SCHOOL OF MATERIALS AND MINERAL RESOURCES ENGINEERING

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CHARACTERIZATION AND PRETREATMENT FOR SILICA SAND IN REMOVING THE ASSOCIATED MINERAL

By

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CHAPTER 1

INTRODUCTION

1.1 Significant of Research Work

Industrial sand or silica sand is a term normally applied to high purity sand products with controlled sizing. It is a more accurate product than common concrete and asphalt gravels. Silica is the name given to a group of minerals contain of silicon and oxygen, the two most abundant elements in the earth crust. It contained of one atom of silicon and two atoms of oxygen resulting in chemical formula SiO_2.

Silicum is the name of silicon form the Latin word with a chemical element Si and atomic number 14. While, oxygenium is the name of oxygen from the Latin word with a chemical element O and atomic number 8. Silica sand is the most abundant mineral found in the crust of the earth and it forms an important element of practically all rock-forming minerals. It is found in variety of forms such as quartz crystals, massive forming hills, quartz sand (silica sand), sandstone, quartz and in with many other forms depending upon colour only the pure crystal or rock crystal, un-twinned, clear and free from any inclusion.

Sand consist of small grains or particles of mineral and rock fragments. Although these grains may be of any mineral compositions, the dominant component of sand is the mineral quartz, which is composed of silica and the other component may be include iron-bearing mineral aluminium and feldspar. Sand with particularly high silica levels that is used for purposes other than construction is referred to as silica sand or silica industrial sand. Silica sands has diversity uses both as a manufacturing application and for industrial, deposits of silica yielding products of at least 95% SiO_2 are preferred. Silica or quartz is hard mineral, chemically inert and has a high melting point, attributable to the strength of the bonds between the atoms. These are value qualities in applications for foundries and filtration systems. Quartz may be transparent to translucent and has a vitreous lustre, hence its use in glassmaking and ceramic. Industrial sand's strength, silicon dioxide contribution and non-reactive properties make it an indispensable ingredients in the production of thousands of everyday products.

The spiral concentrator is one of the most common gravity concentration equipment used in the mineral processing to recover heavy mineral from gangue minerals, perhaps their most extensive usage due to its relative simplicity and high effectiveness compared to other gravity separators. Over the past few decades, spiral concentrators have been used effectively to treat coal and beach sand. Today, it is successfully used to beneficiate a number of ores including chromite, rutile, gold ore, iron ore, etc., mainly due to its operational simplicity and cost effectiveness. Recently, there has been an accelerated growth in the use of spirals for iron ore beneficiation (Mishra and Tripathy, 2010).

Experimentally, feed pulp of between 15 and 45% solids by weight and in the size range 3 mm to 75 µm is introduced at the top of the spiral and as it flows spirals downwards, the particles stratify due to the combined effect of centrifugal force, the differential settling rates of the particles, and the effect of the interstitial trickling through the flowing particles bed, These mechanisms are complex, being much influenced by the slurry density and particle size. Some workers (Mills, 1978) have reported that the main separation effect is due to hindered settling, with the largest, densest particles reporting preferentially to the concentrate, which forms in a band along the inner edge of the stream.

1.2 Problem Statement

The problem statement related to the removal of associated mineral form silica sand such as iron ore (hematite), muscovite and biotite from mica groups that may affect the production of silica sand in the site. The associated mineral is consider as contaminant that can be hard to remove from silica. It also difficult to estimate the associated mineral that containing in the silica by looking the handling sample. So, the characterization of silica should be considered before separation can be done.

The separation process to removed silica sand from associated mineral by using the gravity concentrator, spiral is the one of the extensive usage because of its ease to be operate, low operating cost and most efficient machine compared than other gravity concentrator. Meanwhile, very small of certain impurities in sand will lead to tinted or opaque glass. Iron oxide, in form of ferric oxide (Fe_2O_3) is the most frequent and troublesome impurity that interlocking with silica sand which make it harder to separate by using spiral concentrator.

The grinding process is taken to recover the high grade of silica sand and to separate the silica sand form the impurities that interlocking from it. The grinding machine will break the particle size of silica sand to ensure the impurities is removal and it also will increase the percent grade of silica sand.

