PRE-
FEASIBILITY STUDY OF SILICA SAND PROCESSING PLANT IN SIHANOUKVILLE PROVINCE, CAMBODIA

Mr. Sochea Ros

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering in Georesources and Petroleum Engineering
Department of Mining and Petroleum Engineering
Faculty of Engineering
Chulalongkorn University
Academic Year 2018

การศึกษาความเป็นไปได้ของโรงแต่งทรายแก้วในจังหวัดสีหนุวิลล์ ประเทศกัมพูชา

นายโซเชีย รอส

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาวิศวกรรมทรัพยากรธรณีและปิโตรเลียม ภาควิชาวิศวกรรมเหมืองแร่และปิโตรเลียม
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2561

Thesis Title	PRE- FEASIBILITY STUDY OF SILICA SAND PROCESSING PLANT I N SIHANOUKVILLE PROVINCE, CAMBODIA
By	Mr. {Sochea Ros
Field of Study	Georesources and Petroleum Engineering
Thesis Advisor	Associate Professor Somsak Saisinchai
Thesis Co Advisor	Apisit Numprasanthai, Ph.D.

Accepted by the Faculty of Engineering, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Engineering

____ Dean of the Faculty of Engineering

(Assistant Professor Supot Teachavorasinskun, D.Eng.)

THESIS COMMITTEE

____ Chairman

(Associate Professor Thitisak Boonpramote, Ph.D.)

____ Thesis Advisor

(Associate Professor Somsak Saisinchai)

____ Thesis Co-Advisor

(Apisit Numprasanthai, Ph.D.)

____ Examiner

(Associate Professor Dawan Wiwattanadate, Ph.D.)

____ External Examiner

(Associate Professor Pinyo Meechumna, Ph.D.)

โซเชีย รอส : การศึกษาความเป็นไปได้ของโรงแต่งทรายแก้วในจังหวัดสีหนุวิลล์ ประเทศกัมพูชา. (PRE-FEASIBILITY STUDY OF SILICA SAND PROCESSING PLANT IN SIHANOUKVILLE PROVINCE, CAMBODIA) อ.ที่ปรึกษาหลัก : สมศักดิ์ สายสินธุ์ชัย, อ.ที่ปรึกษาร่วม : อภิสิทธิ์ น้ำประสานไทย

ในการศึกษาครั้งนี้ได้นำเสนอการศึกษาความเป็นไปได้เบื้องต้นของโรงงานแปรรูปทรายซิลิกาในจังหวัดสีหนุวิลล์โดยมีปริมาณแร่สำรองประมาณ 8,750,000 ตัน ซึ่งจัดว่าเป็นแหล่งที่มีศักยภาพสูงสำหรับอุตสาหกรรมแก้วฯ ในงานวิจัยนี้ได้ศึกษาลักษณะของทรายซิลิกา, วิธีการขจัดมลทินที่ประกอบด้วย Fe_2O_3, Al_2O_3 และองค์ประกอบออกไซด์ที่สำคัญอื่น ๆ และการประเมินทางเศรษฐศาสตร์ เพื่อหาคุณลักษณะของทรายซิลิกาวิเคราะห์โดยใช้วิธีร่อนตะแกรง, Frantz isodynamic magnetic separator ,กล้องจุลทรรศน์, เครื่องวิเคราะห์การเลี้ยวเบนของรังสีเอ็กซ์(XRD) และ เครื่องวิเคราะห์ธาตุด้วยรังสีเอ็กซ์ (XRF)ฯ

ดังนั้นเพื่อปรับปรุงคุณภาพของทรายซิลิกาโดยวิธีโต๊ะสั่นแยกแร่, เครื่องแยกแร่ด้วยแม่เหล็กความเข้มข้นสูงแบบเปียกและ Reverse Flotation ผลของตัวอย่าง(SiO_2 = 94.61 Wt.%), Fe_2O_3 = 0.18 Wt.%, Al_2O_3 = 2.50 Wt.% โดยเฉลี่ย และผลจากการใช้โต๊ะสั่นแยกแร่, WHIMS และ Reverse flotation คือ SiO_2 = 96.68 Wt.% 0.10 Wt.% ของเหล็กออกไซด์, 98.80 Wt.% กับ 0.057 Wt.% ของ Fe_2O_3 และ 99.14 Wt.% กับ 0.021 Wt.% ของ Fe_2O_3 ตามลำดับ. นอกจากนี้ผลการวิเคราะห์ทางการเงิน ได้แก่ NPV = 754,615,135.13 บาท WACC = 13.64% Discounted rate = 13% IRR = 69.64% และ MIRR = 33.47% ระยะเวลาคืนทุนภายใน 1.44 ปีฯ

สาขาวิชา	วิศวกรรมทรัพยากรธรณีและปิโตรเลียม	ลายมือชื่อนิสิต ....
ปีการศึกษา	2561	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

5971237321 : MAJOR GEORESOURCES AND PETROLEUM ENGINEERING

KEYWORD: Shaking Table, WHIMS, Reverse Flotation, Pre-feasibility

Sochea Ros : PRE-FEASIBILITY STUDY OF SILICA SAND PROCESSING PLANT IN SIHANOUKVILLE PROVINCE, CAMBODIA . Advisor: Assoc. Prof. Somsak Saisinchai Co-advisor: Apisit Numprasanthai, Ph.D.

In this study was presented the pre-feasibility study of silica sand processing plant in Sihanoukville province. The resources approximately 8,750,000 tons, would be a high potential deposit for the glass industry. In this study focuses on the characteristics of the silica sand, methodology to remove the impurities which contained high Fe_2O_3, Al_2O_3 and another major oxide element, and economic evaluation technique. To identification of silica sand which used sieve analysis, Frantz isodynamic magnetic separator following by electrical microscope, XRD, and XRF.

Therefore, to upgrade the quality of silica sand, which is using Shaking Table, Wet High-Intensity Magnetic Separator, and Reverse Flotation. The result of original sample (SiO_2 = 94.61 Wt.%), Fe_2O_3 = 0.18 Wt.%, Al_2O_3 = 2.50 Wt.% on an average. In the Shaking table, WHIMS, and Reverse flotation SiO_2 = 96.68 Wt.% with 0.10 Wt.% of iron oxides, 98.80 Wt.% with 0.057 Wt.% of Fe_2O_3, and 99.14 Wt.% with 0.021 Wt.% of Fe_2O_3 respectively. Moreover, the financial analysis result which including NPV = 754,615,135.13 baht, WACC = 13.64%, Discounted rate = 13%, IRR = 69.64%, and MIRR = 33.47% within Discounted payback period 1.44 years.

Field of Study:	Georesources and Petroleum Engineering	Student's Signature ....
Academic Year:	2018	Advisor's Signature ....
		Co-advisor's Signature ....

ACKNOWLEDGEMENTS

My name Ros Sochea Master's student in the Department of Geo-resources and Petroleum Engineering at Chulalongkorn University, I would like to express my deepest and sincerest to Asst. Prof. Supot Teachavorasinskun, D.Eng Dean of Faculty of Engineering, I also would like to show my especially thanks Assc. Prof. Thitisak Boonpramote Head of the department of Geo-resources and Petroleum Engineering.

I would like to express my deepest appreciation to my family that has been supporting me everything during my study since I was young until now, and always encouraged me all the time.

I am truly grateful my beloved advisor Assc. Prof. Somsak Sainsinchai, always give me the golden advice and idea during class and my thesis.

I also would like to express my gratefully thanks my co-advisor Dr. Apisit Numprasanthai for friendly discussion and his constant help. I would like to say thank you to Mr. Watcharin Kaewaneewan technical service for helping me during my experiment, and Mr. Hay Kamsan for giving me the valuable sample.

The last but not the least, I would to faithfully thank all lecturer in Department, and I am also expressing my sincere thanks to my committee Assoc. Prof. Dawan Wiwattanadate, Ph.D., and my External committee Assoc. Prof. Pinyo Meechumna, Ph.D. your contribution is very important for my succession.

The finally I would to thanks for the ASEAN Scholarship which provided me with a great chance to succeed in this study, Especially Ms. Pornarin Thiammaka who was taking care of all scholars as her family.

Sochea Ros

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CHAPTER 1
INTRODUCTION

1.1 Background

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depend on the local sources and condition of regional geology, but the most common constituent of sand in inland continental settings and the non-tropical coastal setting is silica [1]. Sand consists of small grains of mineral and rock fragments, these grains size shall be of any mineral composition, the dominant component of sand is quartz, which is composed of silica or silicon dioxide. Another component may include alumina, feldspar and iron-bearing mineral

Sihanoukville province is located at the tip of the rolling hills of a peninsula on the Gulf of Thailand. To its northwest and at its centre it rises to 15 meters above sea level, whereas the land gently and steadily flattens towards extended coastal plains, marshlands and beaches in the south and southeast. These hills, that provide a great variety of housing ground, good perspectives on the coastal plains, the beaches, the rivers, the sea and the islands define the region's natural character and value. Another agreeable fact is the Gulf of Thailand's low depth and the local climate, moderate in contrast to the South China Sea to the east and the Indian Ocean to the west, where taifuns and monsoonal extremes are permanent perils.

Very pure sands are also found at several locations on the east side of Kompong Som bay. Which analysis of the geochemistry and granulometry of sand samples from a variety of location Phum Sralau (103° 42'E, 11 ° 05'N), Phum Nesath (103° 40'E, 11 ° 00'N), Prek Krapeu (103° 42'E, 10° 56'N), Phum Stoeng Thma (103° 43'E, 10° 53'N), and Phum Thma Rong (103° 41'E, 10° 46'N), which grade of SiO_2 greater than 99 wt.% alumina oxides lower 1000 ppm, titanium oxide lower than 300 ppm, and iron oxides lower than 200 ppm.

Sand deposits in Cambodia abundantly occur along the rivers, especially along the Mekong river. A vast amount of sand deposit at the bottom channel or it may deposit along the riverbed. It is a significant source for construction material, those sand deposit called river sand deposit. On another hand, some sand deposits abundantly occur at off the coast of Koh Kong, Kampot and Sihanoukville provinces, its deposit is fundamentally economic for glass and ceramic industries. [2].

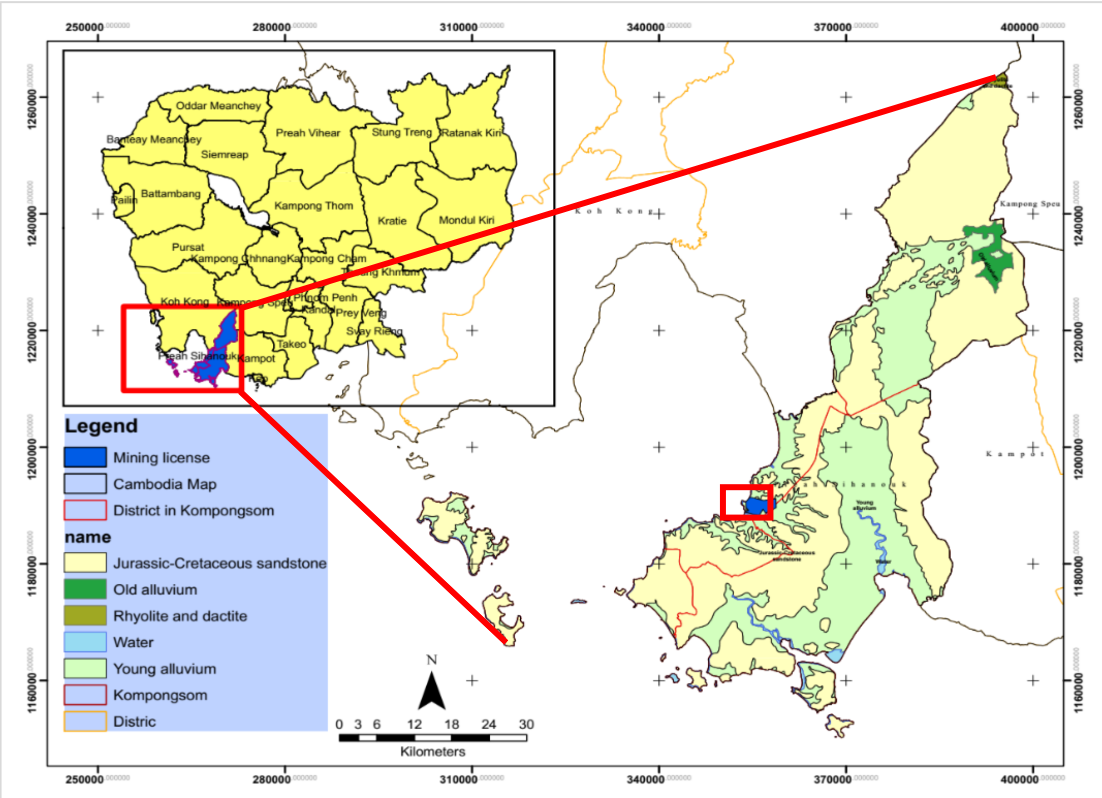


Figure 1-1: Geological map of Sihanoukville province

Sands in this area were occurring from the weathering process of the sandstones and grits of the elephant range and the cardamom highlands to the north and east [3]. In addition, silica sand is one of the essential natural material resources, commonly used as an ingredient in many industries ceramic and glass, which is including silica sand, soda ash, dolomite and limestone for glass manufacturing. The glass manufacturers principally also concerned with the chemical composition of silica sands, and particularly iron, chromite, other refractory mineral contents, and its particle size which is commonly used with size not greater than 841 µm, and not finer than 149-125 µm with the shape of silica sand is commonly angular and semi-angular. The quality requirement depends on the type of glass being manufacture shown in Table 1-1. [4, 5].

Table 1-1: Specification of glassmaking, Sources British Standard BS2975

Grade	Product	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	Cr_2O_3 ppm
A	Optical Glass	99.5	0.013	0.2	15
B	Tableware glass	99	0.01	0.2	2
C	Borosilicate glass	98.5	0.01	0.2	2
D	Colorless container glass	98.8	0.03	0.1	5
E	Flat glass	98	0.1	0.5	-
F	Colored glass	97	0.25	0.1	-
G	Insulating glass	94.5	0.3	3	-

However, glasses have produced by melting silica sand with another glassmaking mineral. Those material needs to characterize the properties before feeding into the furnace whether its impurities could be impacts to properties of glass or not. The typical impurities in silica sand from raw material for glass is an iron oxide (Fe_2O_3), whereas, its presence can cause the colour of glass and strength [5].

1.2 Production of silica sand

Silica sand was widespread mineral and occurring in relatively large quantities. The global demand of silica sand was increasing 5.5 percentage per year, which is approximately 291 million tons in 2018, and 333 million tons cross market in 2023 was reported by International Mining and Resources Conference (IMARC) group. Moreover, the production of high purity quartz industry is positive growth rates 3-5 percent, Production of c (crystalline)-Si in 2007–2011 periods saw compound annual growth rate (CAGR) of 45% while Si-production for 2010–2014 is forecast to slow to CAGR in the 20–30% range reaching 300,000–400,000 tpa in 2014 (2010: 170,000 tpa) [6].

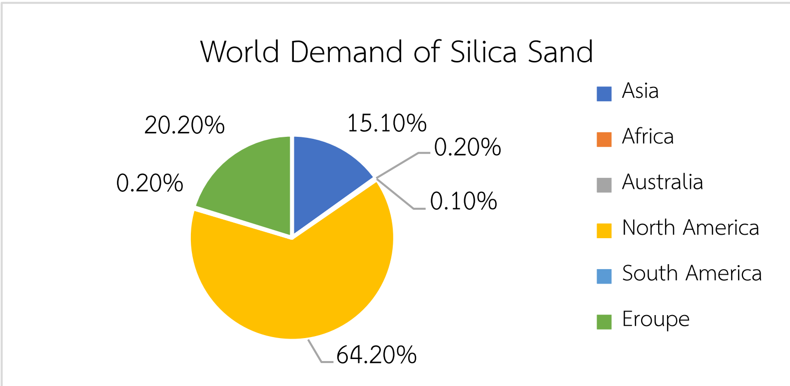


Figure 1-2: Global Demand of silica sand by religion

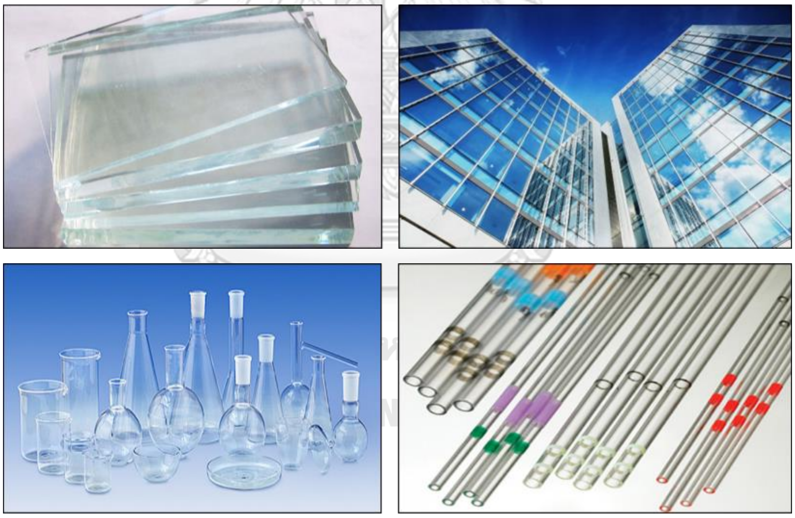


Figure 1-3: Application of silica sand, Sources: http://galereya-okon.marketgoods.ru/goods/fasad-svetoprozrachnyy-profil-alyuminievyy-alutech-alyuteh

1.3 Cambodian Government policy framework on mineral resources

Ministry of Industry Mines and Energy (MIME) were issued the policy on mineral resources activity since 31 July 2001 to convincing either domestic or foreign companies to investigated in geological exploration and exploitation. The law has been defined into 6 categories of mineral license such as

- Artisanal mining license
- Pits and quarries mining license
- Gem mining license
- Mineral [Gemstone] cutting license
- Mineral exploration license
- Industrial mining license

Table 1-2: Law and regulation for mining in Cambodia: sources MIME

Stage	Mining tenements	Provisions	Terms
Mineral exploration	Mineral Exploration License	Exclusive to conduct exploration within a specified area	Valid for 2 years and renewable up to 4 years, maximum $200km^2$
Mineral Development	Industry mining license	Exclusive right to extract minerals within a specified area	Valid for 5 years and renewable for another 10 years

In term of persuading the investor in Cambodia, the government has been increased the legal framework and established the regulation in the way that was positive to private sector investment and business activities in Cambodia. Where's in the mining sector 99.9% are owned by the foreign company, which can employ the expert from overseas in the case company could not found the specialist in domestic. According to the regulation of government and Financial Department was issued the law reverent to Corporate Income tax (CIT). All the foreign companies registered in Cambodia are under the self-declaration regime. In the general PE (permanent established) tax rate of 20 % on profitable, whereas oil and gas and certain mineral exploitation activities rated 30 % on gross profit. And insurance companies taxable at a rate 5% on the gross premium income and at the 20% on other income derived from non-insurance activities, net interest income companies received after 4% or 6% WHT is not taxable income. In term of exhorting silica sand to abroad based on Prokas of MIME article 2 royalties' rate 0.45 dollars per ton (14 baht per ton) in case the price of silica lower than 20 dollars per ton (arm's length price), where 0.5 dollars per ton (15.5 baht per ton) in case the price of silica greater than 20 dollars per ton.

Depreciation method in exploration and development expenditure would be depreciated on a straight-line basis. For both petroleum and mining operations, research and exploration expenditure would be depreciated over the expected life of the commercial production under the development plan or five years, whichever is shorter. For development expenditure, the period is the shorter of the expected life of the commercial production under the development plan, or 10 years for petroleum operations (seven years for mining operations). Where the development plan is for a period of less than one year, the development expenditure would be aggregated with the research and exploration expenditure and depreciated over the expected life of the commercial production under the development plan, or five years, whichever is shorter [7].

1.4 Location and Geological setting of the study area

Cambodia where is the geologically composed of three different structure such as Triassic and Liassic known as Ancient Gulf over a huge area in the East, and Jurassic-Cretaceous continent sandstone, where form importance high land in the West and, between them the Quaternary basin which occupies the whole central plain of the country. Those sand has been found in young alluvium deposit. It is typically made up of a variety of material, including fine particles of silt, clay and larger particles of sand and gravel. Most of the alluvium is geologically Quaternary is age and is often referred to as cover because sediments obscure the underlying bedrock. The most of the sedimentary material that fills as basin (Basin Fill) that not lithified is typically lumped together as alluvial. [8].

Beach sands with a high proportion of heavy minerals such as ilmenite and zircon are generally dominant minerals where investigate, following by rutile and monazite. The Cambodian coastline, from Koh Kong southward to Sihanoukville and Kampot, has very clean sands with a few heavy minerals, which is occurring from river drain the Cardomom highlands, clean sandstone (senu lato) rocks [3].

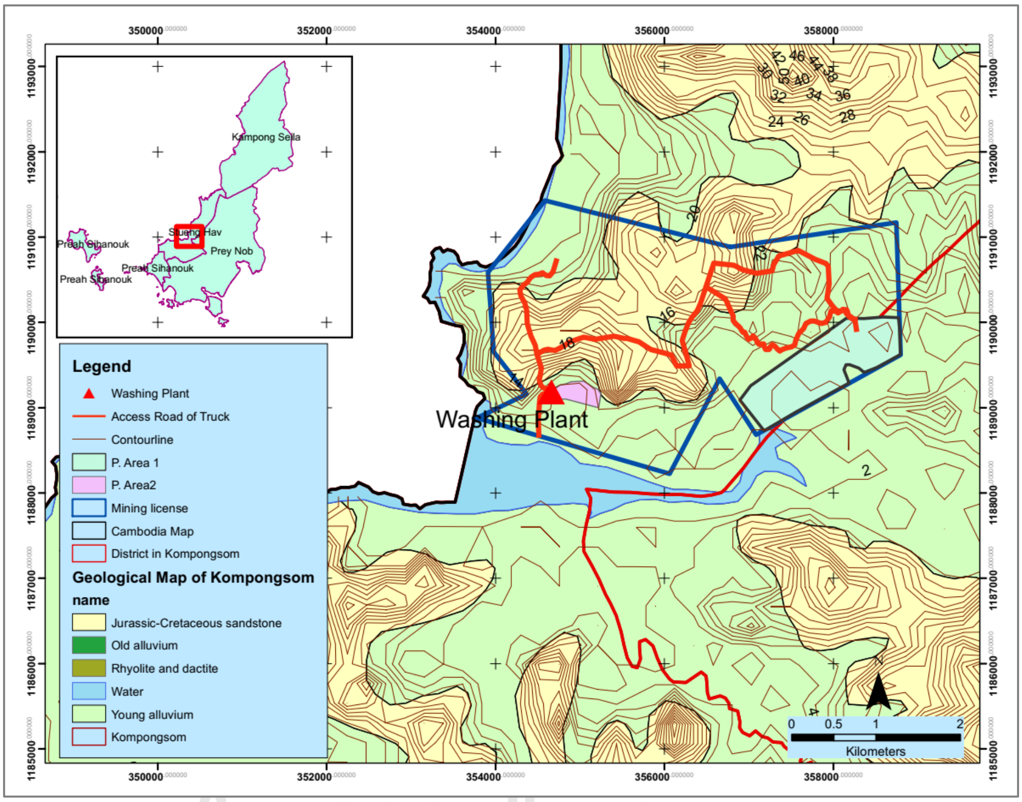


Figure 1-4: Study area overview

The mining license around 1,044 hectares in total area, where is the mains potential area was separated into two areas as shown in Figure 1-4. Whereas, the 1st area approximately 115 hectares, and 2nd area around 12.2 hectares. In addition, the production planned to extract until – 5 meters of depth, which had two mains products A and B shown in

Table 1-4. From Figure 1-5 indicate the profile soil in mining area, at the depth of - 2 meters of layer soil are defined as a product A: Fe_2O_3<0.02%, whereas the depth from - 3 meter to - 5 meters is defined as production B: Fe_2O_3<0.08%. The total resources estimation approximately 14,950,000 tons, and reserve estimation approximately 8,750,000 tons of sand in this area.

