Characteristics of hardness at local propellers with variations of timing by using sandblasting method

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Abstract. Sandblasting is one method of surface treatment that aims to improve the characteristics of material properties, such as the hardness materials. This process was done by spraying abrasive material onto the surface of the object with the pressure. The purpose of this study was to increase the hardness of local propellers as a result of the sandblasting process. In this study, the material used aluminum alloys in the form of propellers of local fishing boats. While abrasive material used aluminum oxide with size 100 mesh. Then the pressure used 3, 4, and 5 bars with 25, 50, and 75 seconds in shooting times by angle 90. Measurement of hardness value used Universal Hardness Tester by macro-Vickers with load parameters 5 Kgf and indentation time of 10 seconds. The results showed that the longer the shooting time, the hardness of the propeller be increased 32.4% from the material that has not been carried out by the sandblasting process. The factor of time variation and shooting pressure has a significant effect on the results of the hardness in the specimen.

1. Introduction
Indramayu is an area with ecological and geographical conditions that are potential for the development of fisheries and marine businesses, then Indramayu has the largest contribution of fisheries and marine resources in West Java Province. The Indramayu Regency Government has a general policy direction that synergizes with the ideas or policies of the KKP-RI by placing increased production in the fisheries and marine sector. Increasing fisheries and marine products in Indramayu include capture fisheries, aquaculture, people's salt production and processing of fisheries and marine products [1].

Indramayu fisheries production contributes a large contribution to fisheries production in West Java, which is 61.61 percent which is the largest fish producer in West Java. Based on data from Diskanla Indramayu Regency, from January to December 2016, fish production was landed at 14 fish auction sites (TPI). The capture fisheries business is carried out by 35,929 crew members, 4,726 boat owners, 2,546 fish basket people, and 6,604 processors, while the fleet consists of 334 units of motorized boats and 5,725 outboard motors [2]. Most of the ships searching for these fish are made from the Karangsong Indramayu area which can be seen along the Prajagumiwang River, fishing boats with a length of about 28 m in length, 36 m in length, and 12 m in width, with weights up to 56 GT (gross tonnage) [3].

Ships are one of the modes of transportation whose growth is increasing because they are considered to be quite effective and relatively cheaper compared to air transportation so that it will have an impact on the use of materials, especially metals as raw materials for shipbuilding and parts such as propellers. The characteristics of the most important propellers are the high level of resistance to fatigue due to
corrosion at sea, high resistance to erosion due to cavitation and high strength to load ratio. Ships consist of many parts, one of the important parts is a propeller. These boat propellers are generally made of corrosion-resistant material because they are operated directly in seawater which is a corrosion medium. The material used for making propellers is aluminum alloy and stainless steel. Other popular materials used are alloys of nickel, aluminum, and bronze which are 10 ~ 15% lighter than other materials and have higher strength. Besides, the material chosen must have good machinability, repair ability and weldability to facilitate the production, maintenance, and repair process [4].

The application of ship propellers for the maritime industry varies. Starting from the use of fishing boats, fast boats, yachts, and commercial vessels that require a certain load and speed. For these reasons, there is a classification of propellers to determine the tolerance that the propeller must have according to their needs. The more accurate the manufacturing of ship propellers, the greater the efficiency produced by the engine [5]. The propeller has two or more blades with a snug position from the hub or boss. The propeller bar is a unified part of the hub, while the propeller hub is positioned on the shaft to be operated by the propeller [6].

The propellers in the field are mostly made of aluminum alloy made using the gravity casting technique with sand mold. The problem is that many fishermen fail on their propellers which generally occur faults on the propeller fins so that plans to find fish will be disrupted by the breakdown of the propeller. Based on the field survey carried out previously, the cause of the fracture was due to the condition of the propeller used, the condition was not good which could be seen visually in the form of many pores on the surface of the blade (figure 1) and several imperfect cracking processes. Crack initiation (figure 2) which will cause the failure of the propeller.

![Porosity on propeller surface](image1.jpg)

**Figure 1.** Porosity on propeller surface.

![Crack initiation on propeller surface](image2.jpg)

**Figure 2.** Crack initiation on propeller surface.
The purpose of this study is to improve the quality of the fishing boat propellers in the form of surface hardness by repairing the surface of the propeller through sandblasting techniques so that it is expected to produce a vane surface that is free of porosity and removes scratches on the surface. Sandblasting method with the use of variations in the form of time and firing pressure to obtain optimum surface hardness results.

Sandblasting is one method that can be used to modify metal surfaces that aim to improve characteristics to improve the surface [7]. The operation of high pressure sandblasting is used to soften rough surfaces and remove sharp residual production and contaminants attached to the material [8]. The sandblasting process is carried out by firing small particles with high pressure which results in the surface of the material experiencing plastic deformation and changes in surface roughness. The farther the distance of the nozzle with the workpiece, the greater the roughness value and will decrease at a distance of 100 mm [9].

Things that determine the results of the sandblasting process include the size of the sand grains and the time of sandblasting. Sandblasting is expected to change the surface structure of the material formed into layers of nano-sized structures to improve the mechanical properties of the material. The highest hardness results reached 39.8 VHN with 40 mesh parameters and 90 seconds of shooting time [10]. The pressure and shooting angle factors also influence the results of the sandblasting process, the higher the pressure and angle used will have an impact on the decreasing corrosion rate that occurs on the surface, and the best angle is 90° [11].