1.3 Study Area

The raw sample used for the study is a raw material from the silica mining area. The sample is collected at silica mining belong to Terengganu Silica Consortium Sdn Bhd which is located at Lot 72124, Jalan Bunga Kemboja, Kampung Bari Besar, 21020, Bandar Permaisuri, Setiu, Terengganu Darul Iman, Malaysia (GPS location of 5°32’41.90”N and 102°51’41.00”E). The mining site is accessible by land and will takes around 27 minutes of driving with distance of 24.7 km from Setiu, Terengganu. While, the distance between Universiti Sains Malaysia, Nibong Tebal, Penang (USM) to project area is 395 km and will takes around 6 hours of driving. The raw material is collected and brought to USM to be characterized and processed by using physical processing.

Figure 1.1: Location of Terengganu Silica Consortium Sdn Bhd.

Figure 1.2: Sand sampling at beach sand mining.

1.4 Objectives

The main objectives of the study are:

I. To characterize of silica sand from Terengganu Silica Consortium Sdn. Bhd.

II. To study the process of silica sand (raw samples) from Terengganu Silica Consortium Sdn. Bhd.

III. To upgrade the silica content (%SiO_2) of the sample using magnetic separator so that suitable for glassmaking process.

1.5 Thesis Outline

Systematic writing in this study containing several things.

I. CHAPTER 1: INTRODUCTION

This chapter relates to the background of the project, study area, problem statement and objectives of the project.

II. CHAPTER 2: LITERATURE REVIEW

This chapter relates more on the types of the sand and the gravity concentrators that used in glassmaking process and the grinding mill that used to increase the purity of silica sand. There is also theoretical explanation on operating machines and information of the machines used for sample processing.

III. CHAPTER 3: METHODOLOGY

This chapter relates the theoretical relationship that has been described in the previous chapter with problem, a complete description and flow chart of research activities conducted, comprehensive explanation of techniques, procedures and formulae that used to conduct the research.

IV. CHAPTER 4 : RESULTS AND DISCUSSION

This chapter involves the results of characterization together with the data obtained from the physical processing method. The data will be examined and discussed in order to complete the objectives of the study.

V. CHAPTER 5 : CONCLUSION AND RECOMMENDATIONS

This chapter contains conclusions and includes recommendation for the future works based on the results of the analysis.

VI. REFERENCES

Contains list of references that used as materials in the planning of the study and the review of research report.

VII. APPENDIX

Contains the complete data used in study, the information and documents that needed to be addressed as any part of research report.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Silica Sand

Silica or silicon dioxide also called as quartz is one of the most common minerals found on the earth’s surface. Sand consist of small grains or particles of mineral and rock fragments. Although these grain may be of any mineral composition, the dominant component of sand is the mineral quartz. Quartz is one of the most abundant minerals and occurs as an essential constituent of many igneous, sedimentary and metamorphic rocks. It also found as gangue mineral and as secondary mineral in hydrothermal veins. ‘Quartz’ appear to replace the name of ‘crystal or ‘rock crystal’ for this mineral. Other minerals may include such as alumina, mica group, feldspar and iron-bearing minerals.

Silica sand deposit most commonly operate by using surface mining in open pit operation, but dredging and underground mining are also employed. Extracted ore undergoes considerable processing to increase the optimum particle size distribution for the intended application. Sand refers to a particle size. All sands are not same. For example, construction sand and gravel is used to build and maintain roads and bridge. Construction sand and gravel consists of many different rock types and sizes. Some rocks are angular and other are rounded. In contrast, silica sand is mined from sandstones formation that have to undergoes geologic process that produced well-rounded, well-sorted and gravel that consist of the almost pure quartz.

2.2 Mineralogy of silica sand

Mineralogy is important to identify the ore and gangue minerals and their textural relationship. The mineralogical study also helps in the modal distribution of ore and gangue mineral which decides the grade of ore. Grain size of the minerals and their textural relationship helps in deciding the size reduction and liberation in mineral processing. An effective liberation of gangue mineral and ore minerals influences the optimum separation efficiency.