Table 1-3: Coordinate of license area UTM 48N Datum WGS84

	Lat	Long		Lat	Long
A	358744	1191172.00	G	354365	1189157.00
B	358793	1189621.00	H	353977	1189652.00
C	357083	1188682.00	I	353909	1190588.00
D	356651	1189340.00	J	354583	1191429.00
E	356058	1188226.00	K	356777	1190884.00
F	353778	1188881.00			

Table 1-4: Selling product to Thailand

Silica sand with Fe_2O_3 < 0.02% (product A)	1,500 baht/ton
Silica sand with Fe_2O_3 < 0.08% (product B)	1,000 baht/ton

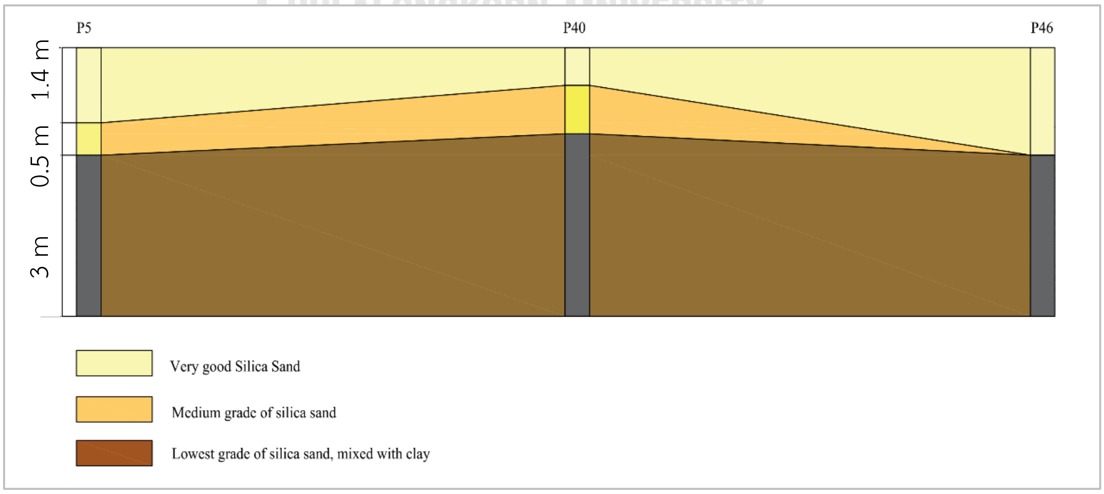
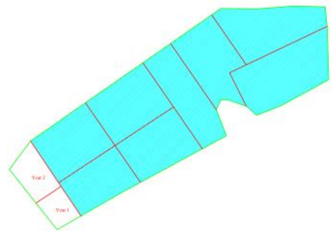
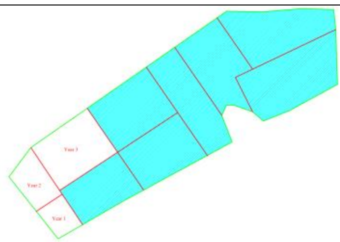
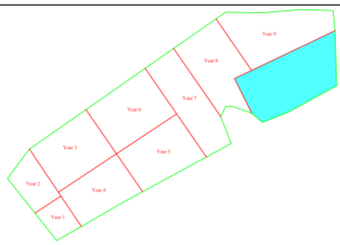


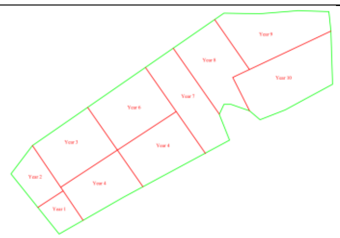
Figure 1-5: Soil Profile of the representative borehole from West to East in this study

From Figure 1-5 shows that the average depth of surface area that contained high grade of SiO_2 approximately – 1.5 meter, which is covering of resources approximately 1,378,798 cubic metrics, whereas the lower grade began from the -1.5 to – 5 meters, resources 10,281,292 cubic metrics of sand. There are two main production areas, the first area is operating within 10 years. Whereas, the second area is operating within two years. On another hand, this washing plant will operate 8 hours per day and 26 days per month. The operation plant based on the capacity of the machinery, which is can be conducted with 100 ton per hour in the first year, 200 ton per hour in the second year, and 400 ton per hour from third to tenth years. Moreover, production A will be produced 50,000 ton every year, and production B = 200,000 tons in the first year, 450,000 tons at second, and started produced 950,000s ton respectively until finished the production as shown in Table 1-5.

Table 1-5: Production plant and geometry of the layout

Year	Production ton/year	Geometry
1	250,000	
2	500,000	
3	1,000,000	

4	1,000,000	
5	1,000,000	
6	1,000,000	
7	1,000,000	
8	1,000,000	
9	1,000,000	

10	1,000,000	

1.5 Statement of problem

Silicon dioxide is the dominant one of only contain a very high proportion of silica but also should not contain more than strictly limited amounts of certain metallic elements. Due to the presence of iron oxide impurity in the silica sand can be more effective the optical properties of glass, higher weight percent of iron oxide the glass will change the colour to brown or green, produces varying shades of green in glass, and also control ultraviolet and infrared transmission of commercial glasses [9, 10].

Grain size is also an important factor since the coarser sand will be difficult to melt, whereas, the more efficiency ranges from 0.1 to 1.0 mm [11]. In ordered to make either colourless glass or optical glass, the raw material must contain iron oxide less than 200 ppm in this study. However, Sihanoukville province in Cambodia has one of the substantial potential raw material of white silica sand, yet it is still containing a high proportion of impurity, especially iron oxide, aluminium oxide and another heavy mineral at the depth -1.5 meters downward.

1.6 Objective of the study

The aims of this study are:

- To implement the method of beneficiation and upgrade silica sand for commercial specification.
- To determine project financial evaluation, discounted cash flow (CAPEX, OPEX, NPV, IRR, MIRR, and Discounted payback period).

1.7 Scope of work

In this study was started from collected the primary data and information from the government to conduct on pre-feasibility study, which divided into two parts.

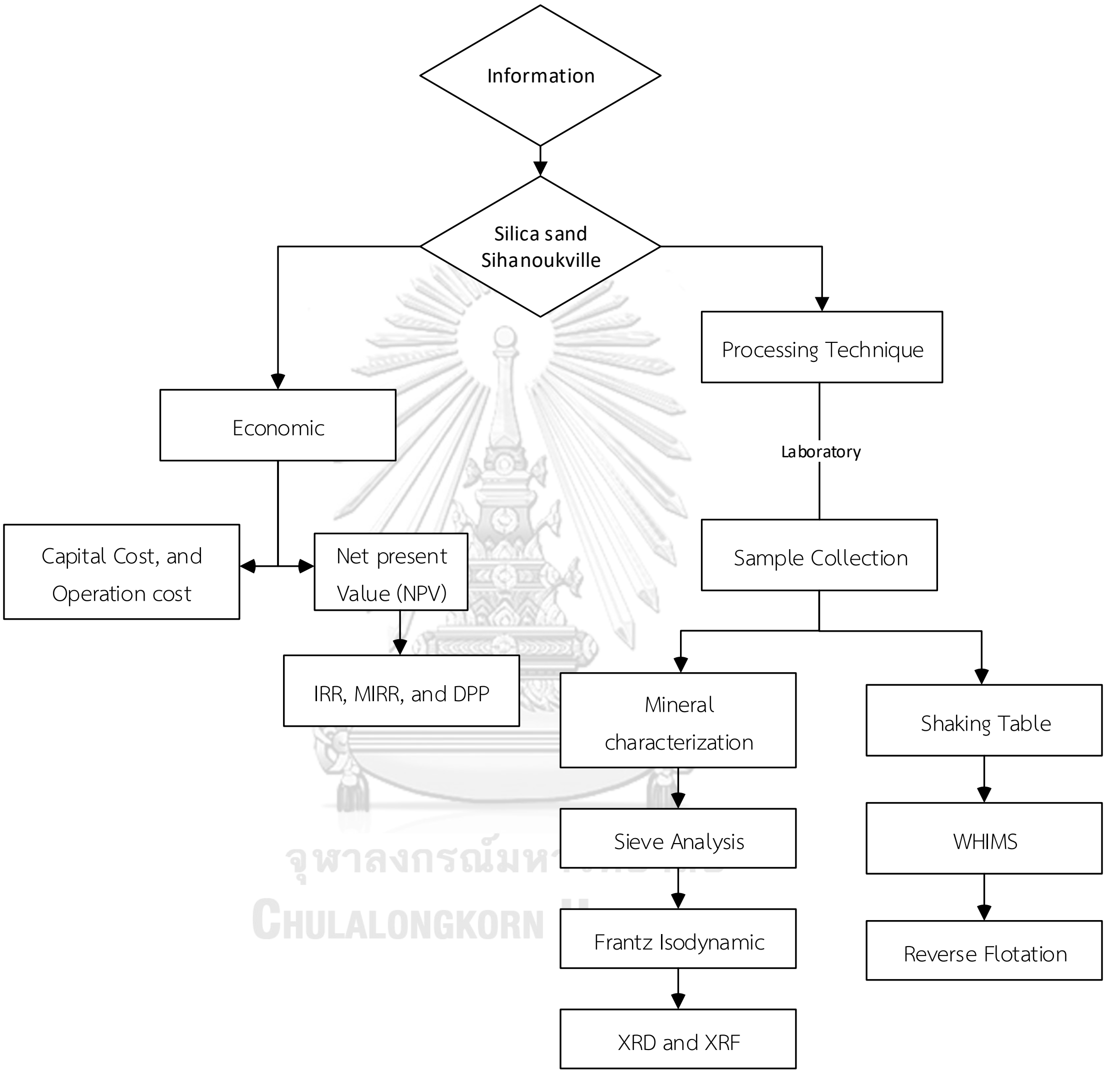


Figure 1-6 Procedure of this study

1.8 Expect benefit

This study can be more benefited for the glass industry including

- Providing the technical for silica sand upgrading by physical and chemical processes to meet a high requirement for very pure silica

- Illustrating the estimation method for project financial evaluation.

1.9 Outline of thesis

To present in this study, which is separated the contents into main fives chapters as follows:

CHAPTER 1: Introduction has indicated the background, the location of silica sand, application of silica sand, its application, and policy framework of Ministry of Mine and Energy of Cambodia. Also demonstrated the objective and expected benefit from this study.

CHAPTER 2: Presented the literature review, the relevant theory, previous study for upgrading the silica sand, and the project evaluation.

CHAPTER 3: Illustrate the methodology for silica sand processing, determine the unit operation, and economic evaluation.

CHAPTER 4: Present the result and discussion from characterized of the sample, Upgrading silica sand, and economic analysis.

CHAPTER 5: Provide the conclusion and recommendation for further study.

CHAPTER 2
LITERATURE REVIEW

This chapter provides an overview of previous research on the topic which is related to this study. It is introduced the methodology, parameter of the condition, and some influence factors to evaluate the project base on its economic analysis. The mains sections are divided into two parts which including the Silica sand upgrading, and Project evaluation.

2.1 Silica sand upgrading

The aims of an upgradation silica sand to provide the specification glass material. There are many methodologies to separate the impurities from silica sand such as gravitational, physicochemical, and chemical treatment. These studies consist with other researchers who have investigated the same response for this methodology.

2.1.1 Physical separation

In term of SiO_2 is purify up to a certain level by physical separation processing. in the general, the process of purifying silica sand comprised washing and desliming the sand to remove the major oxide some part of clay mineral binder, attrition scrubbing, drying. Moreover, the magnetic separator also conducts to remove the heavy mineral from silica sand as they are mostly paramagnetic or ferromagnetic. Those particles are attached by a magnetic field, and non-magnetic fraction defined as silica. This process was suggested by Raghavan, et al, Manel, et al, and Ibrahim et al. [12-14]

Raghavan et al. 2006 [12] were studied on the development of a beneficiation flow sheet for processing silica sand from Cherthala, India. The experiment was conducted with a wet process, scrubbing, screening, attrition following by magnetic separation, classified by hydro-cyclone, the final stage is a spiral classifier. The representative sample size – 600 + 106 μm, a varied condition in this study are percent solid of attrition, and time of scrubbing following by high intensity magnetic 3.2 Amp. Moreover, the optimized condition in this research was scrubbing within 30 min, can removed iron from 0.025% to 0.006%, and 55% solid can be removing impurities iron oxide from 0.021% to 0.0122%.

Ibrahim et al. 2013 [13] also worked on gravity separation method for upgrading the value of silica sand for glass industrial from Egypt. The experiment was carried out with dry sieve analysis, attrition scrubber and Wilfley shaking table try to adopt simple cost-effective, and environment-friendly processing by following this process. The representative sample was using sieve analysis to measure the particle size distribution to rejected + 0.6 mm and – 0.10 mm fractions from the sample, the fraction – 0.6 mm + 0.10 mm to directed to attrition scrubbing with sufficient pulp density, attrition impeller speed and time. Furthermore, the shaking table was carried an outfeed rate of water, stroke length, and deck inclination, the optimized condition parameter pulp density 65-70 % of solid. Plus, the speed of impeller 2400 rpm, time of scrubbing 30min, deck inclination of shaking table from 7.5^0 to 8^0, the stroke length 2.5cm, and the flow rate of water 15 l/min. However, iron and alumina oxides can reduce from 0.039% Fe_2O_3, 0.041% Al_2O_3 to the final products 0.018% Fe_2O_3 and 0.090% Al_2O_3. It was the applicable quality of optical applications.

Manel et al. 2016 [14] have studied on quartz sand beneficiation using magnetic and electrostatic separation for glass application in Tunisia. In this experiment were conducted with attrition scrubbing 10 min, classified particle + 0.1 to – 0.63 mm, then separated into two procedures the first fraction went to shaking table, WHIMs then the final product directly to electrostatic separation with high voltage 28Kv retained the nonconductor are the production sand. Plus, the second fractions went directly to WHIMs (intensity 20,000 Gauss) retained the nonmagnetic fraction are the final products. The products from WHIMs following by electrostatic can upgrade silica SiO_2 from 99.39% to 99.99%, and reduced Fe_2O_3 from 0.12% to 9 ppm, Al_2O_3 from 0.29% to 80 ppm, TiO_2 from 0.033% to 10 ppm. For the products directed from WHIMs can upgrade SiO_2 from 99.34% to 99.51%, and reduced Fe_2O_3 from 0.12% to 310 ppm, Al_2O_3 from 0.29% to 0.14% and TiO_2 from 330 ppm to 100 ppm of concentrations.

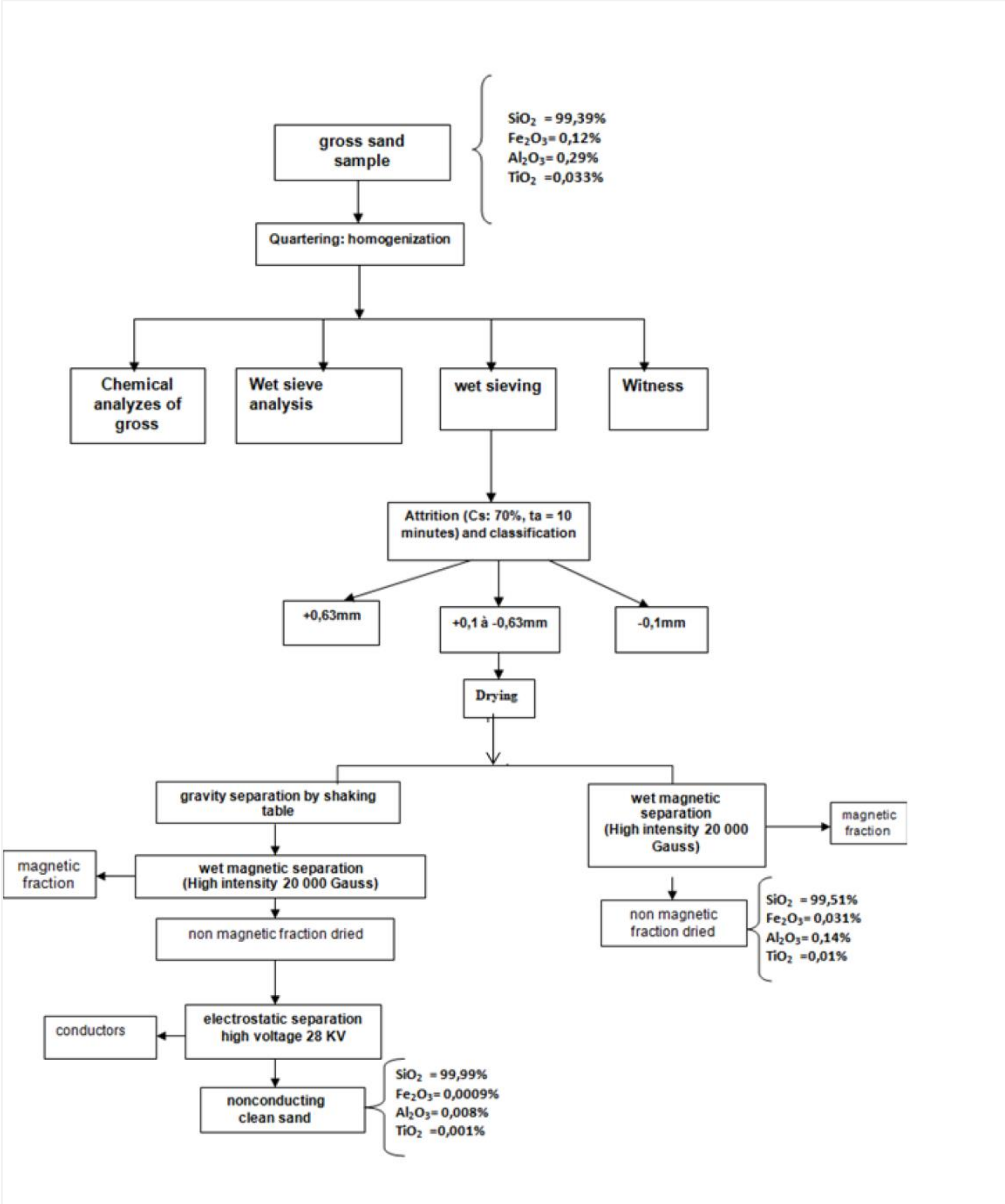


Figure 2-1: Flowsheet of two presented schemes for upgrading silica sand by Manel et al 2016

2.1.2 Frother flotation

Forth flotation selectively separates mineral according to differences in their ability to be wetted, enhance or suppressed by conditioning reagents. The separation will be taking place in a water-filled medium into which the ore is fed to forms suspension which is agitated to avoid sedimentation process of fine particle ore. There were some noticeable factors will be influenced in this process such as frothing agent, hydrophobic and hydrophobized mineral particles. Heavy mineral, feldspar or mica and other impurities attached to the air bubble and raised to the surface forming froth whereas hydrophilic particles sinking down to the bottom of the flotation cell.

D. Mowla et al. 2008 [15] conducted with remove hematite from silica sand by reverse flotation technique in Iran. The experiment focused on the efficiency of iron removal by various the condition of time reaction, temperature, collector's consumption, pulp solid concentration, and pH control. Whereas the result showed that separation of hematite from silica sand by reverse flotation was accomplished, with exists optimization of collector concentration from (Aero 800-series). Moreover, the satisfy result of % solid indicated 20% highest removed iron oxide reached 40% of removal, conditioning time 4 min is optimized, the collector consumption could not more than 1.5 g/kg (1500g/t) can removed iron from 0.022 to 0.018% respectively, and pH (H_2SO_4) = 2.5 is the best condition that can remove iron until 39%.

On another hand, EI EI Win 2015 [16] also studied on upgrading silica sand from Thung Tago Deposit in Thailand. The experiment was conducted with laboratory scale by using a Shaking table, wet high-intensity magnetic separation (WHIMS), flotation, and acid leaching. There are some various parameters in this study, which is optimized for iron oxide remove from silica sand. Undertake inclination of shaking table 10^0, 12^0, and 15^0, WHIMS are using the 12-15 Amps of the current magnetic field (Maximum), whereas the flotation was used AOA and NANZA promoters, H_2SO_4 as a modifier and pine oil as a frother. Moreover, acid leaching was conducted with HF 20ml, 10-70 % solid, from 0.5 to 5 hours ranges. HCL 20ml the same condition with HF, and H_2SO_4 20ml as a final test within 10-70% solid as well, time reaction ranges from 0.5 to 5 hours. The result was shown the best condition from shaking table was 10^0, flotation test is reducing iron oxide from 0.07 wt. % to 0.05 wt. % is the best condition achieved from using 100ml collector's dosages. In another hand, leaching test within suitable condition 5 hours of reaction time with 20% solid of each test.

