SCHOOL OF MATERIALS AND MINERAL RESOURCES ENGINEERING

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GRINDABILITY OF FINE PARTICLE GOLD ORE USING VERTICAL STIRRED MILL

By

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DECLARATIOON

I hereby declare that I have conducted, completed the research work and written the dissertation entitle '**Grindability of Fine Particle Gold Ore using Vertical Stirred Mill**'. I also declare that it has not been previously submitted for the award of any degree or diploma or other similar title any examining body or University

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Witness by

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Date:

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KEUPAYAAN MENGISAR ZARAH HALUS BIJIH EMAS MENGGUNAKAN MESIN GILING PENGACAU MENEGAK

ABSTRAK

Bijih mineral di dalam muka bumi kini semakin menurun dalam bilangan, hal ini kerana aktiviti manusia untuk mengakstrab mineral dan aktivit pembangunan. Perlombongan juga tergolong dalam aktiviti tersebut dimana bijih di lombong sama ada di bawah tanah atau permukaan Bumi. Ini menyebabkan gred bijih bernilai semakin menurun termasuk emas. Di Malaysia, perlombongan emas dianggap sebagai perlombongan untuk gred rendah berbanding dengan tahun dahulu. Kajian ini menekan kan tentang pemprosesan emas untuk mendapatkan unsur emas yang bebas dari mineral bersekutu supaya aktiviti pelunturan berlaku dengan lebih cekap. Kajian ini menggunakan alat mesin gilis pengacau menegak untuk memahami pemboleh ubah yang berkesan untuk mengurankan saiz zarah haus bijih emas supaya emas terbebas dan mengetahui size paling halus ia mampu hasilkan.

GRINDABILITY OF FINE PARTICLE GOLD ORE USING VERTICAL STIRRED MILL

ABSTRACT

The ore mineral in earth are decreasing due to the exploration of the human being activity for the mineral and development purpose. Including mining activity which they mine the ore underneath or on the surface of the Earth. This cause the grade of the precious ore decreasing, including gold. In Malaysia, they consider low grade ore compared to the previous year. With low-grade ore they face numbers of challenge to fully extract the gold ore for the goods. This research highlight about the processing of gold ore to free the gold particle so the leaching process can extract the golf much more efficient. This study used vertical stirred mill to understand the effective parameter to reduce the size of fine ore particle so that the gold can be liberated and determine the smallest size it can produces.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Ultra fine grinding is becoming increasingly common in mineral processing industry in order to liberate valuable minerals from fine grained and low-grade ore bodies, so that the valuable mineral can be separated from the gangue minerals through the exploitation of its physical and chemical properties. The adequate liberation of valuable minerals has become harder in recent years due to the depletion of high grade and coarse grained ore bodies. Low grade and fine grained ore bodies are now regularly mined and poses significant challenges to the traditional comminution stages in terms of liberation of valuable minerals. The traditional comminution stages they commonly relies more on tumbling mill to reduce the size of the particle feed and liberate the valuable mineral from ore bodies. In some cases if the size did not reduce they just loop back the product from the mill into the mill feed in order to reduce the size.

Stirred mills have found wide acceptance in mineral processing operations due to the improved efficiencies over tumbling mills. Despite these developments, the tumbling mills are continuing to be used in fine and ultrafine. This may due to the comfort level of understanding the mechanism of stirred mill is not at the level of that of tumbling mill (Radziszewski, Peter Allen, 2014). Based on the literature observation reported that in certain circumstances stirred milling is significantly more efficiently than ball milling. Over the last 20 years, stirred milling technologies has grown with regards to the mining industry, littler grain measure and other mineralogical qualities have persuaded the need to pound better grinding equipment.

1.2 Problem Statement

The issue in mining of gold in Malaysia arise where about the grade of the gold be mine was in low grade nowadays. In order to retrieve the maximum amount of gold from the ore, the processing part should done their work more efficiently. This is because the gold ore seems to interlock inside the fine grained ore bodies make it difficult for the company to retrieve. Even though, the chemical process have been implemented such as usage of cyanide in order to retrieve the gold back, there are still small amount of gold which not been leach out by the cyanide due to certain reason.

In this study, focus more in the ore particle before been exposed to the chemical, which is in physical processing. As known, the ore coming from the run of mine undergo certain physical process, which help in reducing the size of the ore particle before been introduced to the chemical for extraction of the gold. The physical process involve are crushing and grinding. The crushing process will reduce the amount of the ore or rock to smaller size while the grinding process will reduce the size to even smaller size and liberate process take place. The idea of this study was to increase the amount of the volume been exposed for chemical process. The higher the amount of the volume been exposed the higher the amount of the particle take place in the reaction with the chemical. With this, would allow the gold to be free from any material it associate with. Figure 1.2-i was taken from bulk sample that have been mounting into polished section and picture been taken using optical microscope at 20x magnification.

Besides, the abilities of the ball mill to liberate the mineral from course particle to fine particle are decreasing due to its mechanism, which highly depends on impact and abrasion forces are dominant. Contrast to vertical stirred mill which highly depends on abrasion and cut forces (Samanl and Cuhadaro, 2008).