High grade silica or 'Quartz' which is the dominant mineral of silica sand has a specific gravity 2.7. The separation process of silica sand can be done by physical processing and chemical processing. For physical processing, the impurities from the silica sand can be remove by using gravity separation and magnetic separation equipment. While, chemical separation such as attrition scrubbing is done when the impurities are failed to be separated by physical separation. The mineral grain contaminants can be groped as:

- "Light", those mineral whose S.G is less than that of bromoform, (S.G. 2.89)
- "Heavies", those mineral whose S.G is greater than that of bromoform, (McEwen and Stitt, 1970)

Table 2.1: Specific gravity of common heavy and light minerals (McEwen and Stitt, 1970)

Light Mineral	Specific Gravity	Heavy Mineral	Specific Gravity
Chlorite -serpentine	2.5-3.0	Biotite	2.7-3.1
Calcite	2.72	Tourmaline	3.0-3.25
Dolomite	2.85	Flurotie	3.18

Muscovite	2.76-3.1	Andalusite	3.15-3.20
Glauconite	2.2-2.8	Hornblende	3.2
Plagioclase	2.72	Epidote	3.35-3.45
		Rutile	4.18-4.25
		Chromite	4.6
		Zircon	4.68
		Ilmenite	4.7
		Hematite	4.8-5.3
		Magnetite	5.18
		Pyrite	5.0

2.3 Application of silica sand

Nowadays, silica sand is important as an exploitable industrial mineral. It is used mainly as construction materials, foundry material and in glass making manufacture. It is also processed as a high-grade product commanding a higher value-adding premium price used in chemical industries (Toeh and Kamal, 1993).

Table 2.2: Uses of silica sand (Azimah, 2002)

Silica-based Industry	Uses
Glass Industry	Silica sand (SiO_2), limestone ($CaCO_3$) and soda ash (Na_2CO_3) are fused at 1100◦C to make commercial glass. Com position is usually 75% silica, 10% soda ash. The sand should be of even grain size and have minimum silica content of 99.5%.
Foundry sand industry	Silica sand is used for moulds and cores in metal casting. It is relatively cheap, thermally and chemically stable, and with bentonite clay as binder, is reusable for multiple casting cycles. Specifications require well sorted, sub-rounded grains, with minimum silica content of 98%.

Chemical Industry	Sodium silicate is manufactured form silica sand. This chemical is a starting points for detergents, fillers and extenders in paints, rubber and plastics for use in adhesive, sealants, toothpaste application and in making dessicant, silica gel.
Other uses	Natural abrasives; in the malking of silicon carbide, ceramic and ceramic glaze, as fused silica in optical and laboratory instrument glassware, cement manufacture, water filtration, and as proppant to increase the permeability of oil and gas-bearing rock formation, construction industry, golf bunker sand and water filter.

2.4 Specification of Silica Sand for glassmaking

Silica sand required for making glass has to meet specification in sizing and chemical composition. The requirement for a sand to be manufactured as a glass are it should have a chemical composition constant with a suitable particle size distribution , time and free from gangue or deleterious materials.

2.4.1 Sizing Specification

Generally, the silica sand that used in glass manufacturing should be fine in size (100 - 600µm) so that the glass melting occurs perfectly. If the size of the silica sand used are coarse in general, time taken for it to melt is longer than fine grains. Hence, there are possibility for occurrence of un-melted grains which causing inclusion in final product (Platias et al., 2014). Therefore, the coarse silica sand grains should reground before insert it into the blast furnace. However, if the grain is very fine, the melting will happen rapidly. Thus, the air bubbles will appear and it is hard to eliminate them even using a purification agent. Besides, too fine silica also will blown out of the furnace by the exhaust gases due to it light weight when feed is entered into the furnace (McEwen and Stitt, 1970).

2.4.2 Chemical composition

The application of silica sand in glass industry is most depends on its chemical composition. Drifting chemical composition can lead to problem in processing. It is because certain oxides, particular those of chromium and iron, are both contaminants. However, in the case of coloured glass production, the restriction on the deleterious oxides are not as serve as they are for white glass. Thus, in glassmaking process, the glass is classified into 7 types by the British Standard Institution According to the British Standard Specification for silica sand for glass making (after BS 2975 : 1988), the composition of the silica sand must fall within the limits set out in Table 2.2 for the appropriate grade of glass.