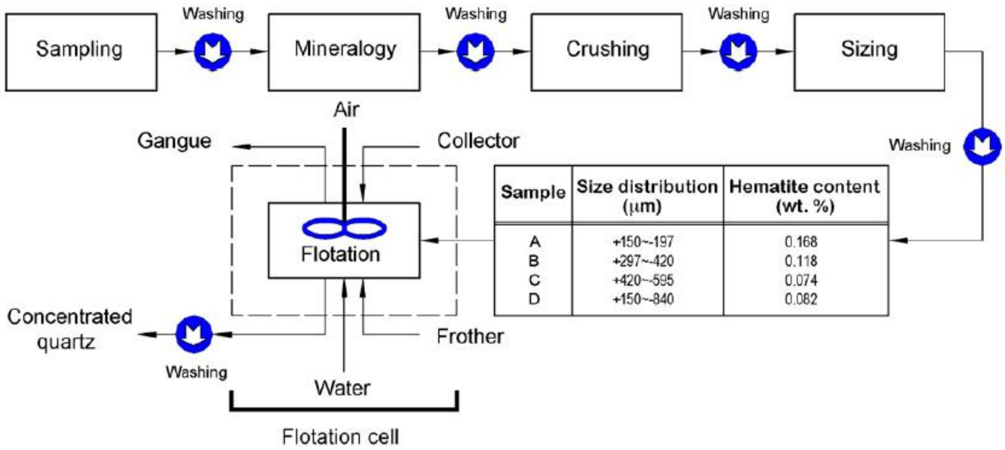


Figure 2-2: Block diagram for hematite removal process, D. Mowla et al. 2008

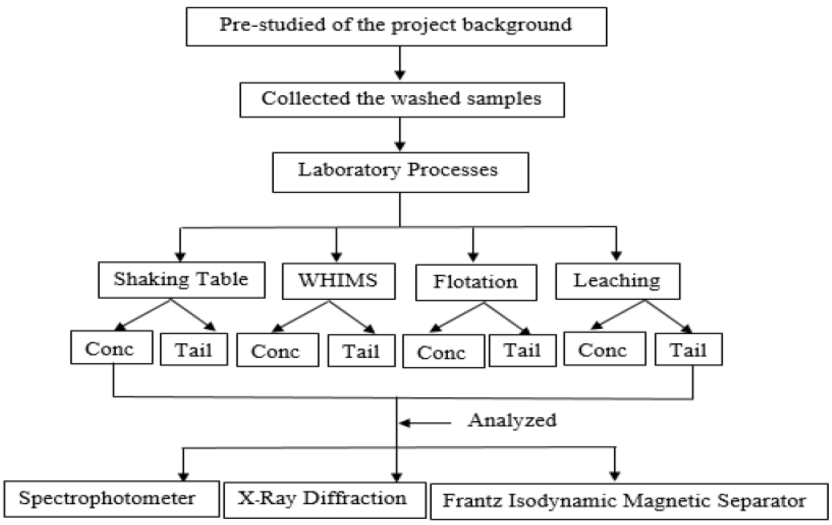


Figure 2-3: The suggestion in silica sand upgrading from Thailand, EI EI Win

2.2 Project evaluation

A pre-feasibility study is used the discount cash flow method to determine the economic factors such as the net present value NPV, internal rate of return IRR, the modified internal rate of return, and discount payback period to figure out the time to recover the capital cost back [17, 18]. Bhagwat et al, 2001 has been studied on feldspar and quartz preliminary feasibility study in Kankakee country, which is used the preliminary economic analysis of the feasibility of extracting and marketing feldspar and quartz sand or silica sand. The result confirms that 74% quartz (silica sand) 21% feldspar and 5% other minerals, the proposed processing plant was designed for an annual capacity of 112,000 tons raw input or 100,000 tons of production.

The basic operating condition assumed two shifts per day and 200 working days per year. The commercially available data were used to estimate the initial mining and processing plant investment and operation cost. Initial depreciable investment including the equipment, transport, and installation range from $ 1.67million to $ 2.41 million, whereas the operation and maintenance cost, ranges $85 to $111 per hour at the discount rate 18%. The pre-feasibility study estimate indicates that profitability increases significantly if the plant is assumed to be operable for three shifts per day and 250days per year, are recommend by operator[17]. On another

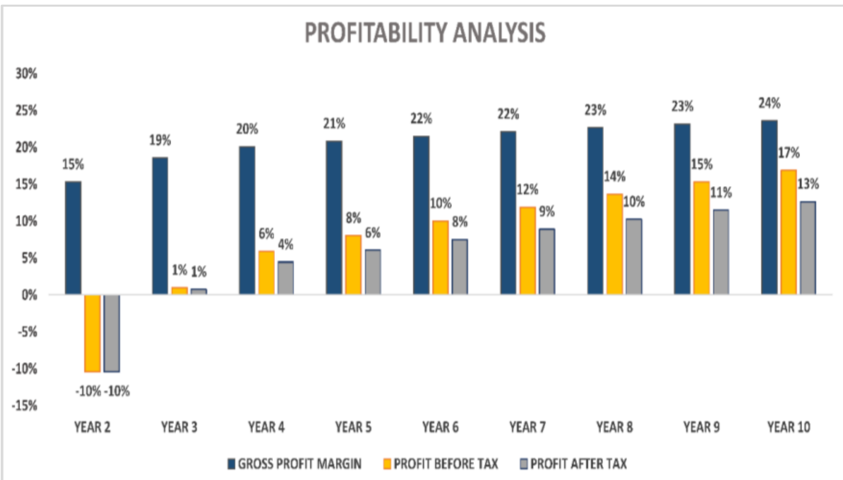


Figure 2-4: Profitable analysis

hand, USAID Pakistan also conducted on silica sand processing plant for float glass manufacture by using pre-feasibility study to identify the projects, for technical strength investment. The result shows that the total cost of operation PKR1.67billion in the first year, expected to rise to KPR4.199 billion by year 10. And the project IRR = 19.31%, NPV = 808,641,858 PKR, equity IRR = 19.74%, and NPV equity = 608,754,835KPR as shown in Figure 2-4. [18]

Kem 2013 [19] has been studied on pre-feasibility of limestone quarry development for the cement industry in Cambodia, were developed a financial analysis involving discounted cash flow model, the net present value (NPV), internal rate of return (IRR) and weight average cost of return (WACC). Moreover, the mine operation also has been calculated within the optimum condition. Which is material handling, truck estimated, loader, and an excavator to fulfil the requirements of unit operation in quarry surface mining. The result was shown NPV = 19.3 million dollars, IRR = 45% higher than WACC = 15%.

Phaisopha 2015 [20] has been conducted with the pre-feasibility study of gold mining development in Lao PDR. In this research focusing on the technique of development in mining method, and financial analysis model using discounted cash flow DCF, a criterion net present value NPV, internal rate of return IRR, and weight average cost of capital WACC. To optimize the operation cost and proposed some mitigation guideline for investment, social impact and environmental impact. The result was shown geological resources of gold approximately 34.87 MT, within approximate reserve 2.44 MT of gold. Therefore, NPV = 1.93 million dollars, IRR = 22% higher than WACC = 12.6%.

CHAPTER 3
MATERIAL AND METHODOLOGY

The aim of this chapter to provide the methodology of silica upgrading value, and project evaluation. It was conducted with a laboratory scale which is using the optimum condition of each processing method either physical or physicochemical (reverse froth flotation) processes. In this study attempt to remove the iron oxide from the third layer of soil which contains high iron (Fe_2O_3=0.18%) to meet the requirement of production A: Fe_2O_3≤0.02%.

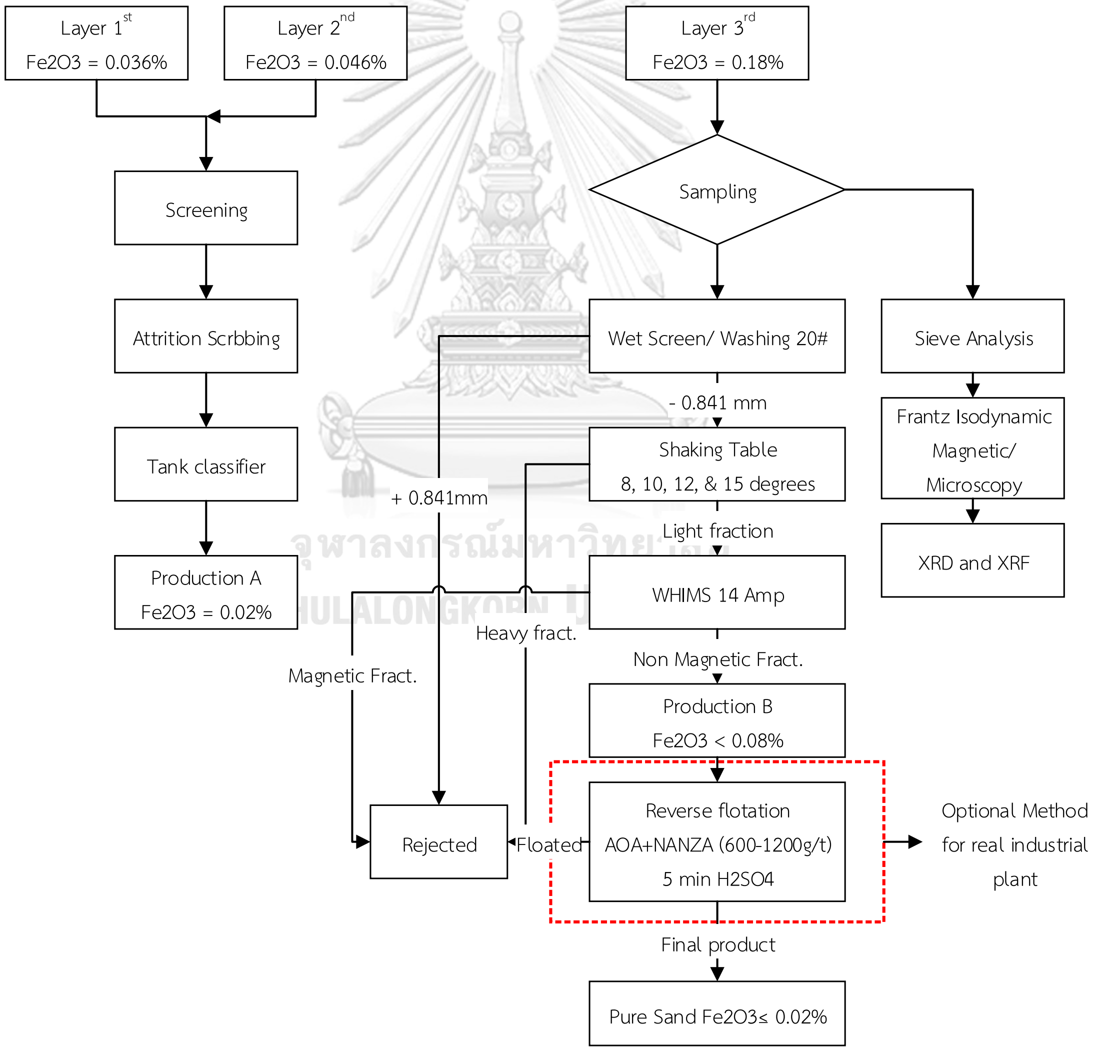


Figure 3-1: Methodology of processing sand

Following the procedure of the methodology upgrading silica sand to meet the commercial specification of glassmaking material. In this study was classified the soil into three layers, the first and second layer are a very good quality of silica, and the third layer is the lowest quality of silica which is conducted in this experiment as shown in Figure 3-1.

3.1 Material and sample preparation

The sample in this study was taken from the third layer of soil from -3meters to -5meters, due to the grade of silica sands are very low which has mixed with clay mineral and silt from that area as shown in Figure 3-2. The bulk sample approximately 5,000gram after dry of each hole of sampling from Steung Hav district, Sihanoukville province, Cambodia. The Hand auger is using for collecting the sample by removed the surface soil with the shovel - 0.5 meters then continuing with the auger to approached - 2 meters depth. Then, take it from field to laboratory approximately 630 km in order to dry 24 hours with 105 $^{\circ}C$ to determine the moisture of sands, and started further experimental in the Mining laboratory in Chulalongkorn University, Thailand.

Figure 3-2: Sampling of Raw Material by removed the overburden and Hand Auger

John riffle is the sampling splitter to get a representative sample for doing a further experiment, it is open V-shape and used to reducing the amount of sample to obtain a reasonable representative. The silica sand flows through alternatively arrange passage, in the opposite direction into the two-collecting pan under the dividing head outlet. The feed sample was taking out 200g to investigate by sieve analysis for 20 minutes.

3.1.1 Characterization of raw material silica sand

3.1.1.1 Particle size distribution

Particle size distribution of raw material was investigated by using sieve analysis to determine the particle size of the sand sample. Before running experiment, the sample has dried for 24hours then further used the john riffle splitter 2000g of sand until 200g is obtaining a representative sample. Furthermore, the 200g of sand was sieved through size including #20 (841 μm), #30 (600 μm), #40 (425 μm), #70 (212 μm), #100 (150 μm), #140 (106 μm), and #200 (75 μm) within 20 minutes shown in Figure 3-3. After finished sieving, weight the each of retained to calculate cumulative passing and retaining represent by plot chart in order to determine the average particle size of all sample by D50. The investigation of particle size of the sample is essential for mineral processing, which is used for equipment selection, pumping machine, and limited capacity of instruments.

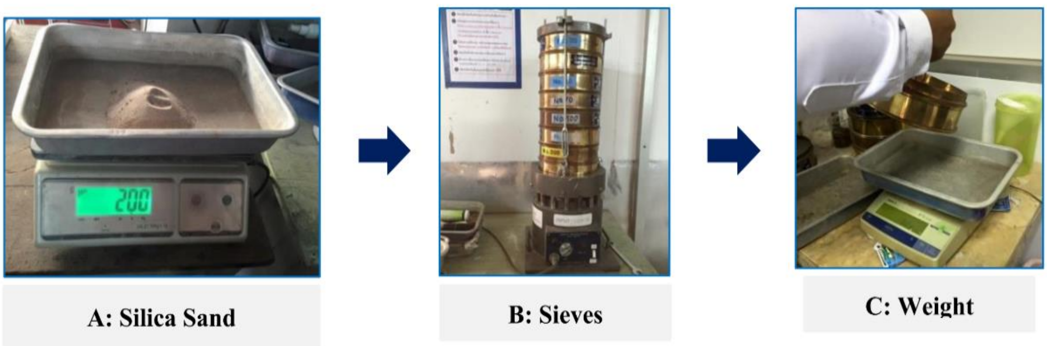


Figure 3-3: Sieve analysis

3.1.1.2 Frantz isodynamic magnetic separator

Frantz isodynamic magnetic separator machine Serial N.1454, made in the USA by S.G Frantz c., Inc. was used to separate and identify a magnetic and non-magnetic mineral by small portion fraction. The side slope commonly uses a fixed to 25 degrees and 10g of each sample feed into the feeder and passed the separator at the current set 0.4 Amp to take out the magnetic fraction, then the non-magnetic directly refeed into vibration cone again at 0.7 Amp and label magnetic fraction. Finally, a process using 1.2 Amp sequence from 0.7Amp, Therefore, both magnetic

Figure 3-5: Frantz isodynamic magnetic separator

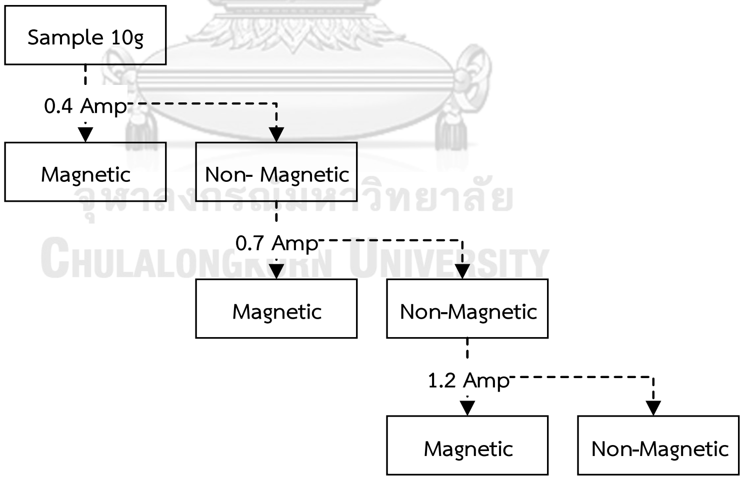


Figure 3-4: Frantz Isodynamic magnetic separator (FIMs) procedure

and non-magnetic fraction was collected to see under a binocular microscope in order to identify particularly sample by physical properties and its magnetic susceptibility to correlated with the result from XRF and XRD was shown in Figure 3-4.

To identify mineral under microscopy for each magnetic fraction separate the grain into various groups. To assign a mineral name to each group, the properties that are most easily recognized under a binocular microscope are colour, luster, cleavage, and shape.

Table 3-1: Type of susceptibility's mineral separated by Frantz isodynamic separator

The magnetic field at Amp	Type of mineral
0.4 A	Garnet, Ilmenite, Siderite
0.7 A	hydro ilmenite, columbite, Tantalite, Wolframite, xenotime, hematite, laterite, tourmaline
1.2 A	Hydro ilmenite, struvite, muscovite, biotite,
Non-magnetic	Cassiterite, rutile, zircon, pyrite, quartz

3.1.1.3 X-ray diffraction and X-ray fluorescence

a. X-ray diffraction

X-ray diffraction is a technique used to study non-destructive crystalline structures, that impact the crystalline surface of the sample at the different angles. The result will be compared to the standard database, to determine the composition compound base on Bragg's law the X-ray absorbed through the crystal layer. This will cause the reflection at the surface of each atom as shown in Figure 3-6. The condition for maximum intensity contained in Bragg's law allows to calculate detail about crystal structure and determine the wavelength of the X-ray following by Equation $n\lambda = 2d\sin\theta$, Where λ=wavelength (nanometer), d = lattice spacing (nanometer), n = order number.

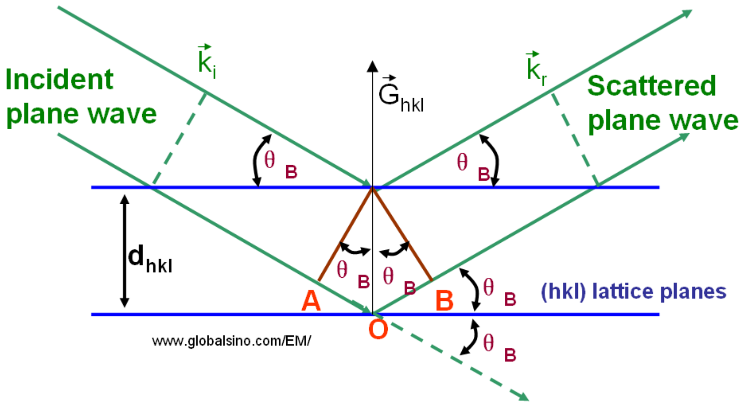


Figure 3-6: Bragg's Law

b. X-ray fluorescent

In this process undertook by using approximately 10g of samples. All the sample putting in this system for analysis that sample must grind by cup mill and compressing by hydraulic into a plate before doing analysis showed in Figure 3-7. In this case, all samples were added chemical binder polystyrene powder RS1100 to prevented from failure or crack. To use this model of XRF correctly and safely carry out following startup before operating.

However, the error percentage is still concerning which occurred during the sample preparation. Some of the samples are rising the contaminate of iron oxide and another heavy mineral which came from an old cup mill. By doing so, to make an accurate to result must be proper preparation and clean the cup mill with the alcohol every time, before ground sample. Make sure the time of grinding is not exceeded 40 seconds if the longer time of ground the sample will be rising the contaminants as well.

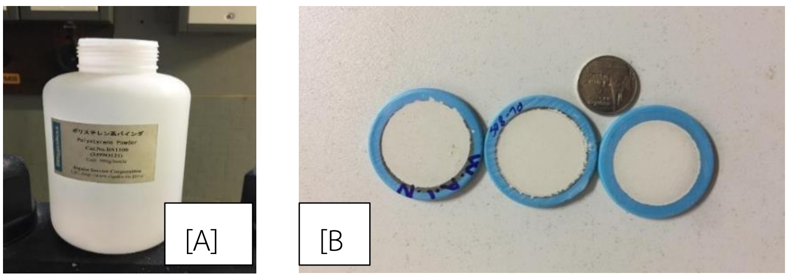


Figure 3-7: [A] Binder chemical RS1100, [B] Sample for XRF

3.2 Wet sieve and hand washing

All samples which were taken from the field directly investigated by wet sieve process using tray number 20 mesh (841 μm) and clean by water spray to remove the biomaterial such as wood, the root of grasses, and charcoal. Therefore, the oversize of 841 μm was rejected as waste and undersize further dry within 24 hours for further.

3.3 Shaking table

Shaking Table has been used in mineral processing base on their properties. In this case using the Wilfley model which is 45 cm of wide, and 100 cm of length within capacity 50 kg per hour. Therefore, 1 kg of the sample was prepared by a sampling of bulk 5 kg through sampler splitter from the previous method of wet screening to get a representative sample before doing an experiment. After drying for 24 h within 105 ^{0}C in the oven before doing the shaking table.

In this process, were repeated until having no longer or a very small portion of middling around six times. There is three mains factor that can be effective in this operation such as deck angle of the table, water flowrate and frequency of shaking. In this study, was using water flowrate 220 ml/s, frequency 276 rpm and various condition of deck angle of table range from 8, 10, 12, and 15^{0} shown in Figure 3-8.