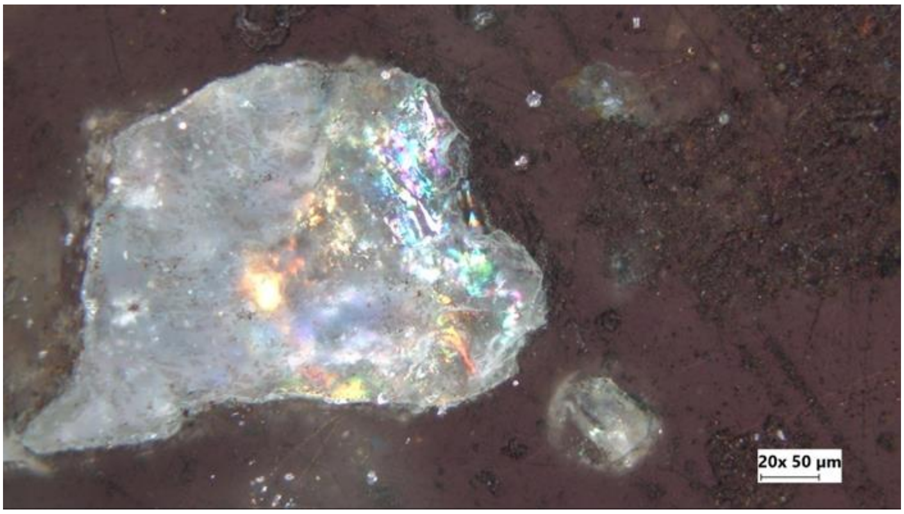


Figure 3.2.5.1-i Shows the interlock mineral inside the quartz

1.3 Objectives

The objective of this study are:

i. To determine the operating parameter of the vertical stirred mill that influence the most in reducing the size of the fine particle.

ii. To study the liberation of the gold ore after the reducing of the fine particle happen.

1.4 Research Background

The sample was receive from primary cyclone overflow and float tailing of the Northber stream of Penjom Gold Mine processing plant located in Kuala Lipis, Pahang. Cyclone was used to separate the crushed rock coming from the grinding process in term of size, the larger in size of the particle will be near the wall of the cyclone due to the contraction force by the pressure then will go underflow, while smaller in size will be draw into inner vortex and go to overflow. The product of this primary cyclone will undergo floatation process to separate the unnecessary particle then undergo leaching process. So, in order to improve the extraction of the gold, the liberation of the gold from the earlier stage of the grinding need improvement. Thus, grinding process by using vertical stirred mill at optimum parameter must be carried out.

CHAPTER 2

LITERETURE REVIEW

2.1 Introduction

Comminution in mining industries is one of the most important step for preparation of sample before introduce it into the chemical in order to extract the valuable mineral that trap inside in the rock. In order to achieve high recovery of the valuable mineral the size of the particle or material should been exposed as high as possible so that the surface volume of the particle been exposed big enough to react with the chemical effectively. Thus, the extraction of the valuable mineral become easier and efficient.

In comminution process it include crushing and grinding of the material. For crushing activity, it crushed the boulder size of the rock containing valuable mineral into small sizes using jaw crusher or cone crusher. Usually in mining, the rock coming from the run of mine (ROM) been blasted into small sizes since it easier for the company to handle and extract the mineral. For grinding, the rock been reduced again into much smaller sizes to increase the total surface volume and liberation occurs throughout the activity.

Nowadays, the adequate liberation of valuable minerals has become harder in recent years due to the depletion of high grade. Low grade and fine grained ore bodies are now regularly mined and poses significant challenges to the traditional comminution stages in terms of liberation of valuable minerals. Today, the grade of the gold been mine in Malaysia is in low-grade gold compared to old days, which they can found in nuggets form of gold. They also consider to dig out the tailing pond since they suspect the existence of gold it either due to poor grinding activities which affects the extraction of gold during leaching process or the chemical been introduce not effective or strong enough to extract the gold that trap inside the rock. In order to avoid the environmental effects by change to stronger chemical, increase the efficiency of grinding activity may be a good idea. Thus in order to increase the efficiency the material need to undergo ultra-fine particle grinding process

2.2 Ore Mineral

Ore minerals are the rock or sediment that have sufficient valuable mineral within it which make it economically viable to be extracted through mining. Ore minerals comes together with gangue minerals which is the unwanted or waste mineral. This minerals are separated during mineral processing using either or combination of both physical and chemical method. Ore mineral also classified into two groups which are metallic and non-metallic minerals. The processing circuit are designed based on the physical and chemical properties of the wanted valuable mineral itself.

2.3 Gold Ore and Mineral

The most important gold mineral is native gold and its varieties as the result of metal substitutions. Pure gold is very rare in nature. Gold minerals are defined as the minerals in which gold is present as a main constituent (e.g. native gold and electrum). Gold carriers are defined as both the gold mineral and the mineral in or on which gold occurs only in trace amount (such as pyrite. Microscopic gold, also known as visible gold, comprises gold alloys, gold tellurides, gold sulfides, gold selenides, gold sulfotellurides and gold sulfoselenides etc. Native gold (Au) and electrum (Au, Ag), found in various types of gold deposits, are the two most common and most important gold minerals. Other gold minerals of economic significance in some gold deposits include kustelite (AgAu), auricupride (Cu Au) tetraauricupride (CuAu), calaverite (AuTe3), krennerite ((Au,Ag)Te2), aurostibite(AuSb) and maldonite (Au2Bi). Microscopic gold in primary ores occurs as pristine grains of varied size and shape in fractures and microfractures, or as attachments to and inclusions in other minerals.

