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Abstract. Stainless steel is a material that is corrosion resistant and can be used as an implant material (type 316L). Cold treatment can only increase stainless steel's hardness, one of which is the shot peening process. This paper aims to remanufacture the shot peening machine for laboratory-scale testing purposes. The methodology used in designing the device, making all the necessary components, assembling it, and testing the shot peening machine with several specified parameters. The conclusion that can be obtained is the shot peening machine has been well designed and remanufactured and has appropriately functioned based on the performance that has been shown in the testing of stainless steel 316L.

1. Introduction

All kinds of human needs are increasing from year to year. Likewise, many problems arise both in the industrial sector and in the world of health. One of the issues that arise from the health sector is stainless steel, which is often used in the medical world. Problem cases occur in the medical world, i.e., the use of stainless steel as an implant material in grafting broken bones. In joining a fractured bone using an implant plate, orthopedic doctors' materials are titanium and stainless steel. The implant material itself must have higher corrosion resistance due to direct contact with the human body. Human body fluids contain many aggressive ions that can cause corrosion, and the implant material must also be malleable to conform to the contours of human bones.

Stainless steel is a material that resistant to corrosion and is easier to form than titanium, so the cost of developing it can be cheaper [1]. However, because the hardness level of stainless steel is below the titanium material, stainless steel needs to go through additional treatment before it is ready to be used as an implant material [2]. Besides, stainless steel has low carbon content, making it challenging to do heat treatment. Therefore, stainless steel is preferable to undergo cold treatment. The cold treatment process is the process of machining [3, 4], sandblasting [3, 4], and shot peening [5].

This activity uses the shot peening method on the stainless steel surface, which can change the material's surface structure due to the impact of the steel shot. The shot peening process can increase the surface hardness of the stainless steel implant material. With the method of firing the steel shot to the stainless steel material's surface, it is hoped that abrasive will not

occur due to abrasion by the steel shot itself. The use of steel shot is a method that is friendly to health than the sandblasting way that uses silica sand which can adversely affect the respiratory tract inhaled during the spraying process. This paper aims to redesign and remanufacture the shot peening machine for laboratory-scale testing purposes.

2. Methodology

In this part of the methodology, the remanufacturing process will be explained along with the working process, and then experimented with predetermined parameters.

2.1. Materials and Tools

The material to be used in the shot peening machine testing is stainless steel AISI 316L. While the steel balls used for shooting the material is steel shot type S-230 with 0.6 mm diameter.

2.2. Remanufacturing and Assembly

The shot peening machine consists of several components, both made and purchased. The parts purchased are the spray gun, the suction hose, the host connected to the compressor, and the specimen holder's vise, while the other components have several parts as described in table 1.

2.3. Experimental setup

The shot peening machine has already made all the components entirely and assembled them to function correctly. Next, the experiment is carried out by referring to the experimental schematic as shown in Figure 1. The parameters used in the test are the shooting time variation (0, 15, 30, 45, and 60 minutes) and the shooting angle (0^o and 45^o).

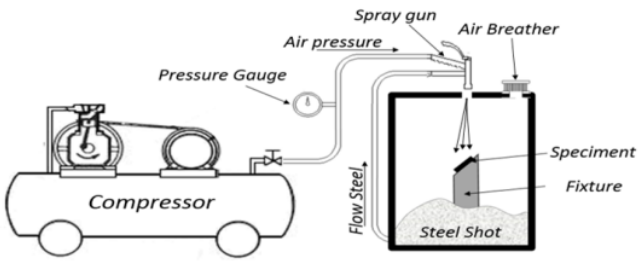


Figure 1: Schematic of shot peening process

3. Results and Discussion

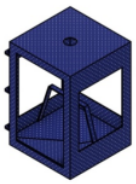
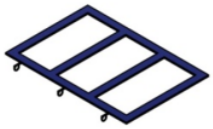
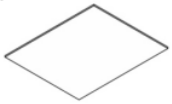
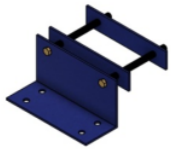
In this section, the results of remanufacturing shot peening machines will be described clearly and will be accompanied by discussion.