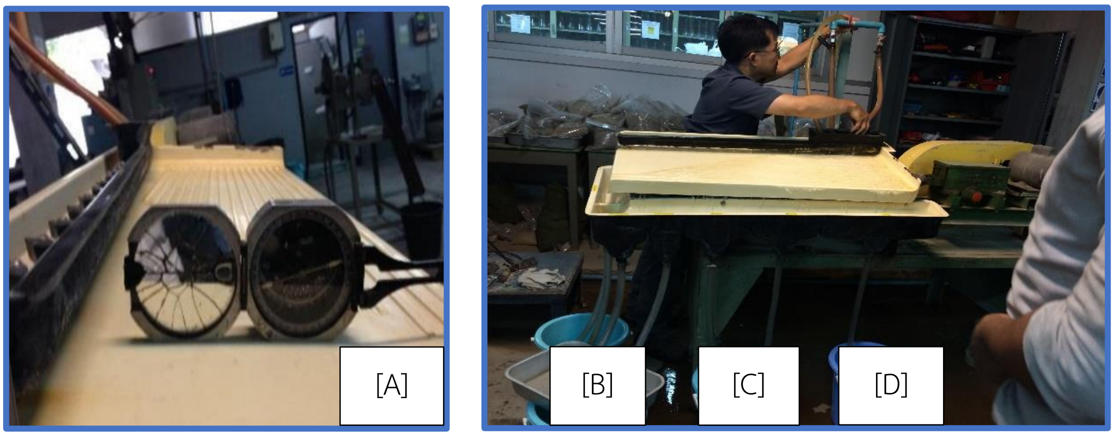


Figure 3-8: Shaking table operation [A] Compass to measure the inclination of deck, [B] Heavy fraction (waste) [C] middling, [D] Light fraction (product)

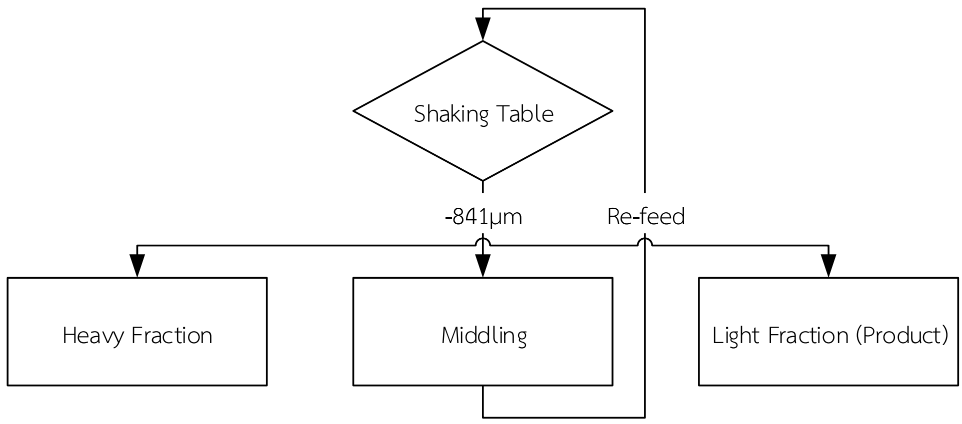


Figure 3-9: Shaking table Procedure

3.4 Wet high-intensity magnetic separator

WHIMs ERIEZ Magnetic T450388 model, it was used water flowrate 70 ml/s, Tension (volt = 70V), Intensity (Ampere = 14-15Amps). This WHIMS machine consists two electromagnetic coils with stainless steel box, which has a flux covering element is located between magnetic poles 20.32 cm of high, 5 cm of wide, and 2.5 cm of deep with inlet and outlet. In this process are repeated only 6 times.

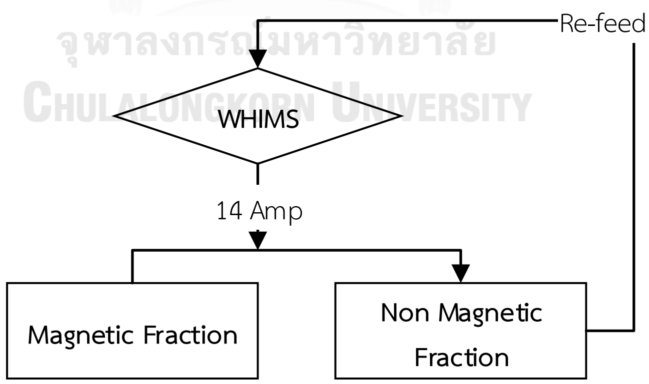


Figure 3-10: Wet High Intensity Magnetic Separation process

WHIMS process first turns on the machine and adjust an ampere button to 14 or 15 Amp that is the maximum of capacity for this model. Adjust the water flow rate by manually then flow the slurry through the magnetic coil so that the iron will be stick with magnetic susceptibility, and nonmagnetic fraction can come through a magnetic field by water flow. After finished turn off the magnetic field and using the water to remove all magnetic minerals repeatedly until having no magnetic fraction. After that, all fractions were dried 24 h in the oven before checking Iron percentage by XRF.

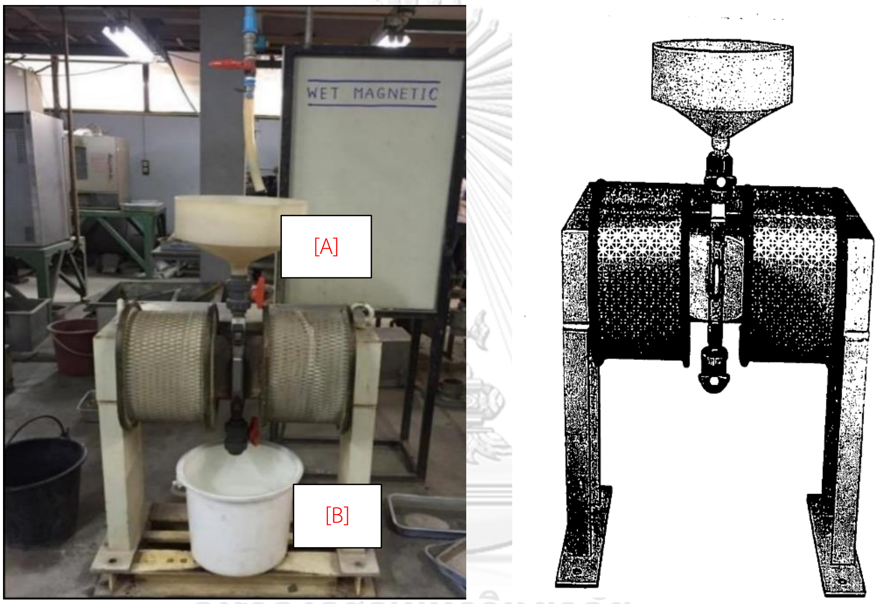


Figure 3-11: Wet high-intensity magnetic separation [A] input slurry, [B] output non-magnetic fraction

3.5 Reverse flotation

In this study, the froth reverse flotation method was applied to remove Fe_2O_3 and associated heavy mineral from silica sand to meet the specification of colourless glass requirements in term of pure silica by using H_2SO_4 as a modifier. The promoter AOA (named by a local company in Thailand is Amine, a cation to recovery the heavy minerals from sand) and NANZA (Petroleum Supinate, anion collector to recovery metal from sand), and pine oil as a frother. The sample washed from WHIMS process range from 700-1000g of each condition with the water 4l to produce the slurry stirring. In this experiment was carried out two conditions to figure out the best condition for either further experiment or real processing plant including AOA + NANZA ranged from 600 to 1,200 g/t, and speed of agitator equal to 1200 rpm. Therefore, Sulfuric acid H_2SO_4 10% equal 600g/t into the cell to modify the physical properties of the solution, which is pH value checked by the paper of pH meter in each experiment range from 1-2 before injected cation collector AOA into the cell to reacts 5 minutes then injected pine oil 20 g/t into the stirring process.

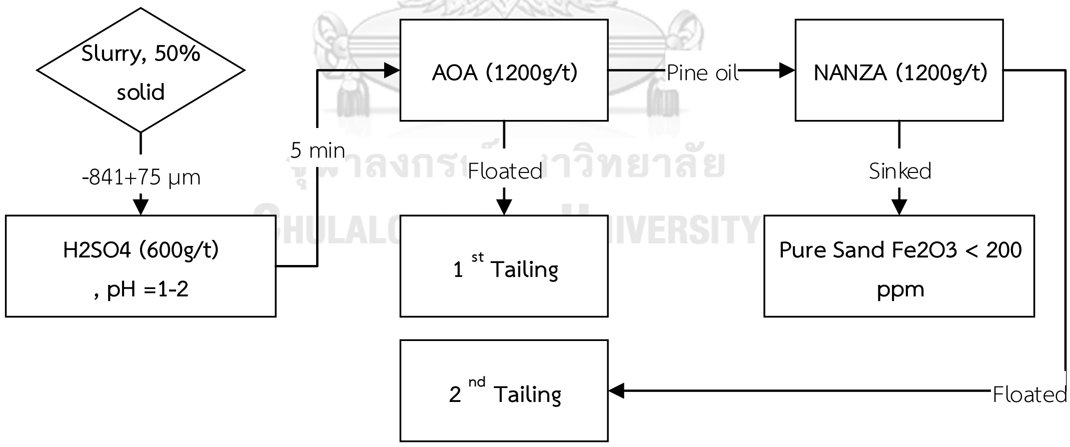


Figure 3-12: Reverse flotation procedure

Figure 3-14: [A] Collector AOA & NANZA, [B] pH paper to measure pH in slurry of sample, and [C] pine oil frother

Figure 3-13: Flotation cell operation (4l capacity)

In the final step, opened the inlet of the air to generate the bubble attached by the collectors and floated it up to the surface. Usually, the air was closed during the experiment before adding pine oil, after finished first cleaner then closed air again. In this experiment is a sequencing process which means that new collector NANZA was added into the cell after removing all bubble from the cell, then kept it stirring for 5 minutes before injecting new pine oil 20 g/t to generate a new bubble. Furthermore, open inlet air to generate new bubbles, a pure silica sand was taken from the cell and dilute water, dry for 24 hours afterwards before checking the chemical composition through XRF.

3.6 Project evaluation

The pre-feasibility study was focusing on method to evaluate the project in order to make the final decision for investment, which is considering as the Net present value, the internal rate of return, the modified internal rate of return, and discount payback period. Basically, there are two types of evaluation techniques such as traditional techniques and discounted cash flow or time adjusted techniques shown in Figure 3-15. In this study will be focused on discount cash flow (DCF) to determine the Net present value (NPV), Internal rate of return (IRR), Modified internal rate of return (MIRR), and discount payback period (DPP).

The cash flow in this study is referring to a net inflow of money that occurs during a specific period Following by some equations below

- Gross profit = gross revenues – operation expense – depreciation & depletion
- Net profit = gross profit (taxable income) – tax
- Cash flow = net profit + depreciation and depletion – capital cost

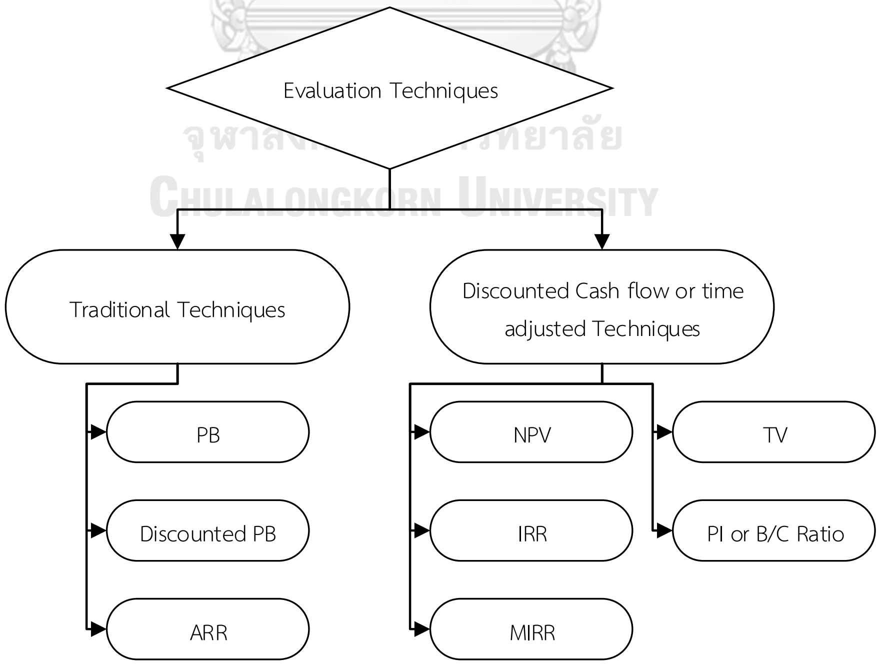


Figure 3-15: Method of Project Evaluation

The discounted cash flow method is widely accepted and used in the industry for all types of capital investment evaluations [21]. It is critical when assessing the profitability of long-term investment where PB = payback period, ARR = accounting rate of return, MIRR = modified rate of return, TV = terminal value, and PI = profitability index or benefit/cost ratio.

3.6.1 Net present value (NPV)

The net present value (NPV), also referred to the present value of cash flow surplus or present worth, which is obtaining by subtracting the present value of periodic cash outflow from the present value of periodic cash flows. The present value calculated by using the weighted average cost capital of the investor also referred to the discount rate or minimum acceptable rate of return [20].

$$NPV = \frac{S_1}{(1+i_d)} + \frac{S_2}{(1+i_d)^2} + \frac{S_3}{(1+i_d)^2} + ... + \frac{S_n}{(1+i_d)^n} - I_0$$

$$NPV = \sum_{t=1}^{n} \frac{S_t}{(1+i_d)^t} - I_0 \qquad \text{Equation 3-1}$$

$$NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+i_d)^t}$$

Where St = the expected net cash flow (gross revenue – LOE – taxes) at the end of year t

I_0 = the initial investment outlay at time zero

I_d = the discount rate,

N = the project's economic life in years

NCF = net cash flow

Rule of investment, If the NPV is positive, the project is acceptable, and NPV is negative, the project is rejected. If NPV is zero meant the discount rate equal to the internal rate of return.

3.6.2 The internal rate of return (IRR)

The internal rate of return (IRR) is another important and widely reported measure of profitable of the project. The rule of making the investment decision when using IRR:

- Accept the investment if the IRR is higher than the return on the alternative use of fund or capital cost
- Reject the investment if calculate IRR is less than the return of Capital cost

Following the Equation 3-3.

$$\sum_{t=1}^{n} \frac{NCF_t}{(1+IRR)^t} = 0 \qquad \text{Equation 3-2}$$

The internal rate of return on either investment or project is the annualized effective compounded return rate or rate of return that makes the net present value of all cash flows both positive or negative from a particular investment dual to zero [22].

3.6.3 The modified rate of return (MIRR)

MIRR is a financial measurement of an investment's attractiveness. It is used in capital budgeting to rank alternative investment of equal size, aim to resolve some problems with IRR [23, 24]. The MIRR is a function of both reinvestment rate and the pattern of cash flow, with higher reinvestment rate leading to greater MIRR [25]. Following by equation below

$$MIRR = \sqrt[N]{\frac{\sum_{t=1}^{N} CIF_t (1+WACC)^{N-t}}{\sum_{t=1}^{N} \frac{COF_t}{(1+t)^t}}} - 1 \qquad \text{Equation 3-3}$$

Where CIF = cash inflow, COF = cash outflow, WACC = weight average cost of capital, N = year, t = discount rate.

$$WACC = \frac{E}{D+E}(r_e) + \frac{D}{D+E}(r_d)(1-t)$$ Equation 3-4

Where E = market value of equity

D = Market value of debt

r_e = cost of equity

r_D = cost of debt

t = corporate tax rate

The decision rule for the MIRR is to invest in a project if it provides a return greater than the cost of capital, which means the investment is expected to return more than a requirement. If MIRR less than capital cost rejected, which mean the investment is expected to return less than a requirement. If MIRR equal to zero are indifference between accepting or rejecting the project, which means the investment is expect5ed to return what is required.

3.6.4 Discounted payback period (DPP)

The discount payback period (PP) is the number of years for the projects to break even. The number of years for which a discounted annual net cash flow must be summed before the sum becomes positive [26]. The Payback period is the time during which the initial cash outflow of investment is expected to recover from the cash inflows generated by the investment.

- Discounted Payback Period = Cut off Period + Initial investment / Cash inflow per period [27].

CHAPTER 4
RESULTS AND DISCUSSION

In this chapter reports the result of all experiments from the first method until the final product of pure silica sand is reported. Due to the experiment gravitational could not upgrading silica sand until meeting the high purity sand, that why the chemical treatment has been applying reverse froth flotation to enriching high grade of silica sand to meet the high-grade specification of glass, and the result of financial analysis.

4.1 Silica sand characterization

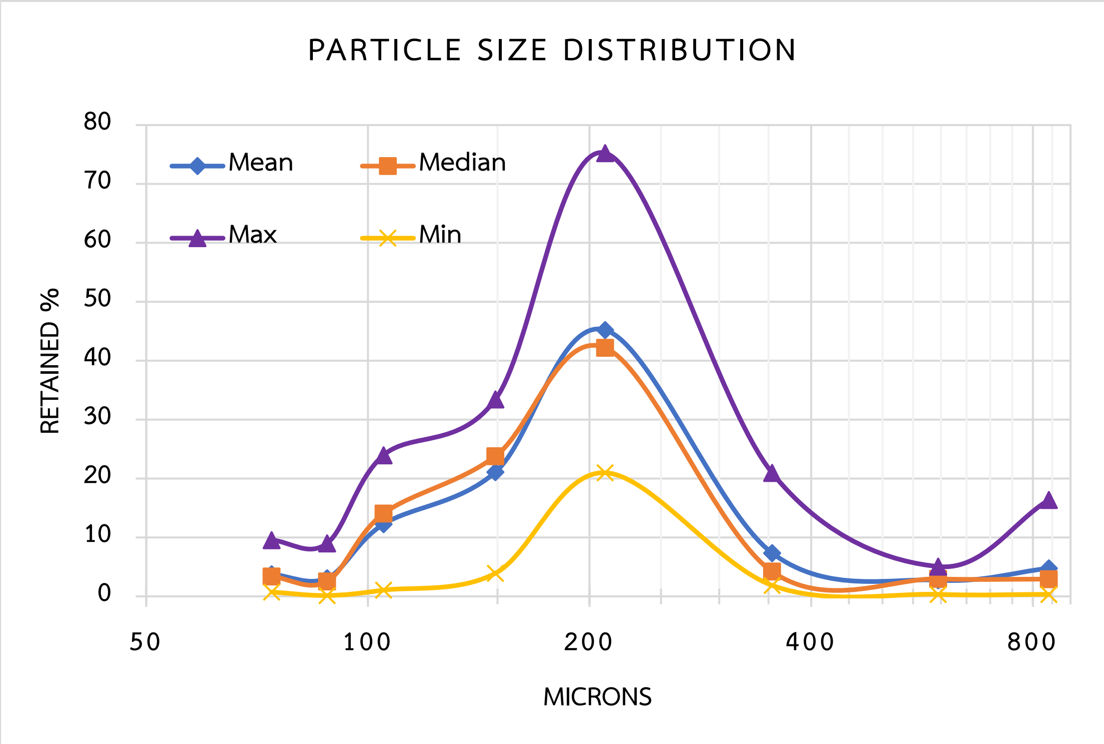
4.1.1 Particle size distribution

The result of particle distribution presented as 200 grams of sand shown in Table 4-1. The analyzed samples show a wide variation in particle size in Sihanoukville sand having a big grained size over 20# (841 μm) around 2% of representative samples, as shown in Figure 4-1, Illustrate that most of the sample is mainly retained on 70# (212 μm) was 45.22 %, and 100# (150 μm) was 21.10 % of size fractions. Plastias et al., 2014 was stated the recommendation grain size for silica sand ranged from 250 to 325 μm [28].

Table 4-1: Particle size distribution

Sample	%Wt. Retained							
Size (μm)	841	595	554	210	149	105	88	74
P32	3.13	3.28	8.63	45.11	25.08	10.95	2.52	1.56
P34	1.29	1.34	5.7	59.73	22.29	7.43	1.49	0.74
P34	0.5	0.35	1.87	46.17	33.45	13.93	2.57	1.16
P37	3.48	3.43	4.09	35.02	25.83	20.43	1.61	7.52

P39	11.81	3.38	4.34	20.99	22.35	23.97	7.42	6.86
P40	3.02	2.56	3.12	27.7	22.62	22.42	9	9.55
P41	1.92	1.97	5.85	56.81	21.8	7.21	2.12	2.67
P42	0.76	1.51	5.9	55.1	27.75	7.06	1.77	0.96
P44	14.38	3.78	3.23	33	24.77	14.18	4.24	3.58
P45	16.37	3.02	2.62	26.85	23.48	17.73	5.54	4.38
P46	3.27	2.92	3.82	39.19	28.17	16.45	2.57	3.62
P46	3.28	2.93	3.83	39.3	28.25	16.5	2.57	3.63
P49	13.77	3.68	3.53	27.55	24.12	18.21	4.59	4.99
W11	0.35	0.6	3.51	38.47	25.83	17.2	5.22	8.83
W12	1.11	2.22	14.21	75.25	3.93	1.06	0.15	2.07
W13	2.84	5.07	20.55	59.45	8.66	1.94	0.6	0.9
W5	2.32	3.07	16.67	65.61	5.44	2.77	0.96	3.17
W7	2.27	4.6	20.96	62.58	6.06	1.31	0.66	1.57
Mean	4.77	2.76	7.36	45.22	21.1	12.26	3.09	3.76
Median	2.93	2.975	4.215	42.205	23.8	14.055	2.545	3.375
Max	16.37	5.07	20.96	75.25	33.45	23.97	9	9.55
Min	0.35	0.35	1.87	20.99	3.93	1.06	0.15	0.74



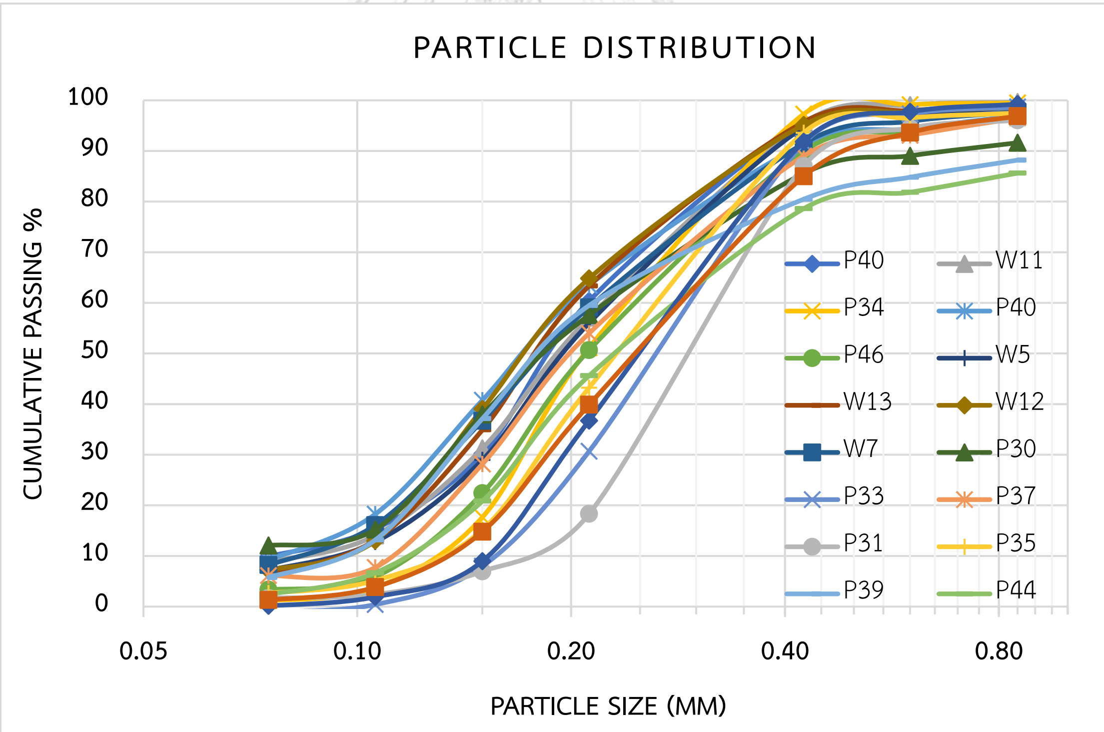
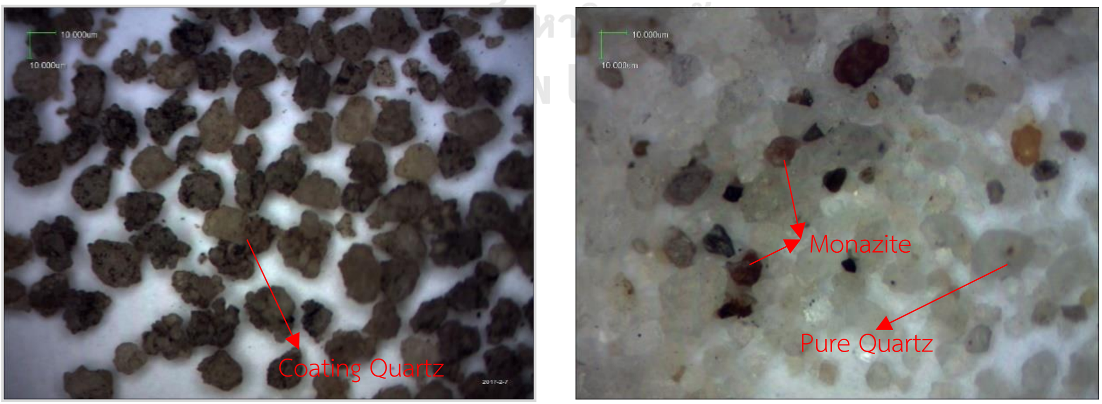


Figure 4-1: Particle Size distribution

4.1.2 Identification of mineral in silica sand

Frantz isodynamic magnetic separator was used to separate the magnetic mineral by a small portion of sample following by microscopy bases on its ampere. The experiment was conducted with 0.4 Amp, 07 Amp, and 1.2 Amp. In generally, FIMS separated a small portion of ilmenite and garnet were separated at 0.4 Amp, rutile, and tourmaline within 0.7Amp, and bearing rutile, and a small amount of garnet was collected at 1.2 Amp tailing. For those magnetic fraction defined as an unwanted product, it may contain iron mineral higher than a non-magnetic fraction.