Gold that is invisible under optical microscope and scanning electron microscope is referred as submicroscopic gold or invisible gold. Gold usually occurs in these ores as discrete particulates (<0.1 µm in diameter) within sulfide minerals (mainly in pyrite and arsenopyrite) Surface-bound gold is the gold that was adsorbed onto the surface of other minerals during the mineralization and subsequent oxidation or metallurgical processing. (Zhou, Jago and Martin, 2004)

2.4 Gold Application and Uses

Gold has been highly valued by men since the early of time. Its rarity is one of the major which makes gold very valuable. Gold mineral occur as one of the native elements. Native element are those element that exist naturally in uncombined form with distinct mineral structure. It usually associates with quartz and pyrite. It is the most useful metal mined from the earth. Its usefulness derived from a diversity of special properties. The melting and boiling point for pure gold is 1377.33 K and 3243 °C respectively. Gold is a good electric conductor, does not tarnish, can be hammered into thin sheets, have attractive color and a brilliant lustre. Since it is malleable and ductile, artists and craftsmen can shape it into something even more beautiful. Primarily, gold is used as jewellery and coinage but it also can be used in electronics, medicine, optic and even in aerospace technology. Its rarity, usefulness, and desirability make it command a high price.

2.5 Ultra Fine Grinding

Ultra fine grinding mills have been in industries for many years for every day application such as pharmaceuticals, clays, paints and pigments before been used in mineral processing industry. In ultra-fine grinding process, usually use either planetary mill, ultra-jet mill or vertical stirred mill for laboratory scale or in industries scale is tower mill. In average, ultra-fine grinding equipment, particle sizes produce about 1µm (Masuda, Higashitani and Yoshida, 2007) and significantly increase the total surface area as well as other potentially desirable properties. Totsuo Tanaka and Yoshiteru (2007) stated that in ultra-fined equipment, it is necessary to increase the collision probability of the particle and grinding medium, and impart a significantly increased surface area including other properties such as, absorption into the blood stream and increased chemical reactivity. In his study, vertical stirred mill has been used as an equipment to grind the powder sample (Masuda, Higashitani and Yoshida, 2007). Ultra-fine grinding techniques are those techniques which are more energy-efficient than conventional milling techniques. During ultra-fine grinding, particle breakage occurs by these mechanisms which are impact or attrition by shear or a combination of both. Apart from increase the chemical reaction with the particle, UFG also increase the degree of liberation of the mill process in gold processing (Ellis, 2013).

