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<td>-</td>
<td>Activated carbon</td>
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<td>ANOVA</td>
<td>-</td>
<td>Analysis of variance</td>
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<td>BB</td>
<td>-</td>
<td>Box Behnken design</td>
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<td>CB</td>
<td>-</td>
<td>Carbon block</td>
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<td>CCD</td>
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<td>EPA</td>
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<td>FESEM</td>
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<td>Field emission scanning electron microscope</td>
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<td>GAC</td>
<td>-</td>
<td>Granular activated carbon</td>
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<td>HEBM</td>
<td>-</td>
<td>High energy ball milling</td>
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<tr>
<td>MnT</td>
<td>-</td>
<td>Million tonnes</td>
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<td>SAJ</td>
<td>-</td>
<td>Syarikat Air Johor</td>
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<tr>
<td>SEM</td>
<td>-</td>
<td>Scanning electron microscope</td>
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<td>UV</td>
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<td>Ultra violet</td>
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<td>$W_p$</td>
<td>-</td>
<td>Mass pass a sieve</td>
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<td>$W_t$</td>
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CHAPTER 1

INTRODUCTION

1.1 Overview

Filtration and purification of drinking water and waste water treatment are among of processes that use charcoal powder in transforming water from dirty to clean condition. One of the factors that contributes to water quality is filtration method. Good quality of filtration method may produce high quality of water. Ceramic filtration, reverse osmosis filtration, UV radiation system, magnetic system and energetic water treatment are among of the popular purification method. Even, charcoal is one of the sources that can be used to remove impurities from water. They are quite excellent in removing organic and carbon based materials from water. According to Environmental Protection Agency (EPA) National Drinking Water Standard, activated charcoal is the best elements shall be used to remove contaminants from water. They noted that charcoal is used in certain metallurgical processes and as a filter to remove organic compounds such as chlorine, gasoline, pesticides, and other toxic chemicals from water and air.

Usually the activated charcoal is packaged in filter cartridges and inserted into the purification device. Then, water needs to pass through the cartridge, contacting the activated charcoal on its way to the faucet. The cartridges need to be
replaced when activated charcoal filters eventually become fouled with contaminants and lose their ability to absorb pollutants.

The amount and size of activated carbon charcoal in a filter are among important characteristics that affect the rate of pollutant removal. By using a correct size of activated carbon charcoal powder, the best quality water shall be produced.

1.2 Background of Project

A ball mill process is used to transform a charcoal into powder shape. Ball mill is an efficient tool for grinding many materials into fine size. By considering all significant parameters on this machine, maximum output of charcoal powder with permitted range size shall be achieved.

In systems optimization, the goal is to optimize the operation or arrangement of existing processes without replacing older, less efficient equipment or incorporating new equipment (Metzger et al. 2009). This project is continuity from previous work of UTM’s student. In previous work, that student had designed and fabricated a ball mill machine. Solid angle bar aluminium were used as main frame of this machine. Each frame was tighten using bolt and nut. Meanwhile, analysis of variance (ANOVA) was used to identify significant parameters that affect output. In completing the analysis, wood charcoal was used as a charcoal material to be ground. This material was chosen because it is easy to obtain compared to other type of charcoals.

This machine was equipped with castors that were attached at the bottom of the structure frame for ease transferring purposes. Basic dimension of machine is
1200mm X 600mm X 600mm with total weight is about 40 kg. Plastic jar was used as a container to fill with a charcoal material. This jar was placed on two sticky rollers horizontally. The jar was rotated by rollers that had been connected to electrical motor. The rollers are connected to electrical motor through V-shape belt type. Inverter was used to regulate the rotational speeds of jar as per required. Sticky carpet ensures the jar rotate simultaneously with speed of the roller. Besides charcoal, jar also is filled with steel ball. This steel ball acts as a crusher to the charcoal. Jar rotation forces charcoal and steel ball rotate simultaneously at a certain speed. This rotation causes them to collide and rub each other, then produce powder size of charcoal. Steel balls inside the container crush the charcoal to small size. Figure 1.1 shows main parts of ball mill machine.

![Main parts of the developed ball mill machine](image)

(1): Jar  (4): Speed controller panel
(2): Electrical motor  (5): Inverter
(3): Belt and pinion system  (6): Aluminium frame

**Figure 1.1**: Main parts of the developed ball mill machine
1.3 Project Statement

Feasible range size of palm oil charcoal powder provides an effective function for filtration of drinking water and wastewater treatment. Initial study found that the developed ball milling capable of grinding charcoal into powder. However, no study was done on the feasible processing parameters to produce charcoal powder at various sizes. In addition to that, the earlier study was merely tested on the wood charcoal only. Very limited reports are available on palm oil charcoal study but even that they are not discussing on the producing method.

1.4 Research Question

a. What are the significant parameters that affect amount of charcoal powder?

b. What are the feasible ball mill parameters to obtain maximum output with micron range size of charcoal powder?

1.5 Objectives of project

i. To determine significant processing ball milling parameters for crushing palm oil mill charcoal

ii. To evaluate the feasible range of crushing processing parameters for palm oil shell into active carbon powder
1.6 Scopes of project

In producing maximum output of active carbon powder from palm oil shell charcoal, the study was focused on the following scopes:

1. Parameters under study were:
   a. Relative speeds between electrical motor and jar
   b. Ball size and number of balls
   c. Processing time

2. The study was conducted using the existing prototype ball mill machine developed in FKM, UTM.

3. The weight of palm oil charcoal used in the experiments was fixed in all conditions.

4. One of the experimental design approaches was employed for planning the experimental trials and analysing the experimental result.
OPTIMIZING CRUSHING PROCESSING PARAMETERS OF OIL PALM SHELL CHARCOAL

ALIMI BIN ABDUL GHAFAK

A project report submitted in partial fulfilment of the requirements for the award of the degree of
Master of Engineering (Mechanical)

Faculty of Mechanical Engineering

MAY 2010
To my beloved mum & dad, wife
ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and most Compassionate

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ABSTRACT

Ball mill is a machine that used to produce powder size of materials from ceramics, glass and coal. This project is optimizing ball mill processing parameters in order to obtain a maximum output with permitted range size of powder. Activated carbon palm oil charcoal is selected as a material to be ground. Powdered activated carbon (PAC) of palm oil has a multipurpose usage such as filter for drinking water and absorption agent in wastewater treatment. In this project, granular activated carbon form of palm oil with a uniform size distribution was used in the experiment. Meanwhile, each experiment also used a constant amount of material, namely 100gram per experiment. Four independent variables were investigated, namely processing time, size of grinding media, grinding media quantity and rotation speed of jar. Sieve shaker was used to separate between coarse and fine particles size of material. Field Emission Scanning Electron Microscope (FESEM) was used to confirm size of powder that had produced. The amount of PAC produced was the main focus and act as a response value. Full factorial experimental designs with two levels of variables were used. Response surface methodology (RSM) was used to find the set of operating conditions for this process variables that result in the producing the maximum output. Result showed that all chosen independent variables were significant and contributes for obtaining maximum output.