Typically, minerals in a magnetic fraction of 0.4 Amp are ilmenite garnet and some unliberated quartz were coming up with an unwanted fraction, at 0.7 Amp magnetic fraction were indicated magnetic minerals such as monazite, hematite, tourmaline and some fraction of ilmenite and quartz, whereas the final product from 1.2 Amp there is two fractions, magnetic and nonmagnetic fraction as shown in Table 3-1. In 1.2 Amp magnetic fraction shown that there is some bearing hydro-ilmenite, struvite, muscovite, and biotite. Hence, a non-magnetic fraction of 1.2 Amp showed some bearing monazite, rutile, and mostly are quartz, the magnetic mineral cannot separate from two previous conditions such a small portion of mineral.



[A] [B]

Figure 4-2: [A] Silica sand defined as original sample before processing, [B] Silica sand after processing

From Figure 4-2, presence of SiO_2 along with other minerals can be observed from stereo microsopic view trace of subrouned quartz was found. And from Figure 4-3 presents the magnetic fraction after 0.7 Amp process, which contained some clay binder, sapnonite $(Ca_{0.5},Na)_{0.3}(Mg, Fe^{+2})_3(Si, Al)_4O_{10}(H)_2*H_2O)$, quartz coated by hematite and biotite. Whereas in Figure 4-4 shows the picture from magnetic fraction 1.2 Amp there some noticable impurities such as hematite, monazite, laterite mineral, rutile and some unidentifable minerals which confirmed with XRD result as shown in Figure 4-5.

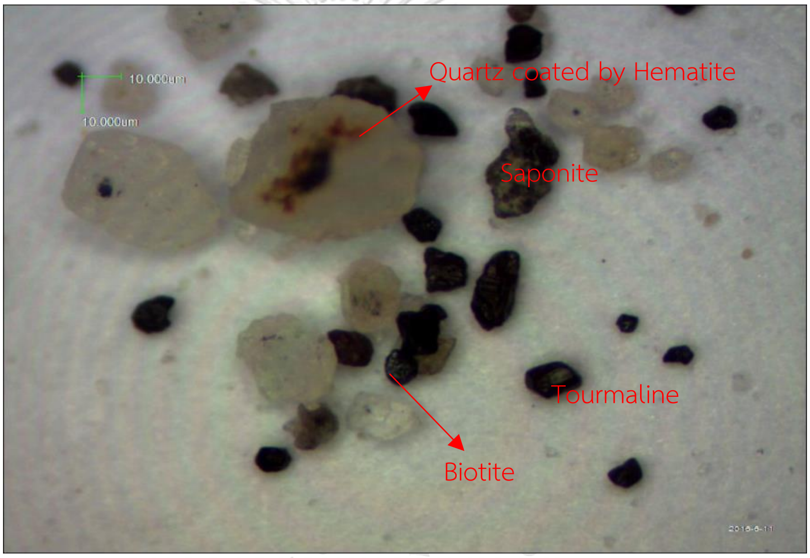


Figure 4-3: Magnetic fraction from Washing silica sand at 0.7 Amp

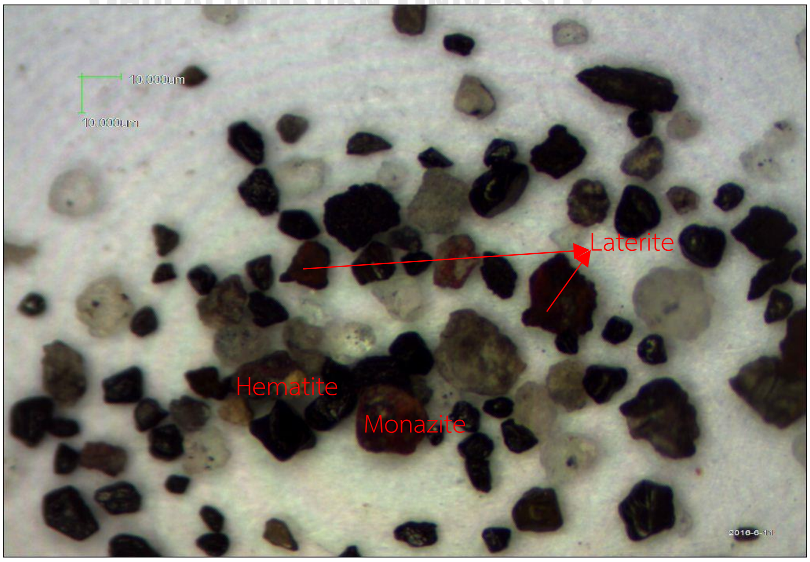


Figure 4-4: Magnetic fraction 1.2 Amp

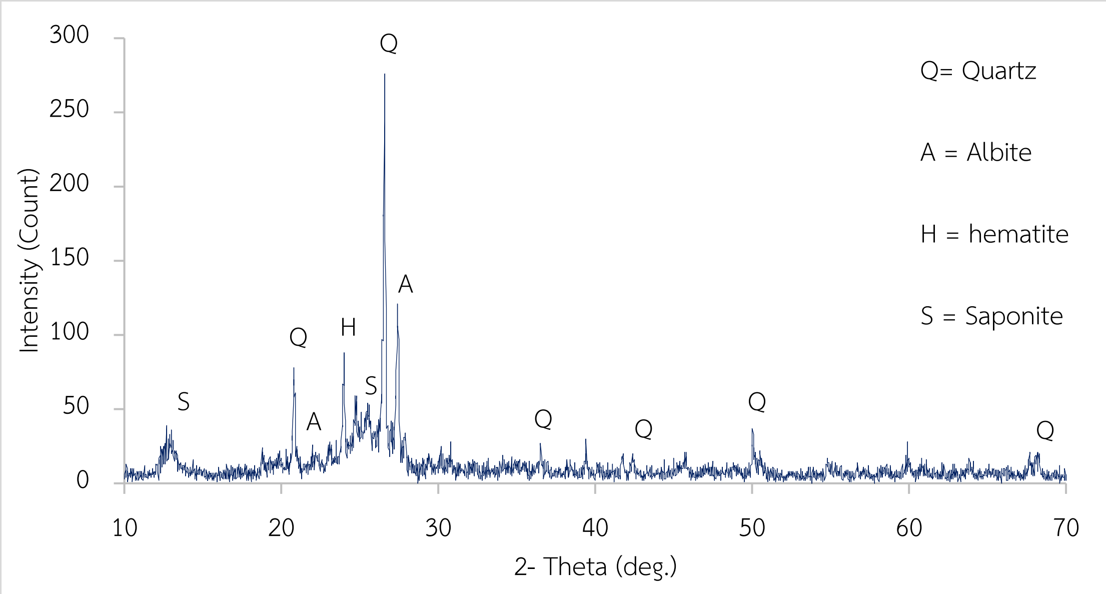


Figure 4-5: XRD pattern of original sample

4.1.3 The chemical properties of silica sand

The representative sand was checked the chemical composition through the X-ray fluorescence model super mini 200 Rigaku (WDXRF). The raw silica sand was taken from the field are mostly come up with the natural glue, charcoal and organic material were shown in Figure 4-2. In Table 4-2: The sample was taken from the field within a depth from -2m to -5m to conduct in this experiment. The result from X-ray fluorescence was showed that silica sand still highly contained with a piece of wood and root of grass. The major oxide namely SiO_2, Al_2O_3, SO_3, K_2O, Cr_2O_3, Fe_2O_3, ZrO_2, MgO, CaO, and TiO_2 are defined as weight percentage (Wt.%).

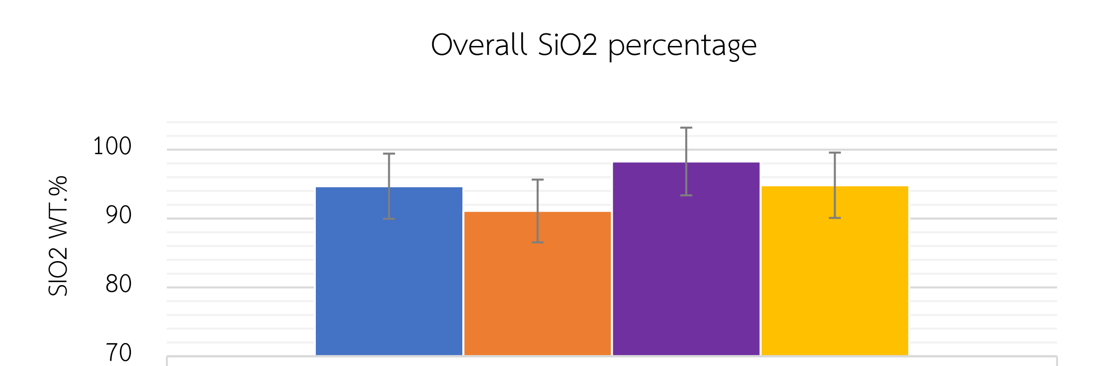
Table 4-2: Chemical composition of silica sand from Steung Hav district

	Original sample									
SAMPLE ID	SiO_2	Al_2O_3	SO_3	K_2O	Cr_2O_3	Fe_2O_3	ZrO2	MgO	CaO	TiO_2	Other
P30	95.10	3.19	0.22	0.19	0.17	0.12	0.04	0.12	0.10	0.16	0.59
P32	91.10	3.29	2.94	0.20	0.16	0.28	0.04	0.20	0.14	0.22	1.43

P34	98.28	0.26	0.04	0.04	0.31	0.16	0.04	-	0.04	-	0.83
P35	97.80	0.90	0.06	0.10	0.26	0.12	0.05	-	-	0.14	0.57
P37	95.30	2.97	0.14	0.16	0.19	0.12	0.03	0.13	0.06	0.17	0.73
P39	91.80	3.80	1.36	0.26	0.22	0.23	0.04	0.24	0.04	0.22	1.79
P40	95.80	2.10	0.10	0.16	0.33	0.18	0.05	0.04	-	0.22	1.02
P41	96.70	1.33	0.44	0.10	0.23	0.14	0.03	0.07	0.02	0.13	0.81
P42	98.10	0.57	0.16	0.05	0.25	0.11	0.04	-	0.01	0.09	0.62
P44	94.70	2.65	0.42	0.16	0.20	0.15	0.04	0.17	0.10	0.18	1.23
P45	93.80	2.94	0.74	0.19	0.22	0.17	0.05	0.19	0.31	0.18	1.21
P46	94.86	1.94	0.53	0.16	0.38	0.26	0.05	0.10	-	0.14	1.58
P48	94.80	1.74	1.50	0.11	0.22	0.22	0.02	0.07	0.09	0.14	1.09
P49	91.50	3.12	1.91	0.21	0.26	0.25	0.05	0.33	0.09	0.24	2.04
W5	91.50	4.06	1.63	0.23	0.33	0.29	0.05	0.11	0.06	0.25	1.49
W7	92.30	4.58	0.50	0.25	0.24	0.23	0.06	0.14	0.26	0.32	1.12
W11	93.40	2.59	-	0.29	0.56	0.14	0.19	0.03	0.02	0.53	2.25
W12	94.80	3.07	0.31	0.18	0.20	0.14	0.05	0.12	0.11	0.20	0.82
W13	96.00	2.46	0.06	0.16	0.21	0.12	0.04	0.06	0.02	0.17	0.70
Mean	94.61	2.50	0.73	0.17	0.26	0.18	0.05	0.13	0.09	0.21	1.15
Median	94.80	2.65	0.43	0.16	0.23	0.16	0.04	0.12	0.08	0.18	1.09
Max	98.28	4.58	2.94	0.29	0.56	0.29	0.19	0.33	0.31	0.53	2.25
Min	91.10	0.26	0.04	0.04	0.16	0.11	0.02	0.03	0.01	0.09	0.57

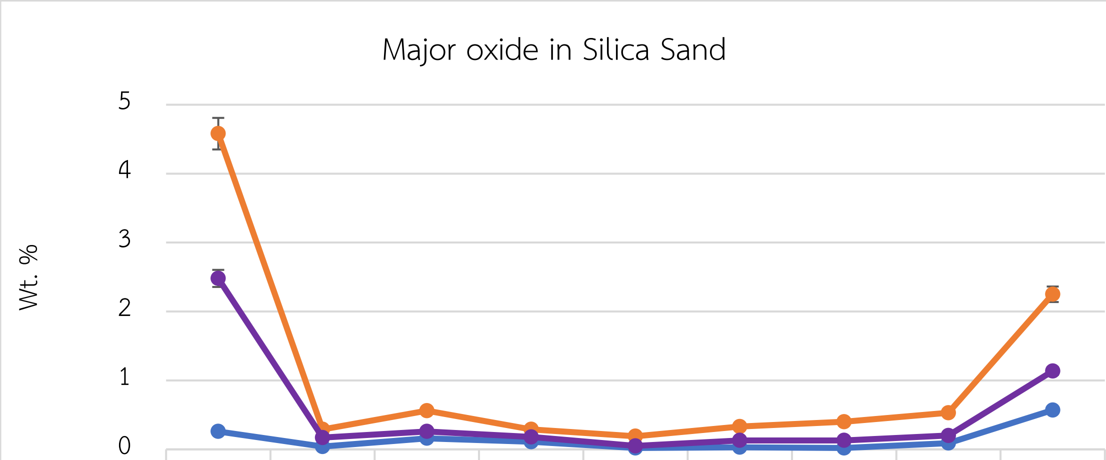
From Table 4-2: summaries the statistics which is Standard Error (S.E) of SiO_2 = 0.52, mode and median value = 94.8, Standard Deviation (SD) = 2.3, sample variance (SV) = 5.078, Skewness = - 0.013, and kurtosis = -0.089. Fe_2O_3 SE = 0.013, SD = 0.06, SV = 0.0036, and Skewness = 0.55, and Al_2O_3 S.E = 0.26, S.D = 1.16, S.V = 1.35, and Skewness = -0.033. TiO_2 S.E = 0.02, SD = 0.10, S.V =0.011, and skewness = 1.62.

Figure 4-6 shows the mean percentile of silicon dioxide from the third layer of soil which the main target in this study, the grade arranges from 91.1 to 98.28%, and the mean value is 94.69%, whereas the commercial specification grade D SiO_2 greater than 99%. As well as, iron oxide and other major oxide from Figure 4-7 shows the mean percentile of major oxide which contained in raw silica sand was 2.48%, 0.18%, and 0.2% Al_2O_3, Fe_2O_3, and TiO_2 respectively. Whereas, the specification limitation of those impurities was 0.1%, 0.03%, and 0.01% Al_2O_3, Fe_2O_3, and TiO_2 respectively.



	SiO2
Mean	94.692
Min	91.1
Max	98.28
Median	94.83

Figure 4-6: Diagram represented statistic overall silicon dioxide composition SiO_2%



	Al2O3	K2O	Cr2O3	Fe2O3	ZrO2	MgO	CaO	TiO2	Other
Min	0.26	0.04	0.16	0.11	0.02	0.03	0.02	0.09	0.57
Max	4.58	0.29	0.56	0.29	0.19	0.33	0.4	0.53	2.25
Mean	2.48	0.17	0.26	0.18	0.05	0.13	0.13	0.2	1.1365

Figure 4-7: Diagram showing statistic summarized of major oxides in silica sand KPS

4.2 Shaking table

The result of the shaking table will be revealed by measurement of X-ray fluorescence. There are some notable according to the result of shaking table after has done the process, the iron oxide, alumina oxide, titanium oxide and other oxide are gradually decreasing after treatment. There are four conditions in this process which are considering on the inclination of the table ranges from 8 - 15 degrees, with the water's flowrate = 0.22 l/s and stroke length = 10 mm. Therefore, the 12 degrees was illustrated highly removal of iron oxide 72.11%, which Fe_2O_3 reduced from 0.09 to 0.025 Wt.% within yield percentage is 93.71% in concentrate as shown in Table 4-3. When the inclination of deck angle increased to 15 degrees indicates that the iron oxide removal is decreased from 72.11% to 58.78% within high yield of percentage 97%. In short, by comparing the iron oxide removal percent shows that 12 degrees are an optimized condition. To apply for either further experiment or industry. In this experiment was conducted with an optimized deck angle of 12 degrees. The result found that the significantly reducing of iron oxide from 0.19 to 0.095 Wt.% as the average value, which is represented the overall reduction was shown in Figure 4-9. After finishing this process all concentrations (light fraction) will further used for raw material next process of Wet high internists magnetic separation (WHIMS) with a single maximum condition which capacity of instrument current 14 Amp.

Table 4-3: Shaking Table various condition of the experiment

DECK ANGLE	Fe_2O_3	FEED	LIGHT FRACTION	HEAVY FRACTION	TOTAL	LOSS %	YIELD %		Fe_2O_3
	Wt. %	gram					CONC.	TAIL.	WT.%
8^0	0.09	1008	594	394	988	1.98	60.12	39.88	0.03
10^0	0.09	1002	835	158	993	0.90	84.09	15.91	0.0311
12^0	0.09	1002	923	62	985	1.70	93.71	6.29	0.0251
15^0	0.09	1011	978	21	999	1.19	97.90	2.10	0.0371

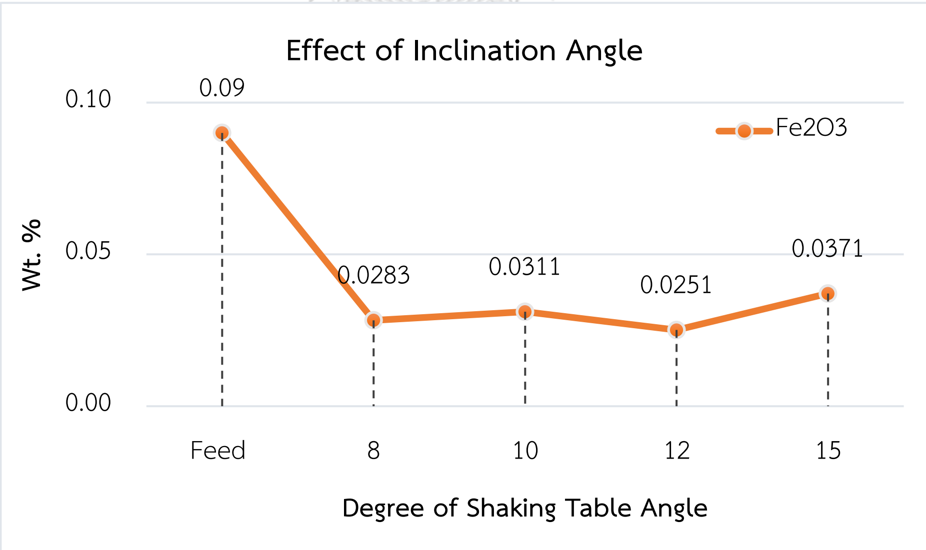


Figure 4-8: comparison of Iron oxide removal from Shaking Table

Table 4-4: Result of Shaking Table Process with Deck angle 12 degrees

Sample	Weight Before Test	SiO_2	Fe_2O_3	Weight %			SiO_2	Fe_2O_3	Al2O3	TiO2
No.	(gram)	Wt.%	Wt.%	Heavy	Mid.	Product	Wt.%	Wt.%	Wt.%	
P30	4010.00	95.10	0.12	2.44	0.72	96.84	97.40	0.07	1.68	0.11
P32	3950.00	91.10	0.28	2.86	0.92	96.22	93.40	0.15	1.71	0.15
P34	3394.00	98.28	0.16	0.32	0.83	98.85	98.64	0.09	0.82	0.00
P35	4756.00	97.80	0.12	1.34	0.96	97.70	99.30	0.07	0.59	0.10
P37	3856.00	95.30	0.12	0.93	1.61	97.46	97.60	0.07	1.46	0.12
P39	4560.00	91.80	0.23	1.91	1.24	96.85	94.10	0.13	2.21	0.15
P40	4105.00	95.80	0.18	0.79	3.52	95.69	97.35	0.08	0.68	0.15
P41	4731.00	96.70	0.14	0.98	0.71	98.31	99.00	0.08	0.26	0.09
P42	4253.00	98.10	0.11	2.31	1.06	96.62	99.10	0.06	0.56	0.06
P44	4215.00	94.70	0.15	1.78	0.31	97.90	97.00	0.08	1.21	0.13
P45	3924.00	93.80	0.17	0.99	0.40	98.61	96.10	0.09	1.43	0.13
P46	4639.00	94.87	0.26	1.95	0.96	97.09	96.87	0.13	0.76	0.10
P48	4325.00	94.80	0.22	1.25	0.69	98.06	97.10	0.12	0.66	0.10
P49	4218.00	91.50	0.25	1.33	0.55	98.12	93.80	0.14	2.29	0.17
W5	4349.00	91.50	0.29	2.35	0.60	97.06	95.10	0.14	2.24	0.18
W7	5366.00	92.30	0.23	1.81	0.60	97.60	95.45	0.11	2.81	0.22
W11	4284.00	93.40	0.14	7.56	4.80	87.64	95.55	0.08	2.37	0.37
W12	4358.00	94.80	0.14	0.60	5.09	94.31	96.75	0.07	1.46	0.14

W13	4538.00	96.00	0.13	2.78	1.06	96.17	97.35	0.07	0.97	0.12
Mean	-	94.61	0.18	1.91	1.40	96.69	96.68	0.10	1.38	0.14
Median	-	94.80	0.16	1.78	0.92	97.09	97.00	0.08	1.43	0.13
Min	-	91.10	0.11	0.32	0.31	87.64	93.40	0.06	0.26	0.00
Max	-	98.28	0.29	7.56	5.09	98.85	99.30	0.15	2.81	0.37

From Figure 4-9 shows that the original sample was contained SiO_2, Fe_2O_3, Al_2O_3, and TiO_2 was 94.61%, 0.18%, 2.4%, and 0.15% respectively. Then after finished the shaking table process the SiO_2, Fe_2O_3, Al_2O_3, and TiO_2 was 96.68%, 0.10%, 1.38, and 0.14% respectively, which mean that this process is possible to remove the heavy mineral by separate from heavy fraction part. Within yield percent 96.69% of production as shown in Figure 4-10. However, the target in this study Fe_2O_3 = 0.02%, so that second method will be requiring to remove the iron oxide sequence from this process. It possible to use WHIMS for further process.