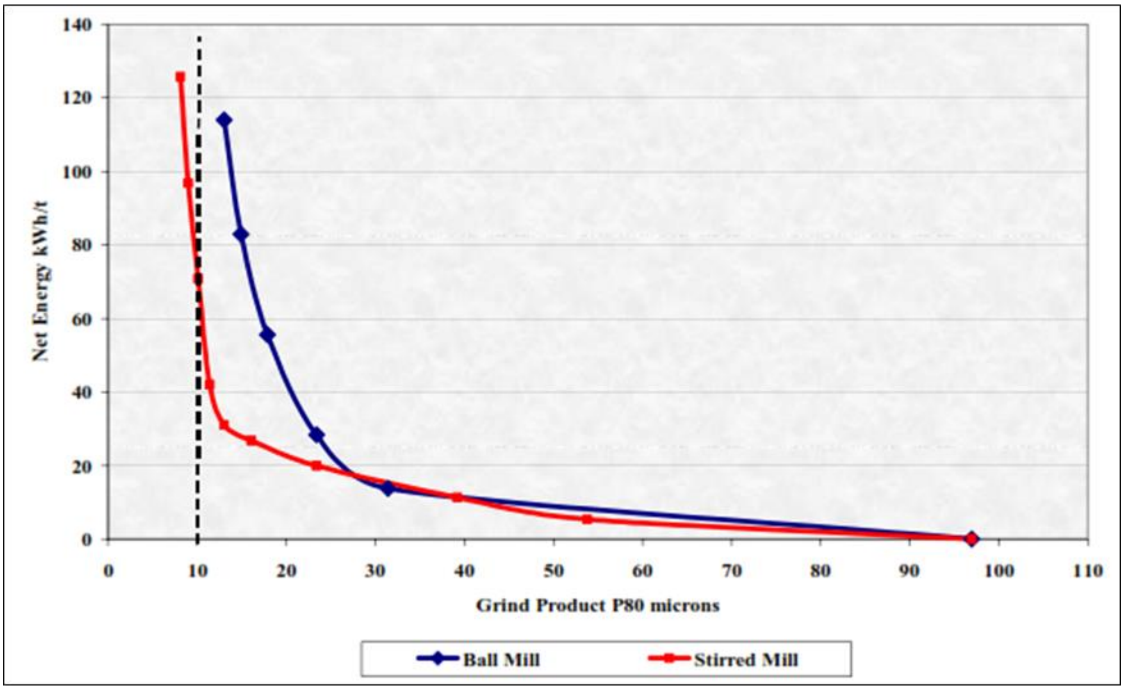


Figure 3.2.5.1-i: Comparison of net energy between Stirred Mill and Ball Mill

2.6 Stirred Mill Operations

Stirred mills principle been introduce during early 1930's but the technology been neglected by mineral industries until Japan Tower Mill Company develop the technology into tower mill which a type of stirred mill (Rahal, Erasmus and Major, 2011)Then, the development of the stirred mills was continued by the introduction of new stirred mill call stirred mill detritor (SMD). IsaMill is another mill that have been installed in many operations around the world. The mill been develop during 1990's by Mt. Isa Mines and Netzsch-Feinmahtechnik GmbH at Mt Isa mines. It is a horizontal mill with perforated discs. The advantage is its capability of stirring at high speed and having a product separator inside the stirred mill (Rahal, Erasmus and Major, 2011). A number of researchers have identified and assessed important variables in the operation of vertical and horizontal stirred mills. In favour of energy efficiency and increased liberation benefits, stirred mills have become the preferred comminution device in fine and ultrafine grinding circuits.

Stirred mills consist of fixed cylinder, fitted with stirrer place placed in this cylindrical chamber. The chamber is filled with mineral slurry containing material to be grind and media. Stirred mills employ stirrers comprising a shaft with disks or pins of various design to agitate the grinding media. Stirred mills can be classified by their shell orientations either vertical stirred mills such as the Sala Agitated Mill (SAM) or horizontal such as the IsaMill (Shi *et al.*, 2009). The breakage mechanism is the same for the two mills, the differences being related to stirrer speed, method of media retention, and size of currently available mills (Ellis, 2013). Research found that recent trend in stirred mills classification is based on the tip speed velocity of the mill impellor. High-speed mills are those with a tip speed greater than 15m/s and low-speed mills operate at speed below 3m/s. The result of this speed differential to size reduction limit are about 5 microns and 15 microns (80% passing) respectively (Jankovic, 2003).

Jankovic (2003) in his study discussed on effect of operating parameter of stirred milling technology for mineral processing by using different type of stirred mill. He found out that three major parameter that have significant effect on the reduction size of the fine particle which is grinding media (density, size, shape), the mill speed and slurry properties (feed and product size, slurry density and hardness). Besides, he also highlight about the “stress intensity” which reflect the energy involved in grinding process and conclude that ‘stress intensity’ method should be used for the stirred milling process optimisation and scale up since the interaction between the others variable is very strong thus the effect of one variable cannot be generalised (Jankovic, 2003).