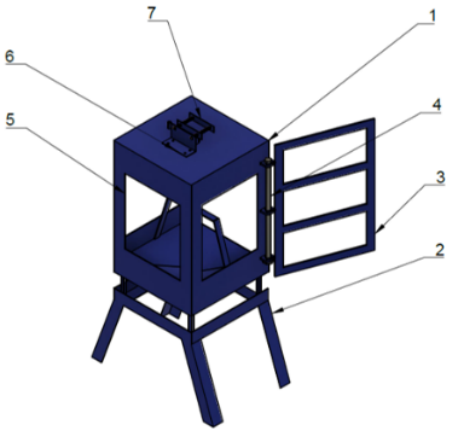
3.1. Results

The shot peening machine has been remanufacturing and can be seen in Figures 2 and 3.

The following table shows the average results for all specimen testing, namely the surface roughness test and the material hardness test.

Table 1: Part of the shot peening machine includes the process and tools used

No.	Components	Making process	Materials and Tools
1.	Frame 	• Cutting a plate (thickness of 2 mm) according to a predetermined size • Cutting brackets according to the specified size • Connecting each part using electric welding • Perforating the parts that have been determined for the installation of components	• The st-37 plate of 2mm thickness • brackets • Electrodes • Hand Grinder • Welding machine • Steel ruler • elbow ruler
2.	Base 	• Cutting a 40 x 40 bracket to the specified size • Connecting the brackets according to a predetermined size using an electric welding machine	• Brackets • Electrodes • Hand Grinding • Welding machine • Steel ruler • Elbow ruler
`3.	Door 	• Cutting the metal strip (20 x 5 mm) to the specified size • Cutting acrylic (5 mm thickness) to predetermined sizes • Cutting a 3 mm thickness plate to be used as a hinge • Making bolt holes in iron and acrylic using a drill • Connecting the plate to be used as a hinge to the metal strip • Connect the acrylic to the metal strip that has been fixed using bolts and double tape	• Metal strip (20 x 5 mm) • Plate (3mm thickness) • Acrylics (5mm thickness) • Bolt (5 mm) • Double tape • Hand Grinder • Drill machine • Drill bit (5 mm)
4.	Acrylic wall 	• Cutting three pieces of acrylic in sizes 470 x 320 each • Drilled several parts to support the installation of other components	• Acrylic (5 mm thickness) • Hand grinder • Drilling machine
5.	Stand for Spray Gun 	• Cutting the plate according to the predetermined size • Drilled several parts to support the installation of other components	• Plate • Drill bit • Bolt • Nut • Hand grinder • Drilling machine
6.	Door hinge shaft	• Connect the nut on the hinge by welding it as a holder	• Nut • Shaft • Electrode • Welding machine • Hand grinder
7.	Stopper for Spray Gun 	• Cutting the plate according to the predetermined size • Drilled several parts to support the installation of other components	• Plate • Drill bit • Hand grinder



Description:

1. Frame
2. Base
3. Door
4. Door hinge shaft
5. Acrylic Wall
6. The base for the Spray gun
7. Lock for Spray gun

Figure 2: Design of shot peening machine

Figure 3: Result of remanufacturing the shot peening machine

Shooting Time (minute)	Surface Roughness (Ra)		Hardness (BHN)	
	Angle shoot 0o	Angle shoot 45o	Angle shoot 0o	Angle shoot 45o
0	0.10	0.38	117.56	117.56
15	2.55	2.26	146.38	138.46
30	2.40	2.11	148.84	142.26
45	2.26	2.06	149.11	144.15
60	2.25	2.04	150.54	146.68

3.2. Discussion

Based on the results of remanufacturing the shot peening machine and testing data has been performed, it can be said that the surface roughness obtained will increase sharply after shooting

the specimen for the first 15 minutes. In the next 15 minutes, the resulting surface roughness decreased slightly. The surface roughness did not change significantly after 45 minutes and 60 minutes, as shown in Figure 4. The effect of surface roughness on shooting time showed the same trend for 0 ^{o} and 45^o shooting angles, respectively. Similar results were obtained in the study by Mukhsen et al. [6], in which it was concluded that the timing of firing influenced the surface roughness induced in the shot peening. The effects of shot peening conditions on medium carbon steels' surface characteristics with different heat treatments were investigated [7]. 3D finite element modeling was used to determine surface topography changes affected by the shooting parameters and processing time [8]. In addition to finite element modeling, other researchers have also discussed the stability and reduction of extensive test features [9–23]. Other studies investigate the influence of controlled shot peening (CSP) parameters (S110, S230, S330, and S550) on the treated material [24].