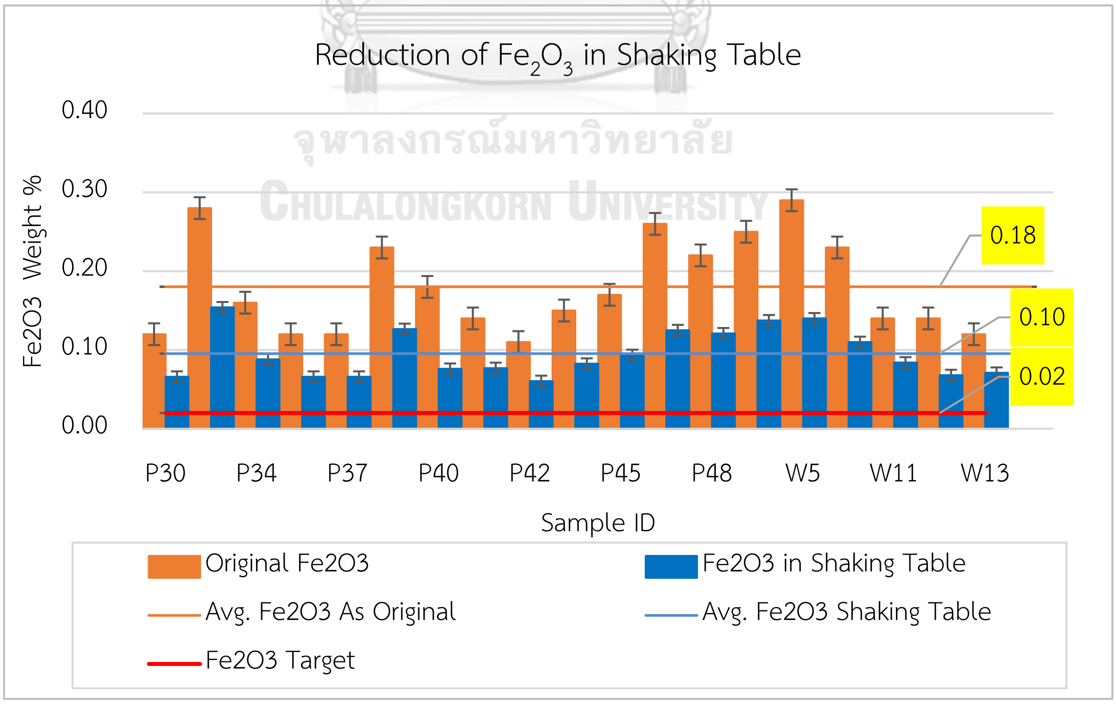


Figure 4-9: Reduction of Iron oxide in Shaking table

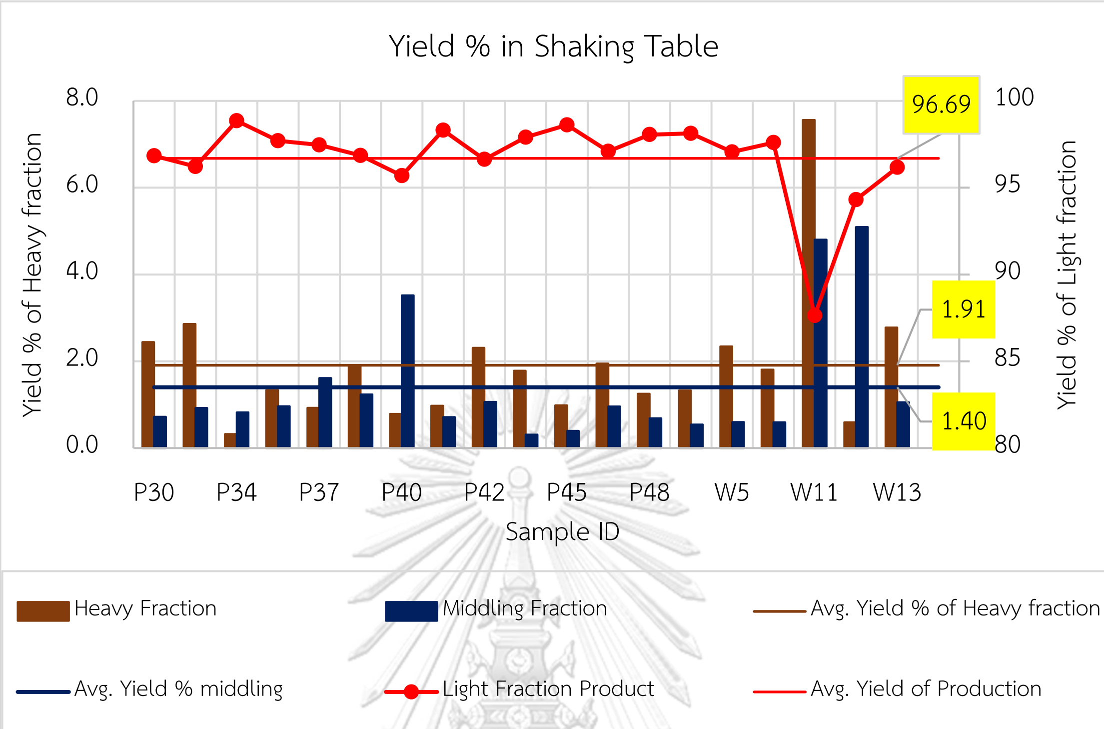


Figure 4-10: Yield percentage (%) in shaking table

4.3 Wet high-intensity magnetic separation (WHIMS)

In the second experiment was sequencing from Shaking Table test, due to the gravity separate still contained high grade of Fe_2O_3. There are some important factors in the influence of the magnetic field intensity which was a fix for 14 Amp. This magnetic field can be reduced the iron oxide by low water flowrate = 0.07 l/s.

In Table 4-5 was shown that after repeated 6 times of operation, silica can be upgraded from 96 to 98.7 wt.%, whereas the iron oxide can be removed from 0.095 to 0.057 wt.%, within the 98.9 % of yield on an average.

Table 4-5: Result of the WHIMS experiment

Weight After Wet Magnetic (Dry Sample)				Weight %			SiO_2	Fe_2O_3	Al_2O_3
Sample ID	Feed	Mag 14 A. (gram)	Non-Mag (gram)	Mag.	N.M	Loss %	Wt.%	Wt.%	Wt.%
P30	3883.10	36.20	3841.90	0.93	98.94	0.13	98.70	0.036	0.75

P32	3800.50	53.14	3742.36	1.40	98.47	0.13	94.70	0.085	0.534
P34	3355.00	23.00	3332.00	0.69	99.31	0.68	99.00	0.046	0.405
P35	4646.70	36.50	4605.20	0.79	99.11	0.11	99.70	0.036	0.492
P37	3758.06	42.30	3710.76	1.13	98.74	0.13	98.90	0.036	0.834
P39	4416.53	26.54	4384.99	0.60	99.29	0.11	95.40	0.070	1.245
P40	3928.10	25.00	3903.10	0.64	99.36	0.63	98.90	0.072	0.534
P41	4651.12	45.50	4600.62	0.98	98.91	0.11	99.80	0.042	0.164
P42	4109.45	24.90	4079.55	0.61	99.27	0.12	99.85	0.033	0.504
P44	4126.64	45.70	4074.94	1.11	98.75	0.15	98.30	0.045	0.548
P45	3869.65	35.40	3829.25	0.91	98.96	0.13	97.40	0.051	0.782
P46	4504.20	11.00	4493.20	0.24	99.76	0.24	98.50	0.084	0.619
P48	4240.99	74.10	4161.89	1.75	98.13	0.12	98.40	0.067	0.492
P49	4138.90	64.50	4069.40	1.56	98.32	0.12	95.10	0.076	1.46
W5	4221.00	118.00	4103.00	2.80	97.20	2.79	98.90	0.048	0.59
W7	5237.00	84.60	5152.40	1.62	98.39	1.61	98.70	0.067	0.637
W11	3754.30	20.00	3734.30	0.53	99.47	0.53	97.30	0.070	2.06
W12	4110.00	17.00	4093.00	0.41	99.59	0.41	98.80	0.054	0.564
W13	4364.00	44.00	4320.00	1.01	98.99	1.00	98.50	0.058	0.838
Mean	4163.96	43.55	4117.47	1.04	98.89	0.49	98.15	0.057	0.740
Median	4126.64	36.50	4079.55	0.93	98.96	0.13	98.70	0.054	0.590
Min	3355.00	11.00	3332.00	0.24	97.20	0.11	94.70	0.033	0.164
Max	5237.00	118.00	5152.40	2.80	99.76	2.79	99.85	0.085	2.060

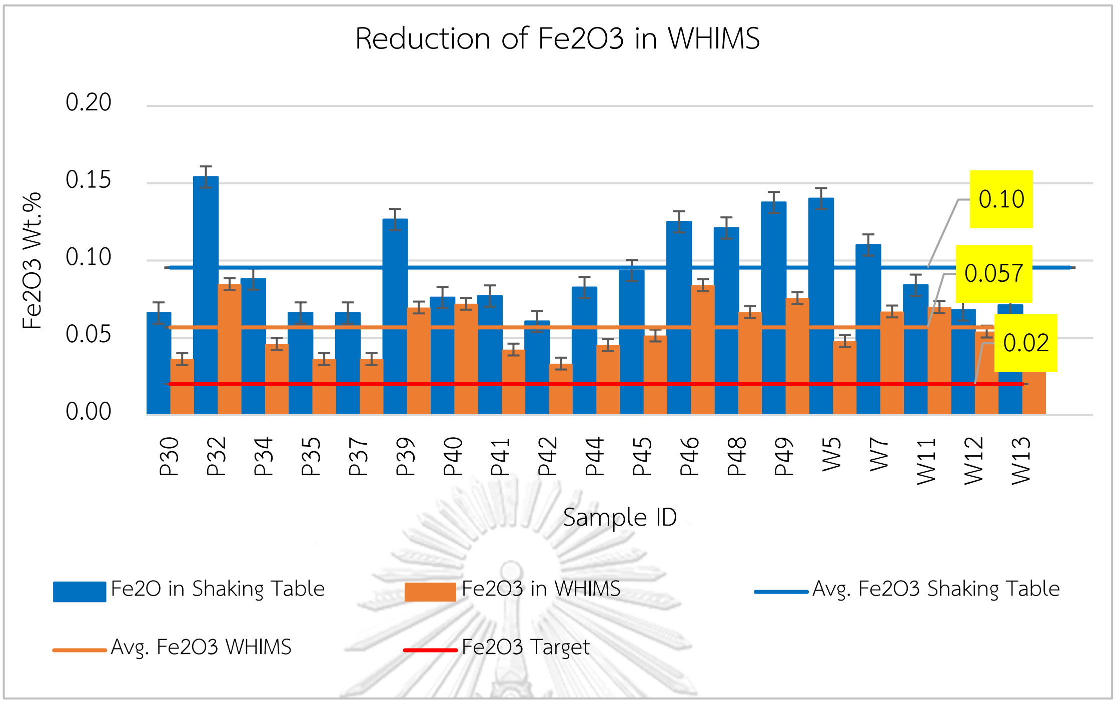


Figure 4-11: Reduction of iron oxide by WHIMS

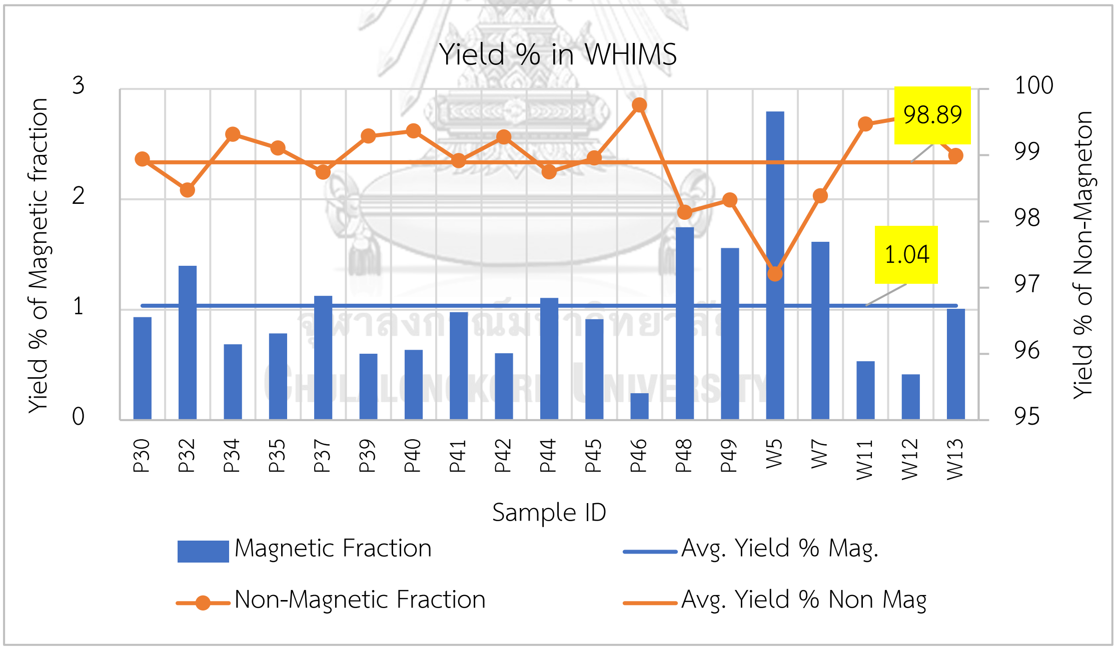


Figure 4-12: Yield percentage (%) in WHIMS

According to the laboratory scale use, which is the capacity of the instrument are limited, that why the maximum of the current magnetic field is used including some manual controls. Due to the production plan in this study, the SiO_2 = 98.9Wt.% and the iron oxide Fe_2O_3 = 0.057Wt.% can fulfil the requirement of production B which is iron oxide lower than 0.08 Wt.% grade, yet due to another production A which required the iron oxide lower or equal to 0.02Wt.% it means physicochemical treat will be conducted in this study.

4.4 Reverse flotation

The sample consists in this test was undertaken from a nonmagnetic fraction of WHIMS process. In this experiment was conducted with 3 samples was varied from 600-1200g/t of collector AOA and NANZA consumption within 50% solids of the slurry, pH valued from 1 to 2 controlled by sulfuric acid H_2SO_4 = 600g/t within 20g/t of pine oil. The result was shown that after applied these collectors can be removed the bearing iron oxide reach the target of study shown in Figure 4-14. According to the previous test on the effect of collector dosage for flotation from Steung Hav was shown in Figure 4-13. According to result from Figure 4-13 illustrate that dosage collector 40ml more significantly removed iron oxide from silica sand more as the optimized conditions for this study, which decreases from 0.17 to 0.037 Wt.%. Therefore, the dosage of collector 1200g/t of concentrate was conducted in the whole experiment from WHIMS process.

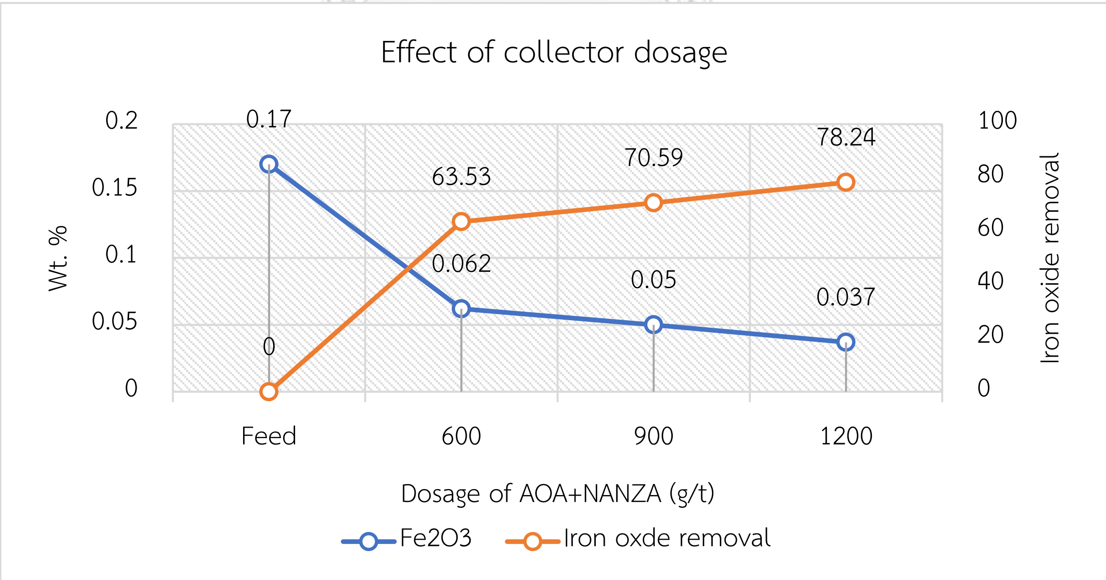


Figure 4-13: Effective by collector dosage

Table 4-6 presents the noticeable significant change of iron oxide removal can reach approximately 200 ppm of concentrate, in some sample probably causes by mill and compressor contaminate during the sample preparation for XRF test.

However, in this experiment lost percentage is higher than another test, which is 2.07 % during flotation could be caused by stirring of agitator and cleaning sample after the process.

Table 4-6: Reverse flotation with collector 1200g/t. converted as a weight percentage

Sample	Reverse Flotation (Weight percentage Wt.%)								
No.	Feed	pH	AOA	NANZA	Concentrate	Loss %	SiO2	Fe2O3	Al2O3
P30	100.0	2.0	0.57	4.73	93.47	1.23	99.20	0.015	0.15
P32	100.0	2.0	0.63	8.00	91.13	0.24	98.70	0.021	0.11
P34	100.0	2.0	0.52	1.38	94.36	3.74	99.20	0.017	0.08
P35	100.0	2.0	1.27	3.52	94.13	1.08	99.80	0.011	0.10
P37	100.0	2.0	0.90	2.79	94.93	1.39	99.40	0.018	0.17
P39	100.0	2.0	1.05	5.84	91.87	1.24	98.90	0.028	0.25
P40	100.0	2.0	0.93	3.74	91.59	3.74	99.10	0.024	0.11
P41	100.0	2.0	1.15	8.96	88.45	1.44	99.90	0.021	0.03
P42	100.0	2.0	1.02	6.35	91.76	0.87	99.94	0.012	0.10
P44	100.0	2.0	0.95	8.37	89.52	1.15	98.80	0.015	0.11
P45	100.0	2.0	0.81	4.25	94.10	0.84	99.40	0.023	0.16
P46	100.0	2.0	0.94	16.65	78.25	4.16	98.70	0.023	0.12
P48	100.0	2.0	1.91	4.08	93.15	0.86	99.30	0.027	0.10
P49	100.0	2.0	1.33	2.43	95.49	0.75	98.10	0.023	0.29
W5	100.0	2.0	2.14	0.75	93.29	3.83	99.00	0.027	0.12
W7	100.0	2.0	1.34	0.82	94.01	3.83	99.40	0.017	0.13

W11	100.0	2.0	11.59	1.86	83.21	3.34	99.10	0.023	0.41
W12	100.0	2.0	0.46	0.58	97.06	1.91	98.90	0.020	0.11
W13	100.0	2.0	1.00	3.13	92.08	3.79	98.80	0.028	0.17
Mean			1.61	4.64	91.68	2.07	99.14	0.021	0.15
Median			1.00	3.74	93.15	1.39	99.10	0.021	0.03
Min			0.46	0.58	78.25	0.24	98.10	0.011	0.41
Max			11.59	16.65	97.06	4.16	99.94	0.028	0.12

From Figure 4-14 presents the significant reduction of iron oxide to met the commercial specification target from 0.057 to 0.021%, within high yield percent 91.68%. However, this method nothing to do with the plant design, because in this study attempts to remove the iron oxide from the third layer to meet the target of production A.