The types of grades of glass set down by the British standard Institution, (after BS 2975:1988) is:-

A. Optical and Ophthalmic
B. Tableware and Lead Crystal
C. Borosilicate
D. Colourless Container
E. Clear Flat
F. Coloured Container
G. Glass for Insulating Fibre

Table 2.3: British Specification for Silica Sand for Glass Making (After BS 2975:1988)

% Weight	Types of Glass						
	A	B	C	D	E	F	G
SiO_2	99.7	99.6	99.6	98.8	99.0	97.0	94.5
Al_2O_3	0.2	0.2	0.2	*Nom.*	0.5	*Nom.*	3.0
Fe_2O_3	0.013	0.01	0.01	0.03	0.1	0.25	0.3
Cr_2O_3	0.00015	0.0002	0.0002	0.0005	-	-	-
L.O.I	0.2	0.1	0.1	0.2	0.2	0.5	0.5
Total Alkalis	-	-	-	-	-	-	2.5
Cu	0.0001	-	-	-	-	-	-
Co	0.0001	-	-	-	-	-	-
Ni	0.0001	-	-	-	-	-	-
V	0.0003	-	-	-	-	-	-

Nom. = nominal amount only

2.5 Source of Silica Sand

Malaysia has a large amount of silica sand resources. The Mineral and Geoscience Department has estimated about 141.8 million tonnes (Mt) of natural silica sand resources throughout the country (Ismail et al., 2010). In Malaysia, the most common forms of silica sand is made of two types (Ali, 2003):

I. Natural sand deposit made up of beach sand and river sand.

II. Man-made deposits of tailing dumps from alluvial mining areas.

2.5.1 Beach Sand Deposits

Natural sand deposits are made of bench sand. Thus, this type of deposit fringe the peninsular almost continuously. The natural silica sand possess silica, SiO_2 ranging from 89.5% to 99%. In Malaysia, the natural silica sand found to be most abundant in Sarawak with reserves tonnage of 56.7 Mt, followed by Peninsular with 47.5 Mt and lastly in Sabah with 44.4 Mt (Ali, 2003). However, in Malaysia, the extraction of natural silica sand is carried out largely in Terengganu, Johor and Sarawak.

2.5.2 Tailing Sand Deposits

Tailing sand is also known as ex-mining sand. This man-made deposit is found in tailing dumps resulting from alluvial mining operations. In order words, tailing sand is the residue mineral from tin extraction which contains between 94% and 99.5% silica (Abdullah et al., 2012). They are located mainly in Perak, Negeri Sembilan, and Selangor. In Malaysia, the tailing sand with potential for construction sand totalled 491.5 Mt (Chu, 1988). Out of the mentioned mount, 305 Mt were reported to have SiO_2 more than 95% (Ali, 2003). The extraction of tailing sand rom tin tailing areas is carried out largely in Perak.

2.5.3 River Sand Deposits

Besides beach sand and tailing sand, another source of sand is river. River sand comprises of low silica content, approximately 85% SiO_2. Therefore, the cost to purify the sand to a premium grade or to a valuable commodity is relatively high. Due to these reason, river sand only being used in local market as a low construction and bricks raw material.

2.6 Mineral Processing Method

Mineral processing are also known as mineral dressing or milling and ore dressing. Mineral processing is a process of physically separating the grains of valuable minerals from the gangue minerals, to produce an enriched portion, or concentrate, containing most of the valuable minerals, and a discard, or tailing, containing predominantly the gangue minerals (Wills and Atkinson, 1991). In mineral processing work, there are two fundamental process which being followed liberation and separation. Liberation process is accomplished by comminution, which involve crushing and grinding that liberate of the valuable mineral from the gangue minerals. While, separation is done when the grain of or minerals are separating from the gangue minerals, to produce a concentrate that containing most of the ore minerals. Applied to a glass sand, this, fundamentally means that the quartz must be freed or liberated from any form of contamination, and then all contaminating minerals must be separated from the clean quartz grains (McEwen and Stitt, 1970). The unit operations basically used to achieve liberation and separation in sand processing are set out in table 2.4

Table 2.4: Unit operations applicable to sand beneficiation

OPERATION	PURPOSE
Screening	Sizing
Comminution	Sizing, liberation
Gravity separation	Separation
Magnetic separation	Separation
Electrical separation	Separation
Attrition scrubbing	Liberation

Froth flotation	Separation
Leaching	Liberation

Generally, physical mineral separation is done based on some physical properties of the minerals that presents in the raw samples such as magnetic properties, specific gravity (S.G), and electrical conductivity. Since the sample used in this study is raw material from sand mining, by logically it can be predicted that the content of clay mineral will be higher than heavy minerals. Thus, gravity concentration is more suitable to beneficiate the raw material based on the specific gravity of the minerals that present in it. Although, the magnetic separator also used to separate the heavy mineral that consider as gangue mineral in this study.