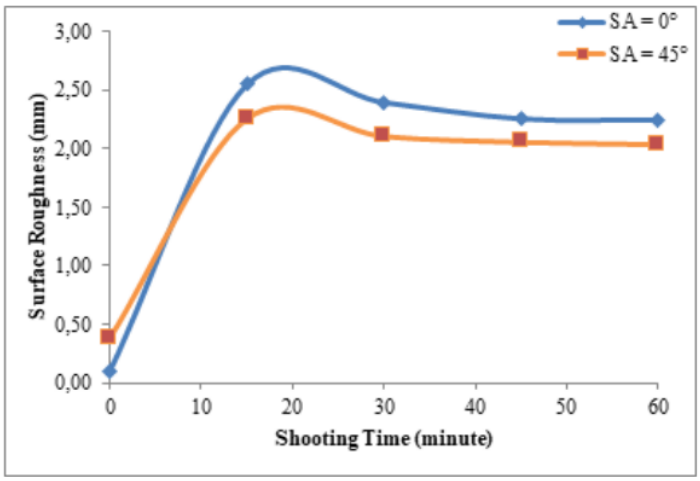


Figure 4: Surface roughness in different shooting time for the shot angle of ^{o} and 45^o

Meanwhile, for the material hardness response, there is a similarity between the surface roughness responses. The hardness obtained will increase after shooting the specimen for the first 15 minutes. In the next 15 minutes, the resulting hardness increased slightly. The hardness did not change significantly after 45 minutes and 60 minutes, as shown in Figure 5.

The effect of surface roughness on shooting time showed the same trend for 0^o and 45^o shooting angles, respectively. In a similar study, the results of shot peening conditions on medium carbon steels' surface characteristics with different heat treatments were investigated [7]. The hardness of the surface was considerably lowered during the tempered workpiece was shot-peened. The hardness distribution shows work softening near the surface. In another study, the main objective was to determine the main factors of the shot peening (SP) process of AISI 1060 high carbon steel on microhardness, grain size, and residual stress [25].

4. Conclusion

Based on the results of the redesign, remanufacturing, and experiments on the shot peening machine, it can be concluded as follows: The shot peening machine can be adequately and wholly remanufactured to the specifications in the shot peening test, which is intended for laboratory-scale purposes. The shot peening machine's performance also provides a reliable ability to increase the hardness and the surface roughness desired for the implant material.

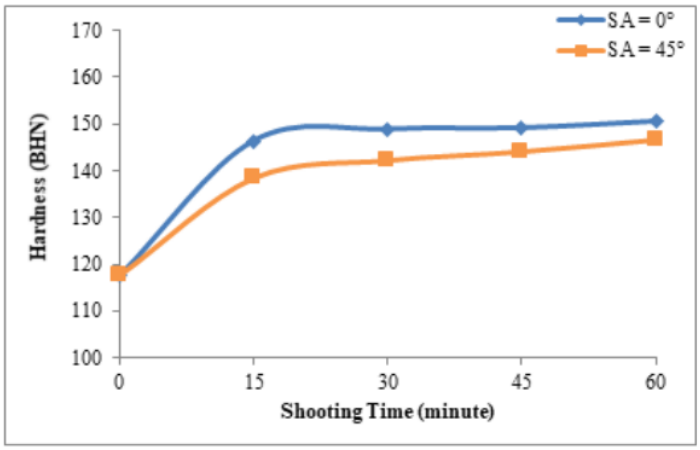


Figure 5: Hardness in different shooting time for the shot angle of 0^o and 45^o

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