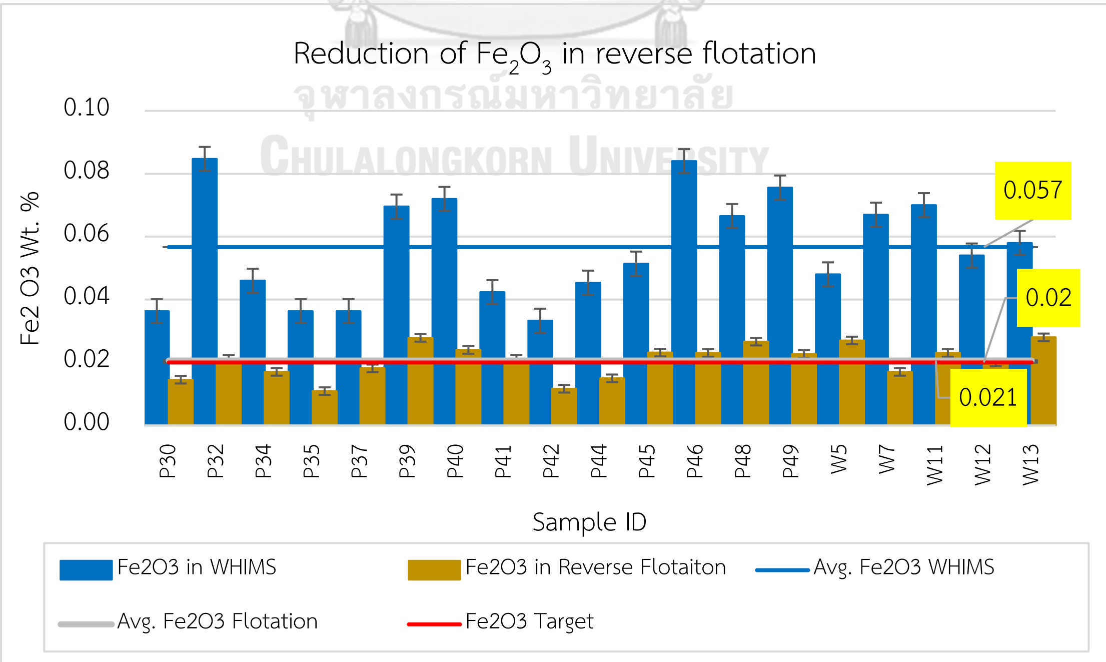


Figure 4-14: Reduction of iron oxide by flotation

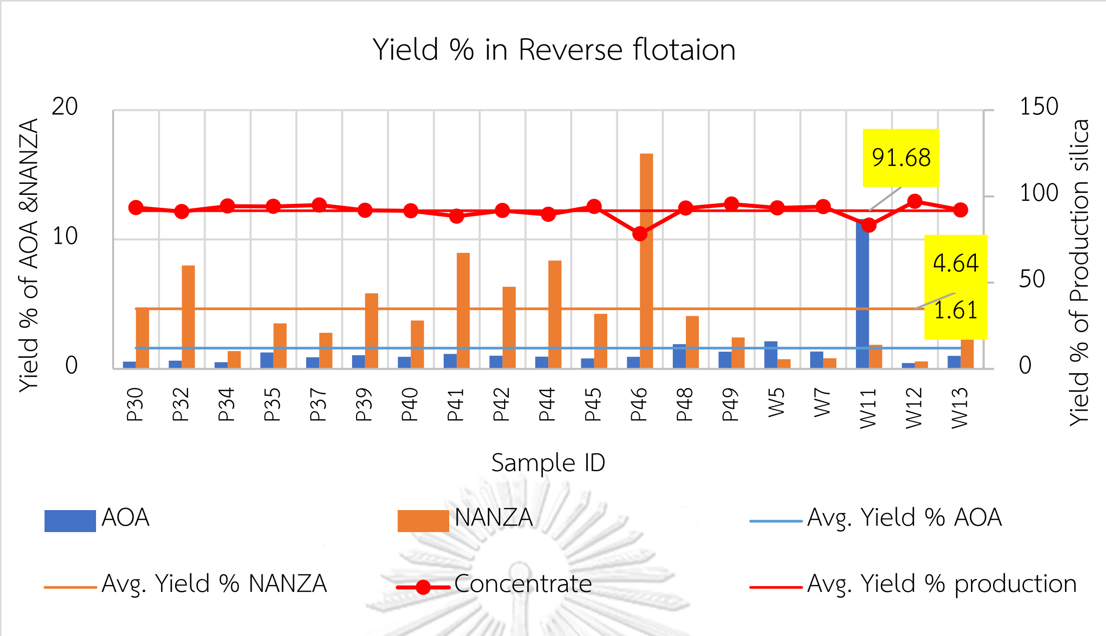


Figure 4-15: Yield percentage (%) in Reverse flotation

4.5 Removal of impurities, and silica sand upgrading

According to the result from previous discussing was shown that in order to remove iron oxide and other bearing impurities can be used the physicochemical method including all parameters, which is more significant for pure glass, but it would be more expensive than another method. In the conventional method silica sand process by using a gravitational method which is more popular, and lower cost. Whereas from Figure 4-16 shows that the reduction of iron oxide from received stage to Shaking Table is gradually decreasing Fe_2O_3 =0.18 to 0.095 Wt. %, Al_2O_3 reduced from 2.5 to 1.38 Wt.%, and TiO_2 reduced from 0.19 to 0.14 wt.%, on an average value including, silicon dioxide (SiO_2) was added more value from 94.69 to 96.68 Wt.%, which is a noticeable process to meet the target SiO_2 greater than 99 Wt.%. In addition, from shaking table stage to WHIMS also illustrated the significantly reducing of iron oxide from Fe_2O_3 = 0.095 to 0.057 Wt.%, Al_2O_3 reduced from 1.38 to 0.74Wt.%, and TiO_2 reduced from 0.14 to 0.109 wt.%, and SiO_2 added more value from 96.68 to 98.15 wt.% on an average. Based on the production plan iron oxide Fe_2O_3 = 0.057 Wt.% which is fulfilled the requirement of production B which is equal to or lower than 0.08 Wt.%.

Finally, the significantly reducing of iron oxide from WHIMS to reverse flotation was met the requirement of pure silica sand grade, which removed from Fe_2O_3 = 0.057 to 0.021 Wt.% showed in Figure 4-14. In a diagram of removed Alumina oxide since received stage until the final stage process, which significantly reducing from Al_2O_3 = 0.74 to 0.15 Wt.%, TiO_2 from 0.109 to 0.055 wt.%, and SiO_2 upgraded from 98.15 to 99.14 wt.%.

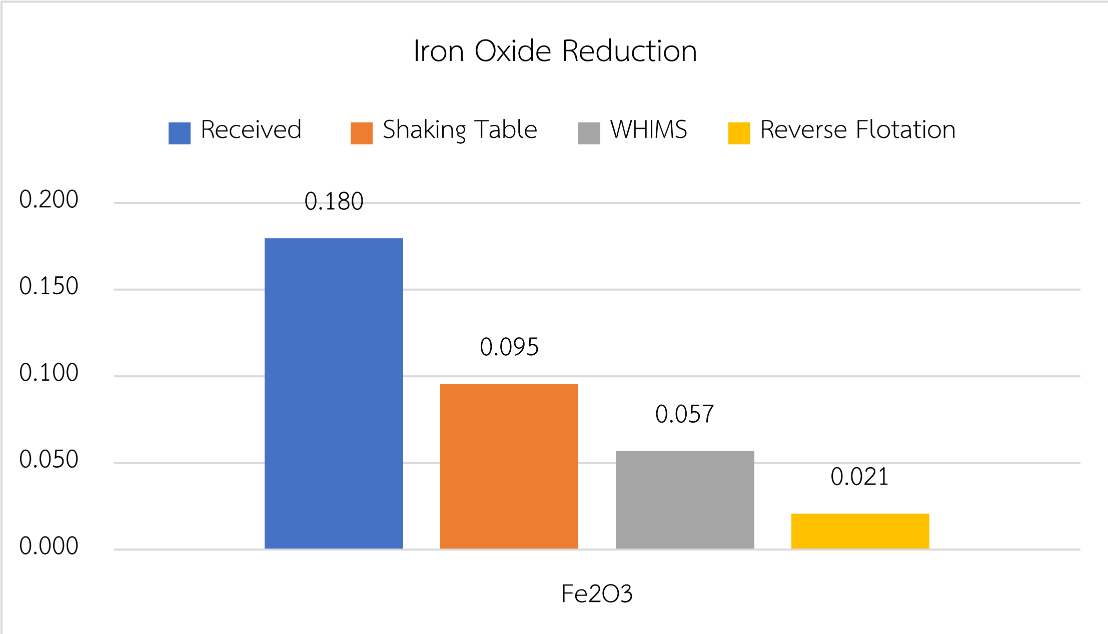


Figure 4-16: Diagram showing the overall reduction of iron oxide in each method

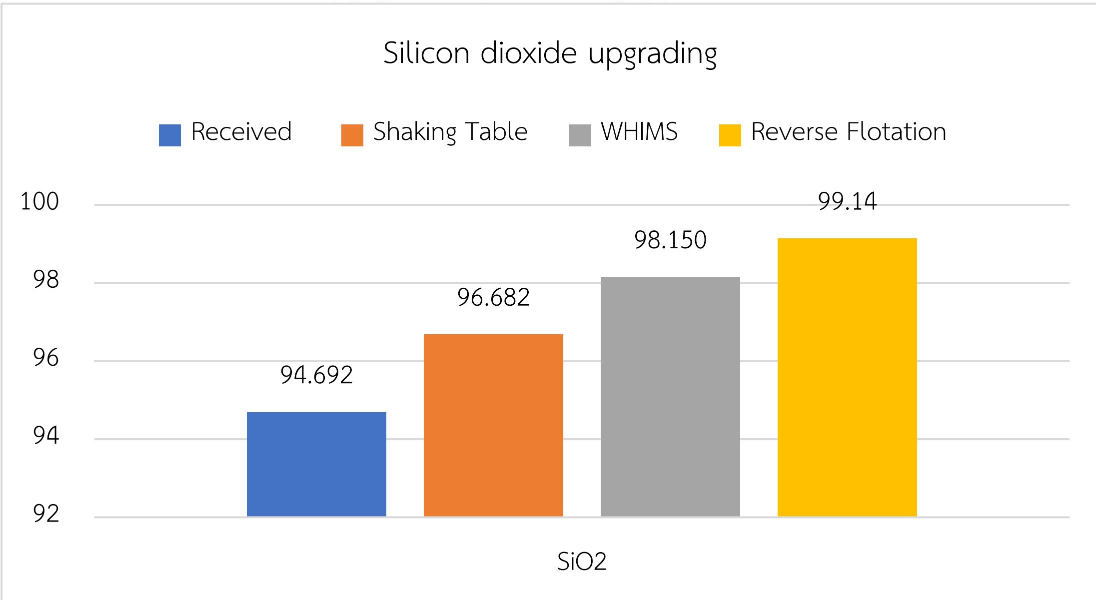


Figure 4-17: Diagram showing the overall upgrading of silicon oxide by a mean value

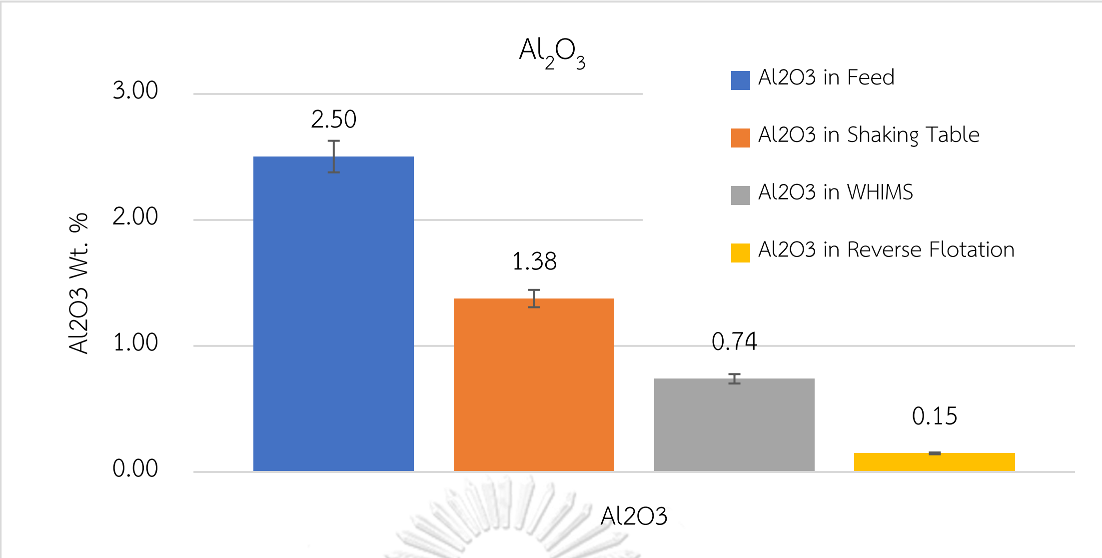


Figure 4-19: Diagram showing the Reduction of Aluminum Oxide by a mean value

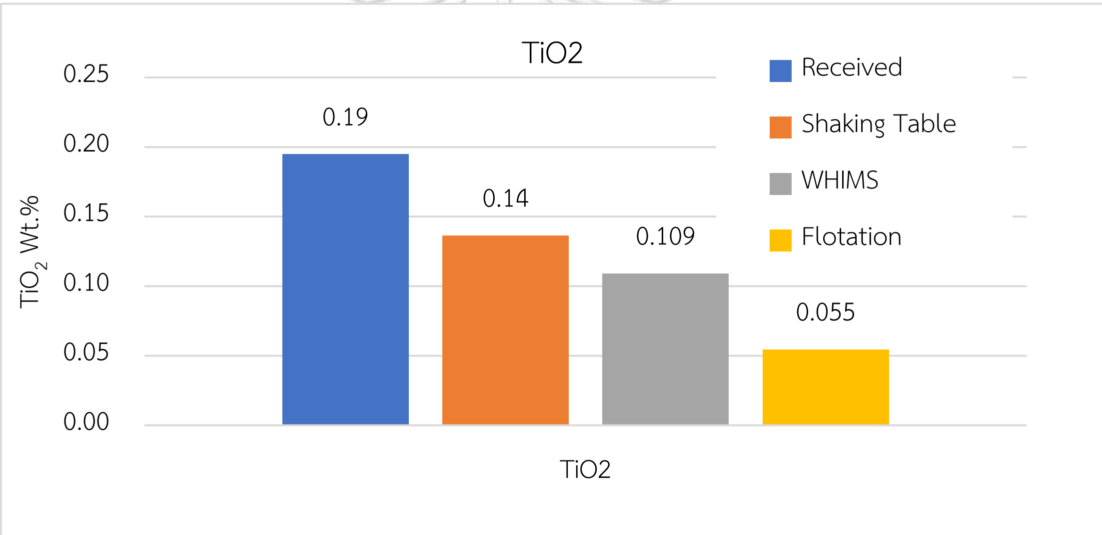


Figure 4-18: Diagram showing Reduction of TiO_2

4.6 Washing plant design

After finishing the experiment from the laboratory, further carry out those conditions and the result from those to design as the real washing plant as shown in Figure 4-20. Silica sand feeds to the hopper by wheel loader, the further fed into trommel (841μm) by reciprocating feeder with the rate of 100 ton per hour, the particle size greater than 841μm will reject. Where the under-size material is conveyed to the second trommel (30 mesh) fraction, which is oversize will reject once again, and undersize further conveyed to attrition scrubber and tank classifier by pumping machine and hydro-cyclone for separate clay and organic matter overflow on the top of a plant. Where the underflow fraction fed to the first arranged of spiral concentrator (4x4) unit for a separate heavy fraction from silica sand. The light fraction from the first stage further feeds to the second stage of the spiral by a slurry pump and hydro-cyclone to control the % solids of a slurry. Finally, the product from second spiral concentrate fed to hydro-cyclone by a slurry pump for dewatering in stockpile which is defined as silica sand product A and B as shown in Figure 4-20.

From Figure 4-21: indicated the method for a process the high-grade silica sand which is using reverse flotation to enhance the quality of SiO_2 from very low grade. However, when applying for the real scale of industrial plant it will replace concentrator spiral from shaking table, and wet screening by trommel and reverse flotation might be not suitable for real industry. Therefore, the attrition scrubber will substitute the flotation cell by cleaning the surface of silica sand before feed into spiral and WHIMS.

At this deposit in the first and second layer gave a good quality silica sand raw material, then the method of processing quite easily which is used only a few stages of a process such as a trommel screening, attrition scrubbing following by tank classifier. The third layer deposit which composed high content iron oxide and a high clay mineral, then the main processing technique should be applied as following the Figure 4-20.

- The attrition scrubber and tank classifier for removing grain coating of sand, it would be ferruginous clay and organic matter by combined of collusion and the difference settling rate of particles.
- Double spiral concentrator for removing heavy mineral by combining the effect of centrifugal forces, the difference settling rate of particles and the effect of interstitial trickling through the flowing particles bed.
- Wet high-intensity magnetic separator for removing high impurity iron oxides such as mica, biotite, tourmaline, ilmenite and another heavy mineral, etc. by an effect of the different magnetic property.

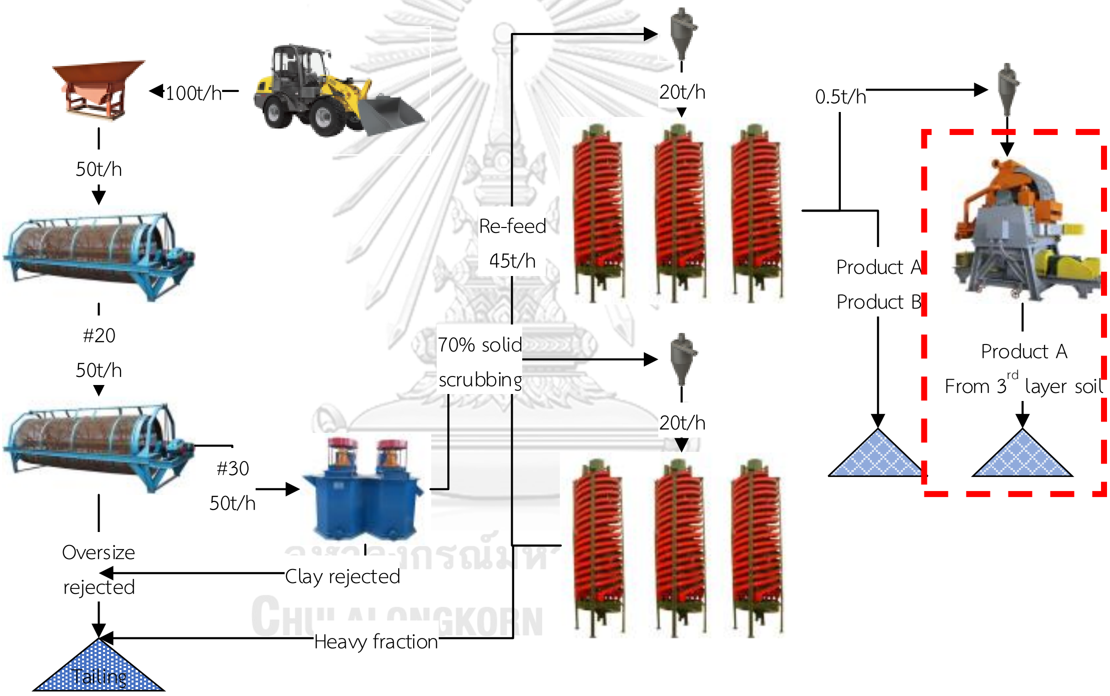


Figure 4-20: Washing silica sand plant arrangement

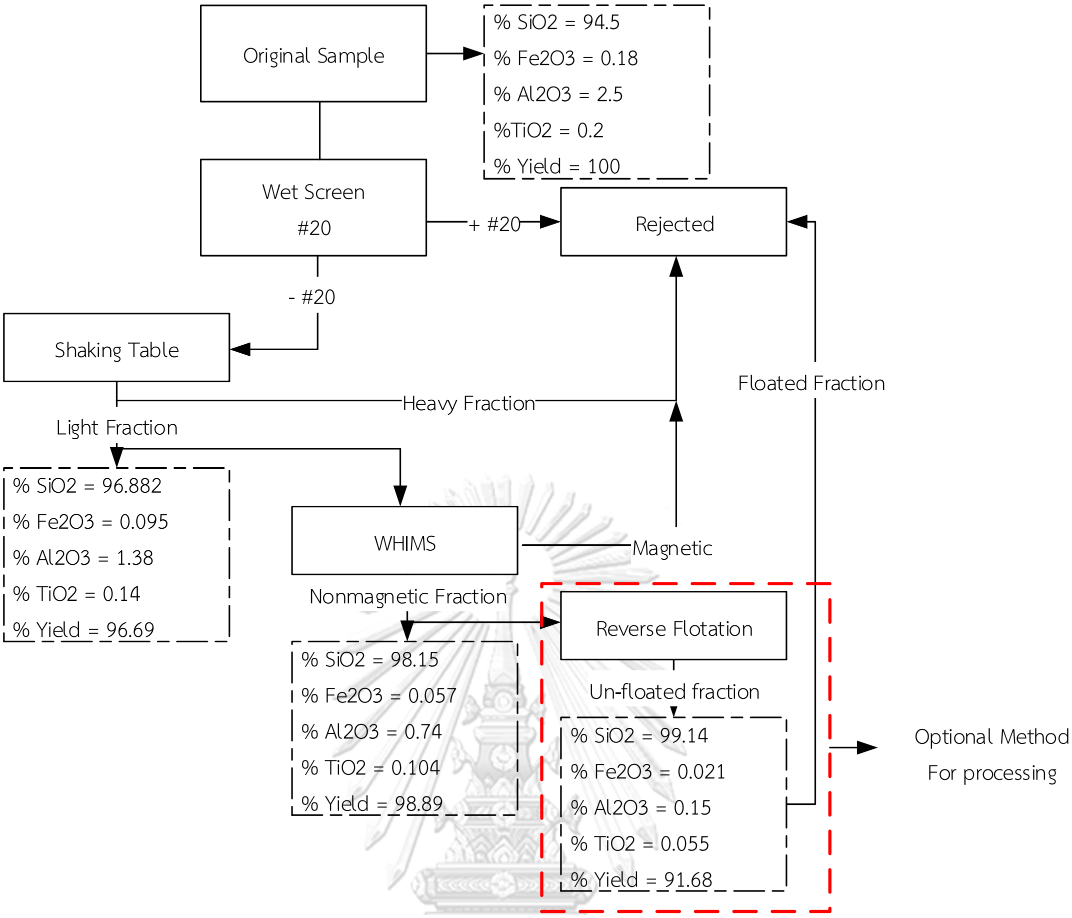


Figure 4-21: Flowsheet of processing silica sand in laboratory

4.7 Financial evaluation

The financial analysis for long-term investment involves the discount cash flow DCF analysis. It provided the critical for net present value NPV at the discount rate of 13 % [29], and the internal rate of return IRR. For all investment projects, there are some essential parameters for considering them to be feasibility are DCF, IRR, and NPV. In DCF calculation is considering about cash inflow and cash outflow, IRR also used for comparing with the interest rate of the project, and NPV is the validated value of the project.