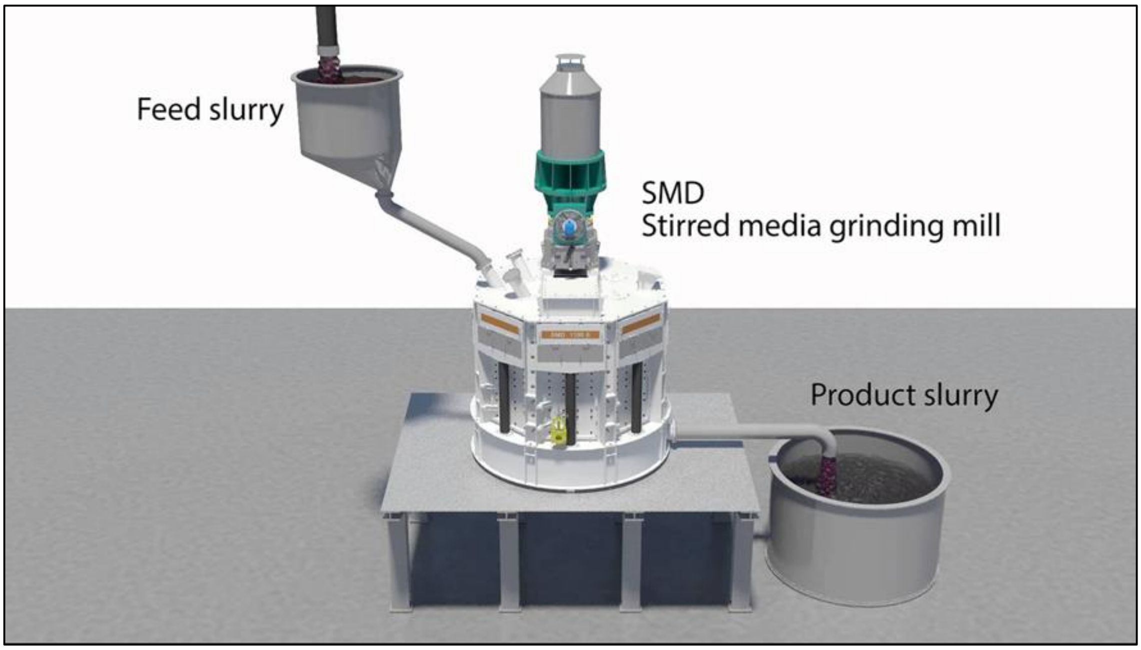


Figure 3.2.5.1-i: SMD Mill available at the industry

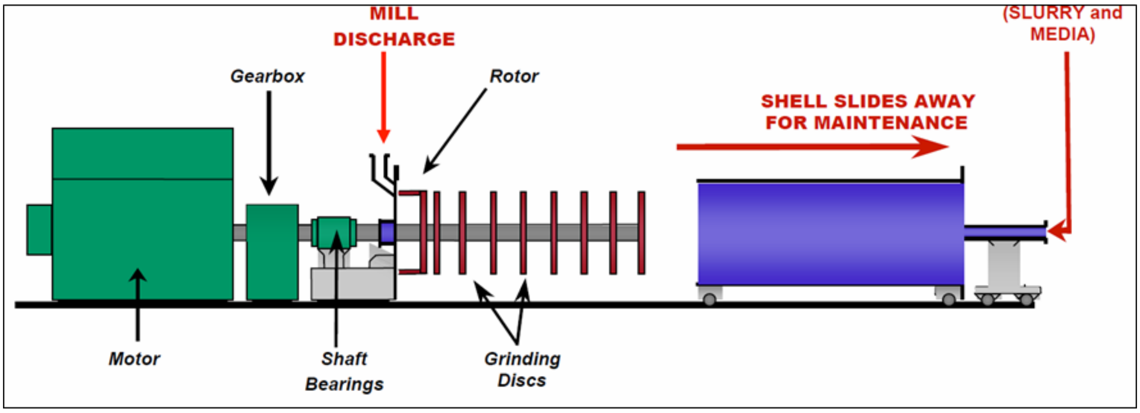


Figure 3.2.5.1-ii: ISA Mill available at the industry.

2.6.1 Solid Concentration

In mineral processing, solid concentration is simply meaning that the percent of solid particle over total material inside the mill. The surface properties dominate the system when the particles are of ultrafine sizes and the solid concentration is high (Edwards, 2016). At high concentration the particle have higher chance to be trap between the grinding media where impact and attrition mechanism takes place, while in low concentration the particle have low chance to be trap between the grinding media. Solid concentration properties usually been relate with energy used or sufficient energy since the entire process were in wet condition, which causes energy required for each process may vary due to solid concentration used for each test. Finer particle contain less internal flaws and become more uniform in structure so the energy required to break finer particle are greater than that of coarser particle (Edwards, 2016).

There are research done on late 90's shows that the as solid concentration increase causes the energy efficiency to increase to an optimum, then decrease as the solids concentration is further increased as shown in (Jankovic, 2003). However, in his study he speculate that a maximum efficiency occurs as the tested solid concentration was not high enough. This is because to give enough time for the particle to be grind with attrition and impact mechanism before been carried away by the water inside the mill. This concept is the same with the critical speed in mill, the faster the rotation of mill per minute does not imitate that the product will be finer since the particle does not have enough time given

Another research done on stress energy on stirred mill state that the target particle size was achieved with the lowest solid concentration but with a very high specific energy consumption. This probably due to the unused collision of the grinding beads inside the mill, as the result obtained in (Ohenoja, Illikainen and Niinimäki, 2013), where the smallest particle sizes were obtained at the lowest solid concentration but the energy consumption was then at its highest.

2.6.2 Stirrer Speed

Stirred speed of the mills is recognise to be one of the most important factors in stirred mills. Stirred speed is the speed of the pin-agitator to spin which will help in reduces the size of the particle. As mention before, while stirred speed of the mill is increased, both product fineness and energy consumption increase, but energy efficiency does not follow the trend. This is because the energy was required to spin the agitator to the speed desire, the higher the speed the higher the energy consumption however energy efficiency was not at optimum usage. Determine the optimum stirred speed play an important role for ensuring the stirred mill is running efficiently. In literature, the range of stirred speed that have been tested was vary depending on the stirred mill type and impellors used. The typical ranges of vertical mills speeds studied using pin-type impellors are; 200-330 rpm by (Mankosa, 1986), 260 – 1000 rpm and 1000 – 1500 rpm by (Jankovic, 2003). The speed ranges of horizontal stirred mills using perforated disc – type impellors are higher than that of that vertical stirred mill pin type impellors. Typical horizontal stirred mill speeds studied are 1500 – 2500 rpm (Edwards, 2016).

When stirrer speed is increased the energy input and product fineness are increased, but energy efficiency declines. This agrees with the work by (Mankosa, 1986) which shows a decrease in product fineness with decreasing stirrer speed at a constant energy input, and that low stirrer speeds are more energy efficient than high stirrer speeds. The work by (Jankovic, 2003) highlights that the best efficiency occurs at low stirrer speeds too. In the study by Bel Fadhel and Frances (2001), they showed using horizontal stirred mills that lower speeds operate more efficiently than higher speeds. In the work by Outtara and Frances (2003), results shows that lower stirrer speeds are more energy efficient than the higher stirrer speeds. Increasing the stirrer speed leads to higher collision rates and collision energies between the media and the particles. This leads to a faster grind time but at the cost of energy efficiency. Regardless of the orientation of the stirred mill it is always observed that lower stirrer speeds are more energy efficient than higher stirrer speeds

2.6.3 Grinding Media

For media selection there are a few factors need to be consider such as media size, type of media, and media feelings. These to ensure that the media is doing its work which to reduce the size with maximum efficiency. For this research, ceramic types of bead was used in order to reduce the size of the fine particle. Since the fine particle contain valuable mineral, ceramic types was pick to avoid any contamination of the steel during the grinding occurred.

