current density is
directly proportional to the value of the corrosion rate. The smaller current density value results in a smaller corrosion rate. With the smaller corrosion rate, the material is more corrosion resistant. Potentiodynamic Tafel shows that the surface produced from the shot peening process affects the corrosion rate. It can be seen that the corrosion rate decreases with the shot peening process. Thus, the specimens carried out by the shot peening process are proven to be able to improve corrosion resistance better [13], [14].

![Figure 2](image1.png)

**Figure 2.** Polarization Tafel resistant non-treatment (raw) brass material and brass material after the shot peening process shot pressure 7, 8, and 9 bars with a duration of 4 minutes.

![Figure 3](image2.png)

**Figure 3.** Polarization Tafel resistant non-treatment (raw) brass material and brass material after the shot peening process shot pressure 7, 8, and 9 bars with a duration of 6 minutes.
Figure 4. Polarization Tafel resistant non-treatment (raw) brass material and brass material after the shot peening process shot pressure 7, 8, and 9 bars with a duration of 8 minutes.

Figure 5 is a graph of the comparison of the corrosion behavior between non-treated Cu35Zn and Cu35Zn which has been carried out by the shot peening process with variations in pressure and duration. A decrease in the corrosion rate is seen when the specimen is shot peening. Chart trends tend to be stable and no significant changes occur when shot peening pressure is added from 7 Bars to 8 and 9 Bars. In specimens with a duration of 6 and 8 minutes, the graph tends to slightly rise when shot peening is added to up to 9 bars. This phenomenon shows the occurrence of overshoot peening at a pressure above 8 Bar which causes the value of the corrosion rate to increase slightly. Based on the overall data, the optimum shot peening pressure value of 7 Bars can be obtained and applies to all duration variations. While the best corrosion rate occurs in specimens with 8 Bar shot peening pressure and 8 minutes duration. The increase in corrosion resistance between raw material specimens (0.076 mpy) and the best specimens was 2.8 times, which was 0.028 mpy.

Figure 5. The corrosion rate of (raw) brass material and brass material after shot peening process with variations in shot peening pressure (7, 8 and 9) Bars and duration (4, 6 and 8) minutes.

The longer the duration of the shot peening process, the surface of the material that is crushed by particles is more evenly distributed and produces a smoother surface. The higher the firing pressure, the greater the energy produced for pulverizing steel balls on the surface of the material, so that the
microstructure density that is formed also increases. Both of these phenomena lead to increased corrosion resistance which is characterized by a decrease in the corrosion rate. [15]–[18]

![Figure 6. Micro structure of Cu35Zn (a) raw material and (b) shot peening](image)

Figure 6 shows that the surface produced by the shot peening process affects the microstructure. It can be seen that the microstructure density of the specimens that have been shot peening is denser than the raw material. The tighter the microstructure can lead to increased corrosion resistance. So that the Cu35Zn surface layer that has been carried out by the shot peening process is more corrosion resistant than the raw material. In other words, the Cu35Zn surface layer that has been carried out by the shot peening process can protect the substrate from corrosion attack.

4. Conclusions

Surface treatment using the shot peening method can be done on the surface of the Cu35Zn. Optimal results of corrosion rate values in the shot peening process are obtained by variations of the 7 Bar shot peening pressure and are valid for all variations of the duration of 4, 6 and 8 minutes. Shot peening has a maximum pressure limit of 8 bars. If the shot peening pressure is increased, it can cause over shot peening so that the corrosion rate rises again. The best corrosion rate occurs in the shot peening parameter with a pressure of 8 bars for 8 minutes. There was an increase in corrosion resistance by 2.8 times compared to raw material which was equal to 0.028 mpy.

5. References

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