2.6.1 Gravity Separation

Gravity concentration method separate minerals of different specific gravity S.G by their relative movement response to gravity. To beneficiate sand when there is a notable difference in the S.G of quartz and the contaminant, the gravity concentration are employed. Mineral characteristics which influence the performance of gravity concentration are:

I. Specific gravity
II. Particle size
III. Volume

As mentioned previously, there are two type of contaminant, which heavy minerals and light minerals with S.G more than 2.89 and less than 2.89 respectively. Many different machines have been designed and developed to enable the gravity separation of silica sand. However, the three most common units are:

I. Spiral Concentrators

II. Shaking Table

III. Pinched sluice separators

It's important for an effective separation to have existence of satisfying density difference between valuable minerals and gangue mineral. The effectiveness of separation is simply a function of gravity difference which is known as concentration criterion (Napier-Munn and Wills, 2006). Concentration can be calculated using equation 2.1

$$Concentration\ Criterion = \frac{Dh - Df}{Dl - Df} \quad \text{(Equation 2.1)}$$

Where Dh is specific gravity of the heavy mineral, Dl is the specific gravity of the light mineral and Df is the specific gravity for the fluid medium. The concentration criterion is directly proportional to the value quotient. In general, if the value of the quotient is higher than 2.5, either positive or negative value, the separation is comparatively easy. Thus, the separation will be harder if the quotient value decreasing.

2.6.3 Magnetic Separation

Magnetic Separation is possible due to the varying magnetic properties among different minerals. The difference in the magnetic properties between the minerals is utilized by the magnetic separators to separate the minerals according to their condition in magnetic field. Generally, the magnetic separators are used to separate valuable magnetic minerals from non-magnetic minerals. Besides, the magnetic separators are also used to separate magnetic contaminants from non-magnetic valuable minerals.

According to Napier-Munn and Wills, 2006 all minerals are effected in some way when placed in magnetic field, although for most substances the effect is too slight to be detected. All minerals can be classified into three groups according to their magnetic properties:

i. ferromagnetic,
ii. paramagnetic, and
iii. diamagnetic.

Ferromagnetic minerals have very high susceptibility to magnetic forces and retain some magnetism even after removed from the magnetic field. This ability is known as remanence. Ferromagnetic minerals can be separated very easily using low intensity magnetic separators and the example of a mineral in this group is magnetite ($Fe3O4$).

Both paramagnetic and diamagnetic minerals are not magnetic, but if the mixture of paramagnetic and diamagnetic minerals is passed through a magnetic field, the paramagnetic minerals will be pulled into the field and diamagnetic minerals will be separated from the field. Thus, paramagnetic minerals can be concentrated in high intensity magnetic separators. Ilmenite ($FeTiO3$), rutile ($TiO2$) and hematite ($Fe2O3$) are the examples of paramagnetic minerals. Conversely, diamagnetic minerals are those that cannot be concentrated magnetically because minerals in this category are repelled to a weak magnetic intensity region when they are exposed to magnetic field. By varying the intensity of the magnetic field, it is also possible to separate different paramagnetic minerals from each other. Roasted hematite can produce magnetite and hence gives good magnetic separations. Tesla (T) is the unit used in the measurement of magnetic induction.

2.7 Gravity Separation Equipment

Gravity separations exploits the difference in specific gravities of minerals to separate them into their respective groups. It is one of the oldest method in mineral processing industry for separating minerals. Gravity separation technique are popular in mineral industry due to its low capacity and operating costs because of lack of chemicals usage and excessive heating requirements. Hence, gravity separation is generally environment friendly techniques.

2.7.1 Spiral Concentrator

In 1941, Ira B. Humphreys Jr. invented spiral concentrator with the aim to purify gold ore from pyrite in Colorado. Since its introduction by Humphreys, spirals proved to be efficient and cost-effective in concentrating a vast variety of ores. Spiral concentrators received the attention from variety of mineral processing industry due to its environmentally friendly characteristic. They are widely used in iron ore iron ore processing, coal, gold, chromites, sand and in soil cleaning. Generally, spiral is operated in the size range of 2 mm to 45 μm to obtain high separation performance (Dixit et al., 2015). Nevertheless, its application to treat the particles smaller than 45μm in size is still unexplored.