2.6.4 Media Size & Material

Different grinding media sizes and different grinding media materials (e.g., glass, steel, ceramic, pebble etc.) are employed by depending on the feed size and the feed material (Ellis, no date). Media material selected usually depends on the type of material to be grind, usually for ore particle; ceramic type of material was preferred so that the composition of the ore does not change or affected by the media such as steel beads. For quarry industries, usually they use steel ball because the hardness and strength of the steel ball can easily break and reduce the size of the rock.

Media size is a critical determinant of the kinetic energy imparted to the media and is related to the size of the material feed into the mill. Usually the media size be likely to been choose after the top size of the sample was known. There are a few approach can be consider to choose the media size to be selected. Firstly, we can vary the size of the media inside the mill, from big to small. Usually this method used for early stage of the grinding or coarse type of material. Secondly, by fixing the size of the media, for this case usually be done for fine type of material. Finer media were found to be more efficient for fine particle grinding (Jankovic, 2003). In his research stated that by decreasing the media size from 12 to 6.8 mm the size reduction achieved in the mill was greatly increased. Further decreasing the media size to 4.8 mm caused mill efficiency to deteriorate. This indicates the existence of an ‘‘optimum media size” for a particular stirrer speed.

2.6.5 Media Filling Ratio

Grinding media filling in stirred mill is a bit differ from typical tumbling mill. For a typical tumbling mill the media filling will be about 40% of the volume of the mill itself including the material feed. As for stirred mill, it was suggested that optimum ball-particle size ratio was 20:1 to achieve maximum breakage rate. While grinding media charge ratio in conventional grinding systems is approximately 40%, this ratio is up to 85% in stirred mills (Celep *et al.*, 2011). With this parameter can leads to the better delivery of the energy.

2.7 **B**reakage Mechanism

Breakage in comminution occurs through three different mechanisms i.e. abrasion, cleavage and fracture (more commonly known as abrasion, impact and compression respectively). This is shown in Figure 2.8 and all these mechanisms occur in the grinding process but normally one mechanism is dominant in the process. Tuzun et al. (1995) observed that 1st order breakage occurs in a vertical stirred mill using a feed of 100% passing 100µm and grinding down to median size of 2µm. 1st order breakage in stirred mills is also observed in the work of Yue and Klein (2005), however below a P80 of 10µm a non-linear relationship is observed which suggests a change in the grinding mechanism. Hogg (1999) shows that abrasion increases the grinding process and leads to an appearance of a non-first- order breakage function in ultrafine grinding

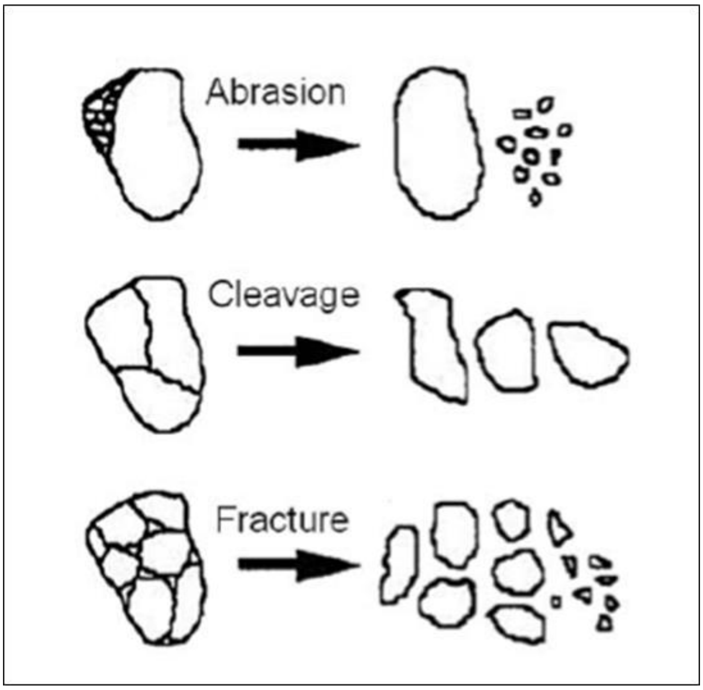


Figure 3.2.5.1-i: Typical breakage mechanism inside the mill.

2.8 Effects of grinding on Froth Flotation

During the froth flotation process the surface properties of minerals involved in the process are exploited, resulting in the separation of the wanted minerals from the gangue minerals. If the minerals are not adequately liberated, and locked in or attached to the gangue, it can lead to low recovery due to minerals reporting to the tails, or low grade due to the locked minerals reporting to the concentrate.

Stirred mills are used in two main areas of application in a typical PGM concentrator – mainstream inert grinding (MIG), P80 < 45 µm (Rule, 2011) to mainly improve recovery, and ultrafine grinding (UFG), P80 < 25 µm (Rule, 2011),to mainly improve concentrate grade.

In fine grinding operations ceramic media is used as opposed to steel media, as it is metallurgical inert in flotation. Steel releases iron into solution and causes the precipitation/adsorption of iron hydroxides onto the mineral surfaces (Rule, 2011).

2.9 Image Analysis

Image analysis is a method to extract meaningful information or measurement from the digital image. It basically, a computer-based process of extracting quantitative information from image by computer algorithm. From literature reading, theis method have been implemented in other field too such as clinical and food nutrition industries. Besides, image analysis can be used for detection of 'abnormalities' in histology sections of a tissue or organ, including for the diagnosis of cancer lesions.