The process of sandblasting using aluminum oxide (Al2O3) on the refinement of cobalt-chromium material concluded that the longer the firing process, the smoother the surface will be produced, the time it takes about 2-3 minutes [Endang Kusdarjanti]. The variation of spraying time will result in small changes in the value of material roughness but may affect decreasing roughness. For large particle sizes (16 mesh) has a higher roughness value compared to mesh 40, which means that the particle size becomes larger, the roughness value obtained will be larger [12].

Variable shooting angle, shooting distance, and grain size are the most influential factors on the roughness of the workpiece is the shooting distance, this refers to the statistical test that produces the highest Ra found at the shooting distance. The highest roughness value is at the shooting angle variable 60° with a firing distance of 45 cm, and the size of the sand grains is 18m with a roughness value of 7.591µm [13]. Application of methods by rotating workpieces/specimens to obtain uniform results on the surface which shows a change in the microstructure of the AISI 316L steel [14]. To obtain a roughness value of 30-85 mm on a low carbon steel plate obtained by the sandblasting method with a pressure parameter of 4 bar for 10 seconds at 45.5 mm or with 6 bars for 20 seconds which produces 76 mm [15].

2. Methods

The material used in this study is a propeller used by local fishermen in Indramayu with the brand KTM system 25 which is based on aluminum alloy. Before testing, at the initial stage material composition testing was carried out using a spectrometer test from a propeller to determine the percentage content of elements in aluminum alloy propellers.

The sandblasting process (figure 3) used aluminum oxide sand with a size of 100 mesh which is fired on a workpiece/specimen with a distance of 300 mm and by using a time variation of 25, 50 and 75 seconds. While the pressure used is 3, 4, and 5 bars. Before the sandblasting process, the object is cleaned first with a dirt-removing liquid attached to the specimen. The firing process for sandblasting uses air pressure from the compressor which will be regulated by the pressure gage regulator so that the pressure released is as desired. Particles coming out of the sandblasting torch are fired directly into the workpiece with a 90° angle manually using the shooting timer. When the shooting takes place it will certainly result in pressure in the box room will increase and cause the air will come out through the air filter so that the sand will not be carried out / the environment. For data collection used as many as 3 pieces for each variation both for time and pressure. After that, the specimens were tested for hardness using the Vickers method for each specimen 3 times.
Hardness testing was carried out with brand macrovickers using a load of 10 Kgf and an indentation time of 15 seconds. The macrohardness test according to ASTM E-384 sets the diamond indenter with the angle between the facing surfaces is 136 ° as shown in figure 4 below.

After the force is removed then the diagonals are measured, so that Vickers' hardness can be formulated by the equation:

\[ HV = \frac{1.8544 P}{d^2} \]  \hspace{1cm} (1)

Where : P = load (kgf)
\[ d = \text{diagonal (mm)} \]

3. Results and discussion

3.1. Material composition

The results of testing the composition of the material of a local fishing boat propeller with a spectrometer test are obtained as follows:
Table 1. Propeller composition.

| No | Element | Value (%) |
|----|---------|-----------|
| 1  | Si      | 5.19      |
| 2  | Mn      | 0.128     |
| 3  | Cr      | 0.0259    |
| 4  | Ni      | 0.0570    |
| 5  | Zn      | 2.30      |
| 6  | Cu      | 1.20      |
| 7  | Fe      | 1.44      |
| 8  | Al      | 89.4      |
| 9  | Mg      | 0.0579    |

Based on table 1. Information is obtained that the propeller is made of aluminum alloy with a content of 89.4% Al and a content of 5.19% Si so that it can be said that the material used in the manufacture of propellers is Al-Si alloy which has the advantage of being able to increase the rate flow during the casting process and has a good surface so that it is expected to produce a good propeller cast product [17]. This propeller with a content of 2.3% Zn, 1.2% Cu and 0.06% Mg, can be used for the heat treatment process to increase its hardness [18].

3.2. Hardness

Table 2. Hardness of propeller after sandblasting process.

![Figure 5. Hardness with variation times and pressure.](image-url)
Based on figures 5, it shows that the hardness value increases with increasing sandblasting shooting time in the specimen with the highest hardness value of 94.6 VHN at 3 bar pressure and 97.1 VHN at 4 bar pressure (table 2). The existence of this sandblasting process has increased the hardness value by 31.6% of the specimens that have not been treated with sandblasting. The hardness value will increase with increasing time and the particle firing pressure to the specimen which reaches its highest value of 97.7 VHN, so that the specimen experiences an increase in hardness by 32.4% when compared to material without the sandblasting process. After the shooting time of more than 50 seconds with a pressure of 5 bars, there will be a decrease in the value of hardness as time increases, this is because the surface of the specimen has experienced saturation. This is related to changes in the characteristics of the material if the longer the surface is crushed with sandblasting, there will be an increase in mechanical properties, one of which is hardness [7].

4. Conclusion
The sandblasting process carried out on a propeller with a local fishing boat containing 89.4% Al and belonging to the type of Al-Si aluminum alloy in general can increase its hardness value by 32.4% from the material that has not been carried out by the sandblasting process. The factor of time variation and shooting pressure has a significant effect on the results of the hardness in the specimen.

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