A spiral is comprised of helical conduit of semi-circular cross-sections (Napier-Munn and Wills, 2006). The feed in the range of 15-45% solids is introduced at the top of the spiral and is allowed to flow down the helical conduit. The combined effects of centrifugal force, differential particle settling rates, interstitial trickling, and possibly hindered-settling (Mills, 1980), effect the stratification of particles. Generally, high density material reports to the inner edge of the spiral, while lower density material reports to the high wall of the spiral. However, sometimes high density particles are misplaced to the outer edge of the spiral. The centre of the spiral trough is in between the inner and outer edge of the spiral. This region contains the intermediate or middling substances that present in the feed. High density, middling and low density material will form a band on the spiral trough at the inner edge, centre and outer edge respectively. They can be removed by using the splitters at the bottom of the spiral concentrators.

The separation is done effectively in spiral via the combination of forces that act on the particles as they flow downward the spiral trough. The main forces known to act on the particle on a spiral are the gravitational forces, centrifugal force, hydrodynamic drag, and lift and friction forces (Kapur and Meloy, 1998). In addition, the performance of spiral concentrators is highly effected by its operating parameters such as particle size distribution, feed percents (%) solid by weight, feed rate and splitter position (Dixit et al.,2015; Gulsoy and Kademli, 2006; Tripathy and Murthy, 2012). However, in most researches done, the particle size distribution of the feed are made constant throughout the experiment.

The performance of spiral in separating the minerals is evaluated based on the recovery and grade of desired mineral after processing. Increase in the grade and recovery of the desired mineral indicates that the performance of spiral is excellent, whereas decrease in the grade and recovery shows that the setting of operating parameters are incorrect. Hence, the influence of operating variables of the spirals on the grade and recovery of certain mineral need to be analysed in detail.

2.7.2 Shaking Table

The shaking table is another gravity separation device that has been in use for many years. Shaking tables are normally used only on cleaning stages because of their low capacity. The principle of separation is the motion of particles according to their S.G. and size moving in a slurry across an inclined table, which oscillates backwards and forwards essentially at right angles to the slope, in conjunction with riffles which hold back the particles which are closest to the deck. This motion and configuration causes the fine, high S.G. particles to migrate closest to the deck and be carried along by the riffles to discharge uppermost from the table , while the low S.G., coarser particles move or remain closer to the surface of the slurry and ride over the riffles, discharging over the lowest edge of the table.

2.7.3 Pinched Sluice Separator

Pinched sluice type gravity separators were popular in the 1960s and 70s, primarily in the Australian minerals sands industry, until the advent of the new generation of spirals. The pinched sluice is basically an inclined slope, over which a slurry containing particles of different SG flows. Due to the gravitational and frictional forces occurring, and a narrowing of the sluicing deck (pinching), segregation occurs with the finer heavier particles migrating to the bottom of the flowing film and the lighter coarser to the top. By means of a slot (concentrate off-take) near the end of sluice the fine heavy particles are removed from the main tailings stream, which passes over the slot and discharges at the end.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the overall steps from the beginning of the study until the ending of laboratory work will be discussed specifically. As mentioned before, the raw sample that used in this project is silica sand from silica mining Terengganu Silica Consortium Sdn Bdn. The flow chart for the experimental work of the project is constructed.

Generally, the project is managed with the aim to complete the objectives of the project, which are the characterization and processing of silica sand to upgrade the SiO_2 content. Therefore, the procedures on how the characterization and processing of silica sand is done will be explained in detailed in this chapter.

In mineral characterization study, the study of mineral is involves in terms of their size, phase structures, morphology, chemical composition and other attributes. Besides, the study of identify the particle size distribution and mineral composition of silica sand are done by sampling, sieving, XRF and SEM-EDX analysis. Furthermore, Humphrey's spiral concentrator is using in processing of silica sand to separate the silica sand from the contaminant such as heavy mineral and clay mineral. The overall flowchart of the project on how the experiment will run from the beginning until the end are shown in Figure 3.1