Image analysing computer was first commercialise in the early of 1960s for grading steel by measuring non-metallic inclusions. It capabilities then been recognized for many different applications in life and materials sciences. It provide information much more faster and they can store the data easily compare to the human brain. Even tough, this technology help in human decision, human analysts still cannot been replace by the computers yet. However, technology with greater versatility have been develop come with great price. It cause the use of this technology or application was limited.

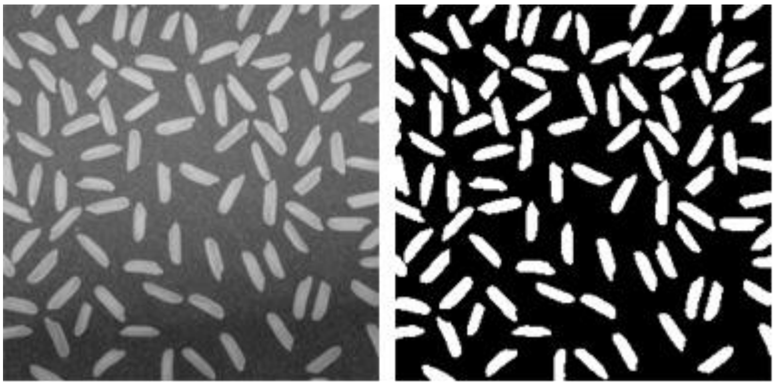
Image analysis can be performed by variety of software, including open architecture software, such as Image J and CellProfiler, commercial imaging software, such as MetaMorph and Volocity, or a high-level language for data analysis and visualization, such as MATLAB. Each of the software mentioned above has its own strength and weakness. Image analysis involves processing an image into fundamental components in order to extract statistical data. Image analysis can include such tasks as finding shapes, detecting edges, removing noise, counting objects, and measuring region and image properties of an object.

Image analysis is a wide term that covers a range of techniques that generally fit into these subcategories:

- Image enhancement to remove noise

- Image segmentation to isolate regions and objects of interest

- Morphological filtering to remove more noise



- Region analysis to extract statistical data

2.9.1 Pixel based IA vs Object based IA

Pixel based Image Analysis approach is based on the conventional statistical techniques (binary method), such as supervised an unsupervised classification. In supervised classification the image is analysed by the pixel categorization process by specifying the computer algorithm, numerical description of the various land cover type present in a scene. In other words the supervised classification the user selects representative samples for each land cover class in the digital image while unsupervised classification not. In pixel-based Image Analysis, the multispectral data are used to perform the classification and the spectral pattern present within the data in question for each pixel is used as the numerical basis for categorization.

In contrast to pixel-based classification methods that classify individual pixels directly, object-based classification first aggregates image pixels into spectrally homogenous image objects using an image segmentation algorithm and then classifies the individual objects (Liu and Xia, 2010). Object-based IA classification is very different in that it generates objects as of different shape and scale. The process is called multi-resolution segmentation. Multiresolution segmentation produces homogenous image by grouping pixels. Object that are generally generated with different scales in an image simultaneously.

The differences between object-based and pixel-based classification methods can be viewed from two aspects of the classification problem: classification units and classification features. On the one hand, the object-based approach has advantages over the pixel-based approach in these two aspects. First, the change of classification units from pixels to image objects reduces within-class spectral variation and generally removes the so-called salt-and-pepper effects that are typical in pixel-based classification. Second, a large set of features characterizing objects' spatial, textural, and contextual properties can be derived as complementary information to the direct spectral observations to potentially improve classification accuracy.

CHAPTER 3

Methodology

3.1 Introduction

This chapter will describe about the experimental method been used throughout the research. The grinding process been done with laboratory scale vertical stirred mill at pilot plant. Various parameter of the mill will be tested to study the effect on fine particle. The output by the mill will undergo particle size analysis to analyse the most affective parameter to grind the fine particle and identify the smallest size of particle it could be reduce too. Figure 3.2 shows the overview of the procedure used in this research.

3.2 Experimental & Method

3.2.1 Material

The material used for this study was gold ore from one of the gold mine in Peninsular Malaysia which in fine size. The material comes from 2 different equipment which from underflow of primary crusher with approximately 15 kg of material and the other one is from floatation of the underflow of primary crusher with approximately 2 kg of material. Figure 3.1 show the size distribution of feed sample.

