Development of polishing machine for preparation metallographic specimen with re-manufacturing

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Abstract. A metallographic specimen should be performed to determine the microstructure of a material. One of the processes of preparation of metallographic specimen is polishing process. The designing and manufacturing a polishing machine will be very helpful in the process of polishing the metallographic specimen. This paper was proposed to design and manufacture a polishing machine for laboratory scale. In this research, several stages of the process are performed, such as designing the model, preparing tools and materials used, making components, assembling and testing the polishing machine. The results obtained are polishing machine that works well and can be used for the metallographic test for students and researchers. It can be concluded that this polishing machine can produce the level of specimen preparation for a metallographic test.

1. Introduction

The nature of mechanically polished surfaces and the mechanism by which they are produced have been subjects of inquiry for a considerable period of time. All held the view that polishing is a cutting process in which asperities on the surface are cut away so that the topography of a polished surface consists of a series of fine grooves—the finer the polishing medium the finer the resultant grooves—until eventually a mirror-like specularly reflecting surface is obtained.

In more recent times, Samuels [1,2] has seriously questioned the concept of the Beilby layer, particularly in regard to surfaces of metals mechanically polished by the methods commonly used in the laboratory and in an industry that employ fine abrasives held by a comparatively soft backing. Moreover, Samuels obtained evidence supporting the earlier conclusions that polishing is usually a cutting process that differs from abrasion essentially only in degree. He has also concluded [2] that a polished surface is crystalline but plastically deformed and, moreover, that the severity of plastic deformation at the surface decreases progressively with increasing fineness of polish.

This paper was proposed to design and manufacture a polishing machine for laboratory scale. A particular objective was to investigate polished surfaces by a microscope.
2. Grinding and polishing process
In the process of metallography, polishing is the final process of the precipitating part of the test for obtaining a smooth surface of the surface by using a metallographic machine which is composed of rotating plates and in it using force [2]. Polishing is often used to enhance the glossy, smooth work piece, prevent the contamination of medical equipment, remove oxidation, or prevent corrosion of the pipe [3]. In metallography and metallurgy, polishing is used to make plates making the work surface free from defects so easily in the inspection of microstructures of metals with a microscope.

To ensure proper graphite retention, use of an automated grinder-polisher machine is recommended. This equipment makes possible, in comparison to manual specimen preparation, uniform control of the desired load on the specimens and the time for each preparation stage. Furthermore, this equipment ensures uniform specimen alignment against the preparation surface, influencing the graphite retention.

The general principle is that the number of grinding and polishing stages should be minimized to preclude the risk of pulling out of the graphite phase. Also, the loading of the specimen should be most favorable to achieve a correctly polished surface in the shortest time. Four specimens with five different types of graphite were chosen as examples to study an effect of grinding/polishing processes on graphite shape and [4,5] They are:
1. coarse, needle, “star shape” graphite combined with regular medium size flake graphite in a hypereutectic gray iron;
2. spheroidal graphite in ductile iron;
3. compacted graphite;
4. temper graphite in malleable iron

3. Experimental Setup

3.1. Designing Method
The polishing machine is designed and manufactured for the purpose of improving the quality of the preparation of metallographic test specimens. This polishing machine is designed using Autodesk Inventor 2011 software, as shown in figure 1.

**Figure 1.** Design of polishing machine

Where:
1. Pulley discs
2. Axis
3. Water pump
4. Hose
5. Bearing
6. AC motor
7. Water faucet
8. Discs
9. Water tank
10. Machine frame
11. Speed control button
12. Water switch
13. Water switch
7. Pulley motor 14. On/Off switch

3.2. Manufacturing Method
After the design process, then proceed with the process of making. In the manufacture of polishing machines, need to pay attention to the sequence or procedure either of the design to be made. The manufacturing process was performed in accordance with the work in groups of each component, so that at the time of assembly process easier. Polishing machine manufacturing procedure includes several components, namely:
1. Main components, such as a frame, polishing discs, and machine cover,
2. Sub-components, such as electric motor, water pump, pulley, belt, axis, and bearing.

Assembly stage was the next stage after the making stage. The assembly process is a process of assembling or combining each component into a mutually supportive form so as to form a tool in accordance with the planned.

Testing of polishing machine is done in the mechanical laboratory of Mechanical Engineering Department PNUP. The materials used are steel with different hardness (VCL and VCN code). Variable of data that is researched is the result of polishing and time polishing. The result of polishing is obtained by varying the use of the type of sandpaper paper and limited by the time of polishing. The data collection result of polishing was taken at every time polishing has finished. The polishing process will be finished if the polishing results have been glossy, then microstructures are tested using a microscope and take pictures of the workpiece result.

4. Results and discussion
Based on the design concept, the manufacture of polishing machine has been produced. This polishing machine consists of the frame, transmission drive, 2 pieces of disc and body cover of the engine. The resulting assembly of polishing machine can be seen in the picture below.

Figure 2. The manufacturing result of polishing machine

A polished machine completed will be tested for steel material by using different types of sandpaper and polishing time. The result of polishing test on steel can be seen in figures 3-9.

Figure 3. Polishing result using a) VCL (360) and b) VCN (360) for 15 minutes
Figure 4. Polishing result using a) VCL (500) and b) VCN (500) for 15 minutes

Figure 5. Polishing result using a) VCL (800) and b) VCN (800) for 15 minutes

Figure 6. Polishing result using a) VCL (1200) and b) VCN (1200) for 15 minutes

Figure 7. Polishing result using a) VCL (2000) and b) VCN (2000) for 15 minutes

Figure 8. Polishing result using a) VCL (3000) and b) VCN (3000) for 15 minutes
The polishing results as shown in Fig. 3 - 9 show that the ability of the polishing machine has been reliable for use as a means of preparing a metallographic specimen. The results of this polishing are in line with the preparation of specimens performed by Unnikrishnan [6] to investigate the structural development of un-stabilized ultra-low carbon steel. Also in their experiment [7] using the polishing process to prepare the specimen of dental glass.

5. Conclusion
Stages of design, manufacture, and testing polish machine has been completed, it can be drawn conclusion as follows:
5.1. The polishing time can be reduced for approximately 24 minutes for the VCL sample and 22 minutes for the VCN sample.
5.2. Testing results prove that the length of time polishing and rotation speed of the disk will affect the level of fineness of the test specimen. While the level of coarse sandpaper roughness is directly proportional to the level of fineness of the test object polish.

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