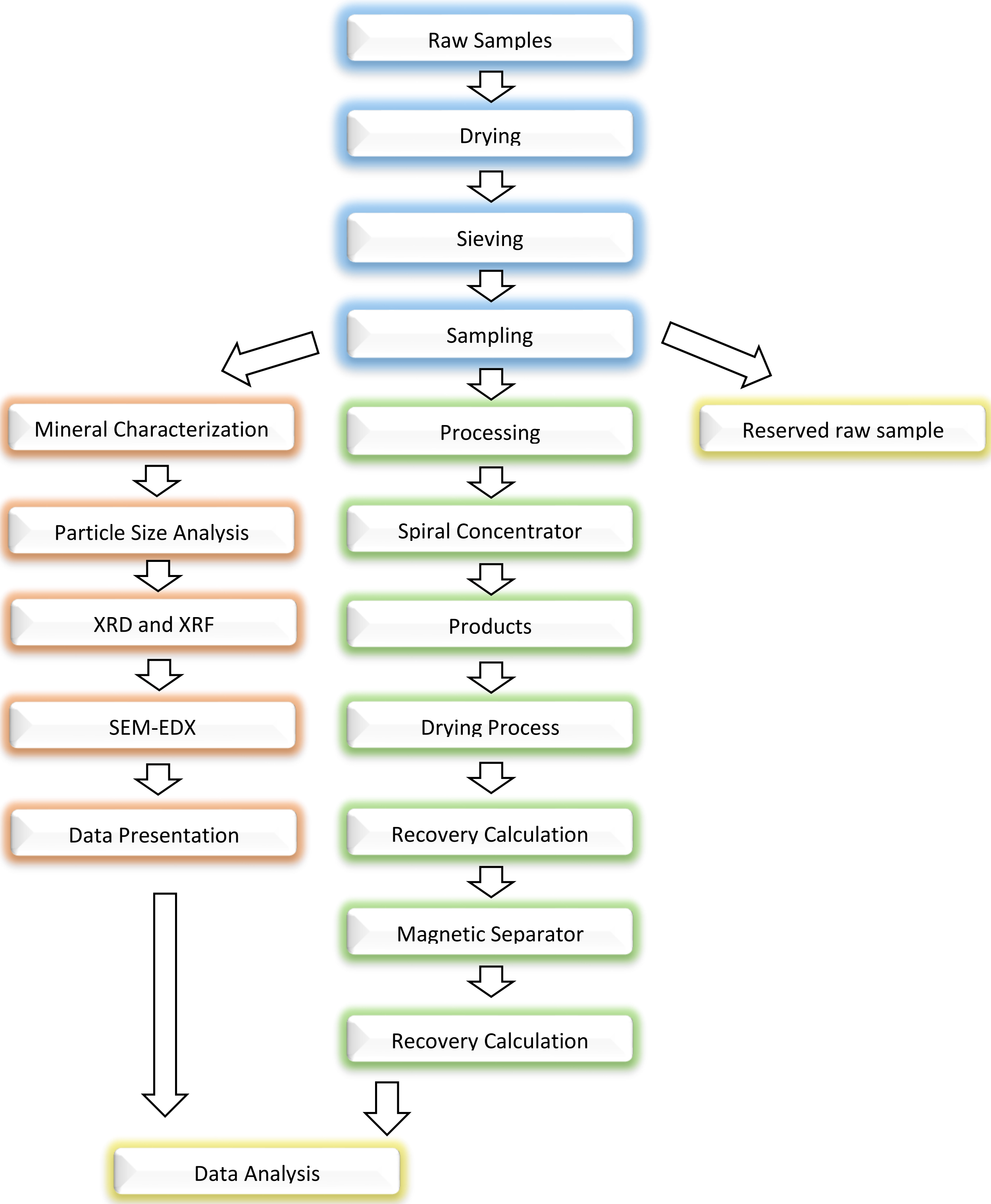

Figure 3.1: Flowchart of the Project

3.2 Sample Preparation

Sample preparation is a process of preparing the raw sample of silica sand that suitable for undergo characterization and processing. There are three common stages in sample preparation; namely drying, grinding and sampling. The raw sample of around 150 kg is taken from silica mining belong Terengganu Silica Consortium Sdn. Bhd. in Setiu, Terengganu. Site sampling is refers to choosing of representative raw samples to be further characterized and processed in laboratory. In this study, the raw samples is collected from two different location. First location known as raw samples no 7 and no 8 and the second location known as raw sample 9 and 10. The different of two location are the raw samples that taken from first location is below the top soil or top layer, its mean grab sampling is done after the top soil is been removed than the raw samples are ready to collected. While the raw samples from the second location are taken in the large bulk of stockpiles knows as tailing from plant processing. This samples are then mixed together before drying and sieving process.

Figure 3.2: Grab sampling at silica mining site.