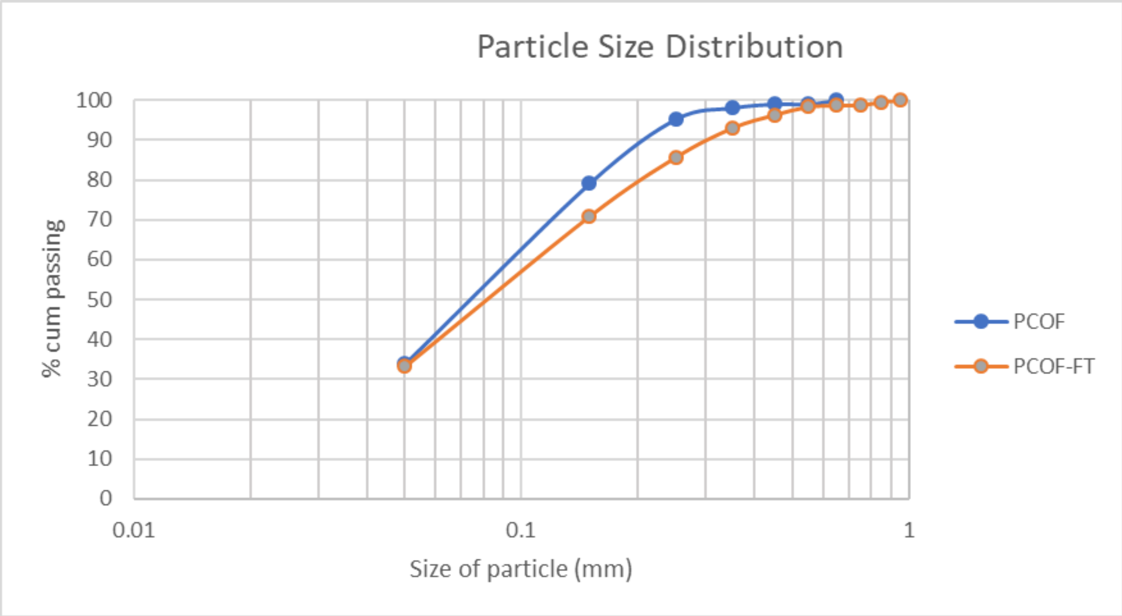


Figure 3.2.5.1-i: Shows the size particle distribution of both bulk sample.

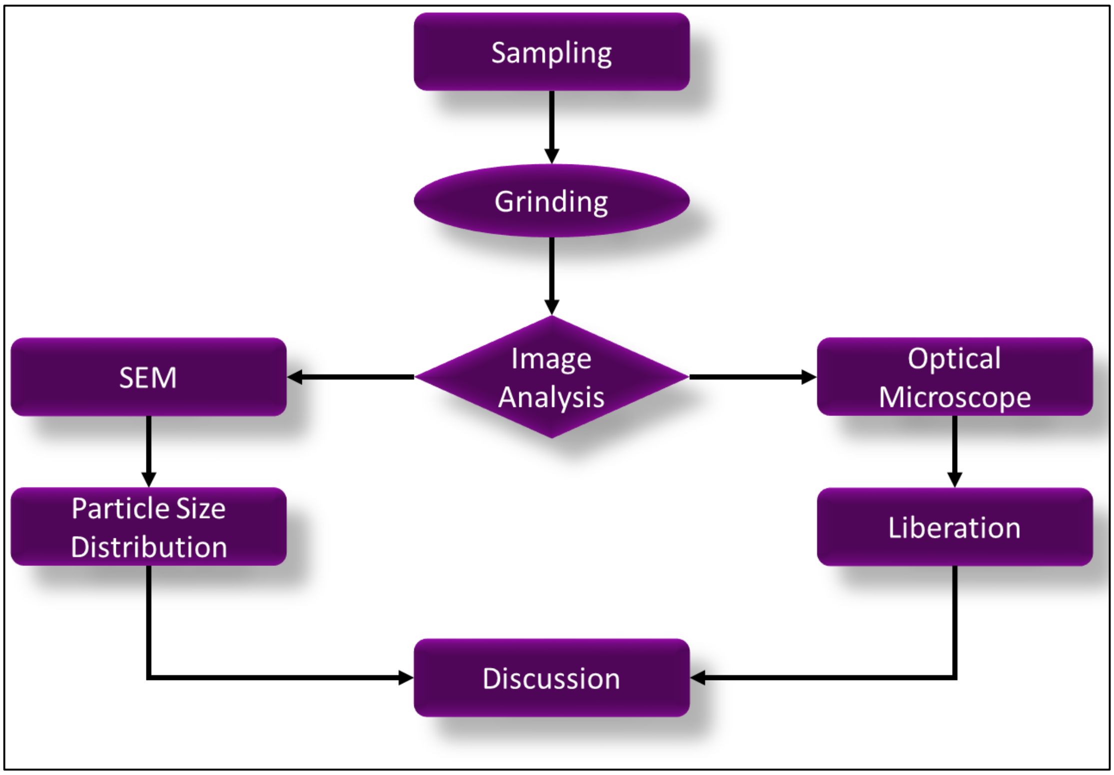


Figure 3.2.5.1-ii: Overview of the procedure

3.2.2 Sampling

Sampling can be define as a small amount of material been taken out from the bulk by certain method to achieve sample that are truly representative of the bulk. This step is very important because this step will influence the data obtained and will affect the interpretation of the study.

In this study, Jones Riffles splitter method been used as a method for sampling. This is because the material is in fine size, which make it easier to be handle compare to cone and quartering and to reduce the loss during the process. First and foremost, the material been dump in a bucket and weighted to estimate number of split to be consider to achieve desire weight of sampling. The sample is poured into the feeder and it divide a sample into two approximately equals parts. Then the material to be sub-divided been poured back into the top of the splitter and emerges as two equals parts. This method is repeated until achieve desire weight of the sample which suitable for analysis. The material been provide are coming from two different source which coming from overflow of the cyclone and the float tailing of the overflow cyclone.

Figure 3.2.5.1-i: Shows the John-Riffle equipment used.