4.7.1 Discounted cash flow calculation (DCF)

There were many stages to determine the discounted cash flow, whereas in this stage there are some parameters input to calculating such as capital cost (CAPEX), operation cost (OPEX), depreciation cost, tax rate, and royalty rate sale cost. In this case was operating within two products of grade sands A and B, which contained Fe_2O_3 difference A lower than 0.08 Wt.% and B is lower or equal to 0.02 Wt.% as shown in

Table 1-4. The product A will be produced 50,000 ton/year every year, and product B 200,000 ton per year for first year, 500,000 ton per year at second year, and 950,000 ton per year from third to tenth years. The tax rate of profitable 20 %, within the royalty 14 baht per ton, whereas discount rate 13%.

Table 4-7: Capital Expenditure

Investment	Unit	Baht/unit	Value	Year
Land	1	108,500,000	108,500,000	12
License	1			
Machinery/ Plant/ construction/ Installation	1	93,000,000 *	93,000,000 *	10
Wheel loaders	2	2,170,000	4,340,000	10

Total	205,840,000.00

Remark * is referred to the appendices Table 5-1: List of equipment and plant installation

Table 4-8: Cost of the Operation input

Items	Baht/ton
Raw material + Mining (subcontractor)	303.00
Transportation to Thailand per ton	200.00
Other additional expense	100.00
Operation cost	100.00
Total Cost	703

In this study was spent on capital cost (CAPEX) or initial investment cost approximately 225,154,162 baths, which converted into 6,839,537.25 dollars of USA. Whereas the cost of operation (OPEX) was 1,233,750,000 baht from year 1 to year 2,115,000,000 baht from year 4 to year 6, and 2,820,000,000 baht from year 7 to year 10, and the total 6,190,430,400 baht. Table 4-9 was indicated the total operation included labour cost and all expensed, also the labour increasing rate of 10% per year. In addition, this report also considers the welfare and management assumed it 20% of the investment, which is including CSR terms to the social surrounding the washing plant.

Table 4-9: Total operation cost (Baht unit)

Year	-	1 to 3	4 to 6	7 to10
Processing Coast		1,233,750,000	2,115,000,000	2,820,000,000
Labor cost increase 10%/year	7,476,000	24,670,800	31,399,200	52,332,000

Welfare and management 20%		4,934,160	6,279,840	10,466,400
Total Operation Expense		1,238,684,160	2,121,279,840	2,830,466,400

4.7.2 Net present value (NPV) and WACC

To determine NPV sum of DCF annually cash flow and present value. In this case, if NPV value is positive, it would be considering to further process of feasibility process report, and if its value negative meant this project will be rejected, non-feasibility report. Based on the excel calculation NPV is 754,615,135.13 baht which is approximately 24,342,423.71 US dollars. So that, this project considers financially feasibility to requesting an exploitation license from MMIE of Cambodia showed in Table 4-10.

Table 4-10: The calculation of NPV value in baht currency

Year	-	1 to 3	4 to 6	7 to 10
Product A (ton)		150,000	150,000	200,000
Product B (ton)		1,600,000	2,850,000	3,800,00
Total		1,750,000	3,000,000	4,000,000
Sale Product A	1,500.00	225,000,000	225,000,000	300,000,000
Sale Product B	1,000.00	1,600,000,000	2,850,000,000	3,800,000,000
Gross Revenue		1,825,000,000	3,075,000,000	4,100,000,000
Royalties	14.00	24,500,000.00	42,000,000	56,000,000
Marketing Expanse 1%		18,250,000.00	30,750,000	41,000,000

Sale Expanse		42,750,000.00	72,750,000	97,000,000
Net Revenue		1,782,250,000	3,002,250,000	4,003,000,000
Depreciation		34,128,248.60	33,694,248.60	44,925,664.80
Operation Expense		1,238,684,160	2,121,279,840	2,830,466,400
Income before Tax		509,437,591.40	847,275,911.4	1,127,607,935.2
Tax 20%	0.20	101,887,518.28	169,455,182.28	225,521,587.04
Income after Tax		407,550,073.12	677,820,729.12	902,086,348.16
Cash Flow	(205,840,000)	441,678,321.72	711,514,977.72	947,012,012.96
NPV@13	THB		754,615,135.13	

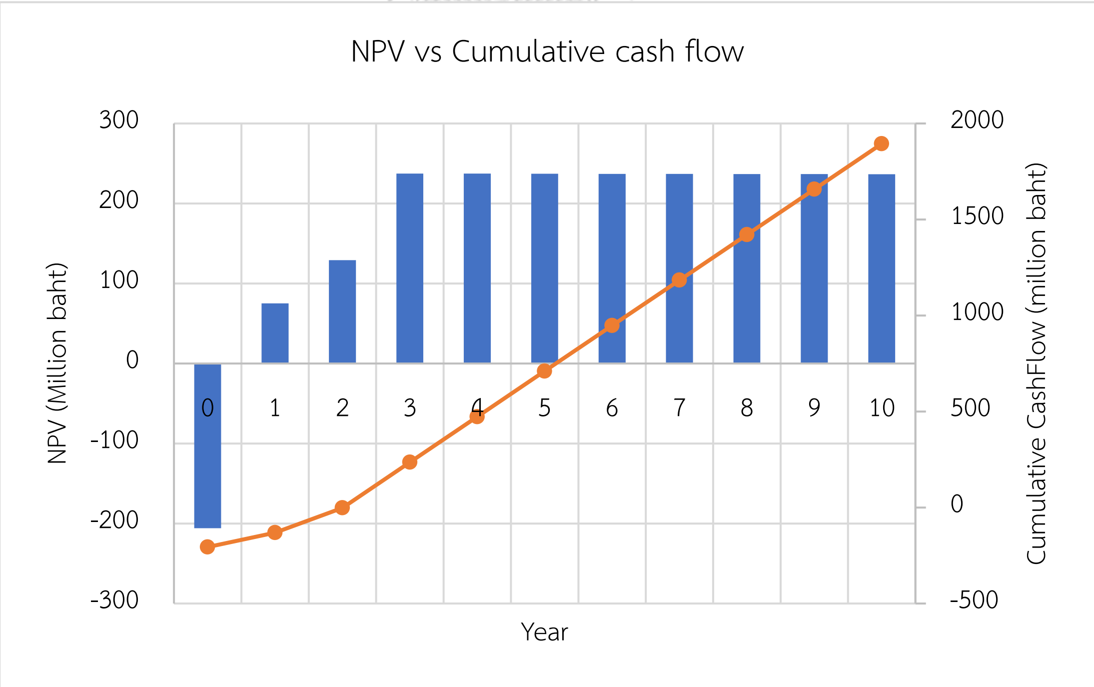


Figure 4-22: NPV and cumulative cash flow

From Figure 4-22 was illustrated the total capital is (205,840,000) baht invested in the year zero, and the gross revenue is rising at year 1, due to the price of operation quite lower than the capital, it means this project can be recovered the investment cost in short period of time.

In either mining or processing, there were two types of capital budget. The first budget was borrowed from the bank and another budget will get from the owner of the project or shareholder. However, this study was assumed that 30 percent fund from the bank and 70 percent from a shareholder. In Cambodia WAAC on construction material was stated by WACC Export range from 11.22% to 17.13%, which is the weight of debt 21%, corporate tax 20%, cost of debt 7.32%, annual inflation rate 2.9%, country risk premium 4.8%, risk free rate 2.52%, and market premium 6.63%, So the value of WACC is 13.64%.

4.7.3 Internal rate of return (IRR), modified rate of return (MIRR), and DPP

The internal rate of return (IRR) was the rate which is measuring the return generated by an assuming that the reinvestment rate of cash flows. IRR is the rate which made the NPV value equal to zero, it is very essential for investment, and used for identifying the discounted payback period of the project, or when the project can get the profit. However, if IRR equalled to discount rate or WACC, the net present value equalled to zero which meant this project will not get any profit. In this project NPV was 733,918,999.72 baht, IRR was 69.64% and MIRR was 33.47%. In Figure 4-23 was illustrated the relationship between Net present value and a discount rate of the project, which is more affected by increasing the value of discount rate. When the discount rate rising then the net present value is gradually decreasing as shown in Figure 4-23.

However, the NPV and IRR methods may give the confliction results in case of mutually exclusive projects. Therefore, the MIRR was concerned in this project, which is changing the assumed rate of reinvestment growth from stage to stage in the project, also the most common method to input the average estimated cost of capital. In additional, MIRR is designed to generate one solution to rid of the issue multiple IRR. Moreover, the payback period also conducted to determine how long the project to recovery back its initial investment, which is the number of years to recover initial costs. In this project payback period (PP) was 2 years whereas Discount Payback Period (DPB) = 1.42 to recovery initial cost back. In Figure 4-24: shows that the value of IRR gives an overly optimistic picture of the potential of the project, while the MIRR value gives a more realistic evaluation of the project.

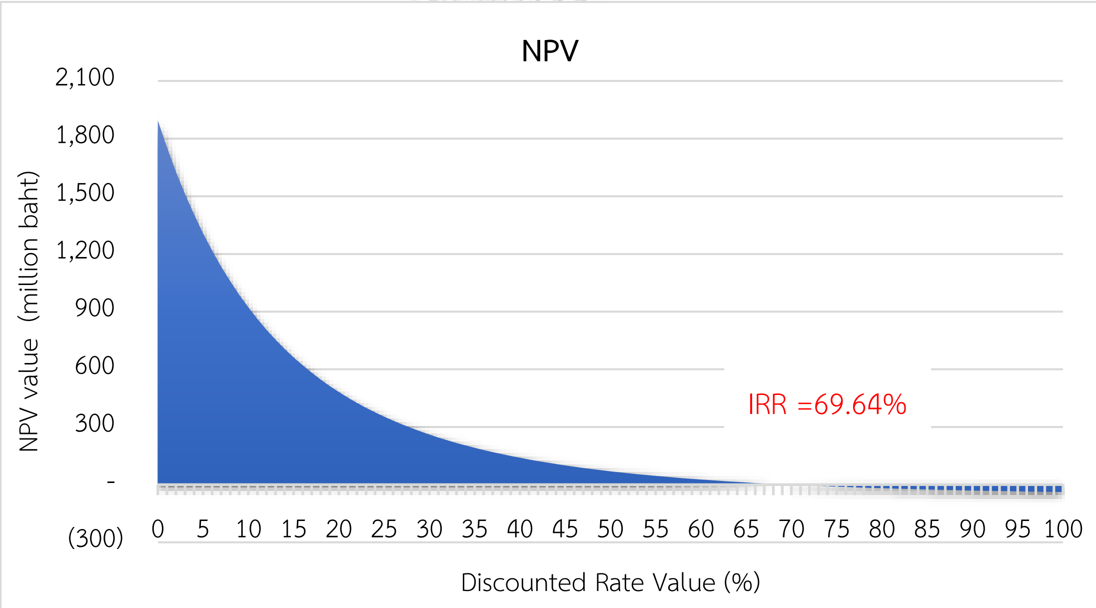


Figure 4-23: Diagram shows the relationship between NPV and IRR

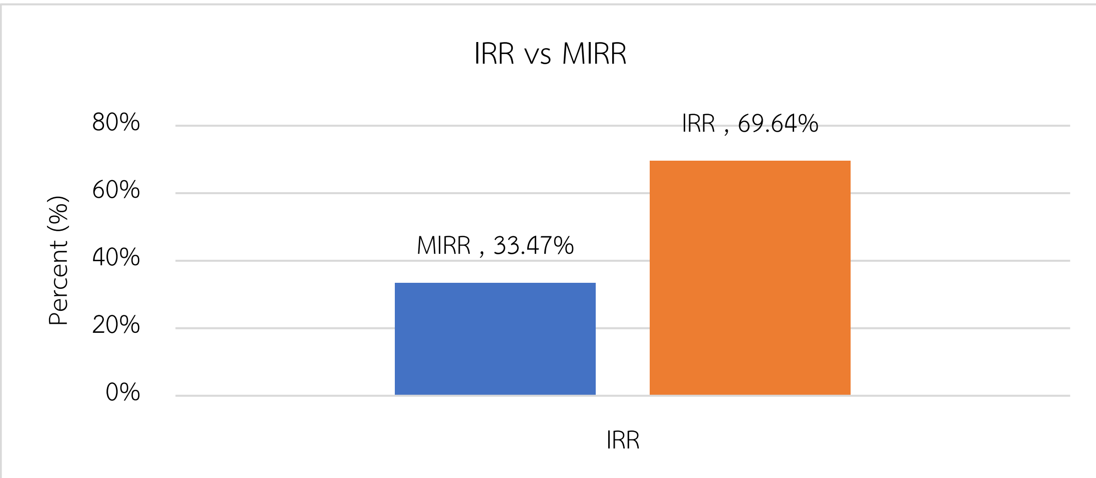


Figure 4-24: Initial rate of return and modified rate of return

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the result in this difference laboratory scale experiments in this thesis was conducted with 3 mains objectives upgrading silica sand, unit operation, and economic analysis. In term of beneficiation of sands which is characterize the raw sample was following by SiO_2 = 94.6 Wt.%, and Fe_2O_3 = 0.18 Wt.% which is represented all phases of raw silica sands. Whereas the particle size distribution D_{50} = 210 µm from the representative sample. Therefore, the laboratory scale shaking table has been used for enriching the value of SiO_2 from Steung Hav district, Sihanoukville province. The experiment was conducted with a wet sieve and hand washing before investigated the effected of an inclination deck angle, which is varied from 8^0 to 15^o. The result was shown that 12^o condition can be removed iron oxide more than other condition, which is removal efficiency η = 72% within yield percentage = 96.9% was set as a fixed condition for further test. Moreover, Wet high-intensity magnetic separator process was conducted following from shaking table to eliminate the iron oxide which is using the maximum condition 14-15 Amps. The obtained non-magnetic fraction still contained higher Iron oxide and silicon dioxide did not meet the specification, which is SiO_2 = 98.15Wt.% and Fe_2O_3 = 0.057Wt.% within yield percentage = 98.89%. To reach the target of the specification, the physicochemical process was conducted by using reverse flotation including collector AOA + NANZA = 1,200g/t, modifier H_2SO_4 = 600g/t to control the pH =1-2, and pine oil to prevent the bubble during the experiment, which is upgrading the silicon dioxide from 98.15 to 99.1 Wt.% whereas the iron oxide reduced from 0.057 to 0.023 Wt. % within yield percent = 91.67%, and iron oxide removal percent η = 87%, as the average value.

In this study was required two wheel loader capacity is 115 ton per hour for feeding operation. Therefore, in washing plant was required a hopper 100t/h, a belt feeder 100t/h, three pumping 20t/h per unit, four spiral concentrator (4x4 spirals)

20t/h per unit, a tank classifier 40t/h, four hydrocyclones 20t/h, three trommels 50t/h, and a magnetic separator 0.5t/h to operate for upgrading silica sand.

On another hand, the financial analysis in this study including the initial investment CAPEX was 205,840,000 baht. The raw material price is 303 baht per ton, including subcontractor price of mining excavate, the transportation to Thailand price was 200 per ton, the operation cost 100 per ton, and the total processing cost is 703 baht per ton. Whereas the OPEX was 6,190,430,400 baht, the net revenue was 8,787,500,000 baht, the depreciation cost was 112,748,162 baht the income before tax 20% was 2,484,321,438 baht, and income after tax was 1,987,457,150 baht within 10 years of operation. Therefore, the Net present value was 754,615,135.13 baht approximately 24,342,423.71 dollars, including WACC rate was 13.64%, IRR was 69.64%, and MIRR was 33.47%. Which is can be recovered back from initial investment within 1.44 years.

5.2 Recommendation

There some recommendations for either further study

- The site investigation in term of geological sub modelling, to evaluate more specified data of sands which deeply beneath, and more accurate on mineral identification.
- The physical method by gravitational process rather use concentration spiral instrument, which is higher capacity than shaking table, and another hand can be the low cost of operation. Shaking could subject for precious metal recoveries such as gold, copper, and other metals.
- Reverse flotation used another collector to compare with AOA and NANZA such as Aero-801 and Aero-825 reagents to figure out the optimized cost of operation.

REFERENCES

1. Marzia Hoque, T., *Upgradation of locally available silica for the production of solar grade silicon.* 2014.
2. Wu, J.C., *The mineral industries of Cambodia and Laos.* USGS Science for a, 2007.
3. Pacific, U.N.E.a.S.C.f.A., *Atlas of Mineral Resources of the ESCAP Region: Cambodia : explanatory brochure*. 1985: United Nations Economic and Social Commission for Asia and the Pacific.
4. Ubaldini, S., et al., *Removal of iron from quartz sands: A study by column leaching using a complete factorial design.* Hydrometallurgy, 1996. 40(3): p. 369-379.
5. Sereiratana, E., et al., *Comparison of Silica Sand Properties from Kandal Province, Cambodia and Tapah, Perak, Malaysia and Characterization of Soda Lime Silicate Glass Produced From Cambodian Silica Sand.* Advanced Materials Research, 2013. 858: p. 248-253.
6. Marzia Hoque, T., *Upgradation of locally available silica for the production of solar grade silicon*, in *Material and Metallurgical Engineering*. 2014, Bangkladesh university of Engineering and Technology: Dhaka-1000, Bangladesh. p. 135.
7. Heng Thy, L.K., Lang Hy *PWC* 2018; Available from: http://taxsummaries.pwc.com/ID/Cambodia-Corporate-Taxes-on-corporate-

income.

8. Miller, M. and K. King, *Sustaining Ontario's Land Resources: A History of The Department of Land Resource Science University of Guelph 1874-2004*. 2009, Department of Land Resource Science.

9. Uchino, T., et al., *Prediction of optical properties of commercial soda–lime-silicate glasses containing iron.* Journal of Non-Crystalline Solids, 2000. 261(1-3): p. 72-78.

10. Kadono, K., et al., *Effects of iron on the formation and annihilation of X-ray irradiation induced non-bridging oxygen hole centers in soda-lime silicate glass.* Journal of Non-Crystalline Solids, 2010. 356(4-5): p. 232-235.

11. Persson, R., *Flat glass technology*. 1969: Springer.

12. Raghavan, P., et al., *Development of a beneficiation flow sheet for processing silica sand from Chertala Area of Kerala.* 2006.

13. Ibrahim, S.S., A.Q. Selim, and A.A. Hagrass, *Gravity Separation of Silica Sands for Value Addition.* Particulate Science and Technology, 2013. 31(6): p. 590-595.

14. Manel, B.F., G. Wissem, and A. Saadi, *Quartz sand beneficiation using magnetic and electrostatic separation to glass industries.* JOURNAL OF NEW TECHNOLOGY AND MATERIALS, 2016. 6(1): p. 60-72.

15. Mowla, D., G. Karimi, and K. Ostadnezhad, *Removal of hematite from silica sand ore by reverse flotation technique.* Separation and Purification Technology,

2008. 58(3): p. 419-423.

16. Win, E.E., *AN UPGRADING OF LOW QUALITY SILICA SAND FROM THUNG TAGO DEPOSIT IN THAILAND*. 2015, Chulalongkorn University.

17. Bhagwat, S., et al., *Feldspar and quartz from the dunes of Kankakee, Illinois: a preliminary feasibility study.* 2001.

18. Accountants, K.T.H.C.C., *Pre-feasibility report on Float Glass Manufacturing Facility*. 2014, Office of the Economic Growth and Agriculture; USAID Pakistan: Pakistan.

19. Kem, S., *A Pre-Feasibility Study of Limestone Quarry Development for Cement Industry in Cambodia*. 2013, Chulalongkorn University.

20. Phaisopha, S., *The Pre-Feasibility Study of Gold Mine Development, A Case Study of Sepon Deposit, Savannakhet Province, Lao PDR*. 2015, Chulalongkorn University.

21. Dayananda, D., et al., *Capital budgeting: financial appraisal of investment projects*. 2002: Cambridge University Press.

22. Feibel, B.J., *Investment performance measurement*. Vol. 116. 2003: John Wiley & Sons.

23. Lin, S.A.Y., *The Modified Internal Rate of Return and Investment Criterion.* The Engineering Economist, 1976. 21(4): p. 237-247.

24. Beaves, R.G., *Net present value and rate of return: implicit and explicit*

reinvestment assumptions. The Engineering Economist, 1988. 33(4): p. 275-302.

25. Fabozzi, F.J. and P.P. Drake, *Capital Budgeting Techniques.* Handbook of Finance, 2008. 2.

26. Herbohn, J.L. and S.R. Harrison. *Introduction to discounted cash flow analysis and financial functions in EXCEL*. in *Socio-Economic Research Methods in Forestry: A Training Manual*. 2002.

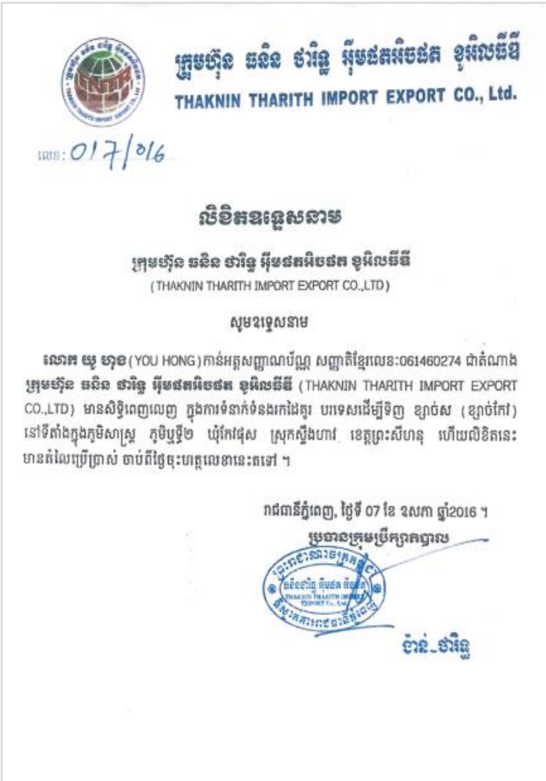
27. Main, M., *Project Economics and Decision Analysis, Volume I: Deterministic Models.* PennWell Publishing, Tulsa, 2002.

28. Platias, S., et al., *Suitability of quartz sands for different industrial applications.* 2014. 14: p. 491-498.

29. Philippe Chazalon, A.M., François Bard, & Alexis joulié, *WACC Expert.* 2018.

APPENDICES

License and Agreement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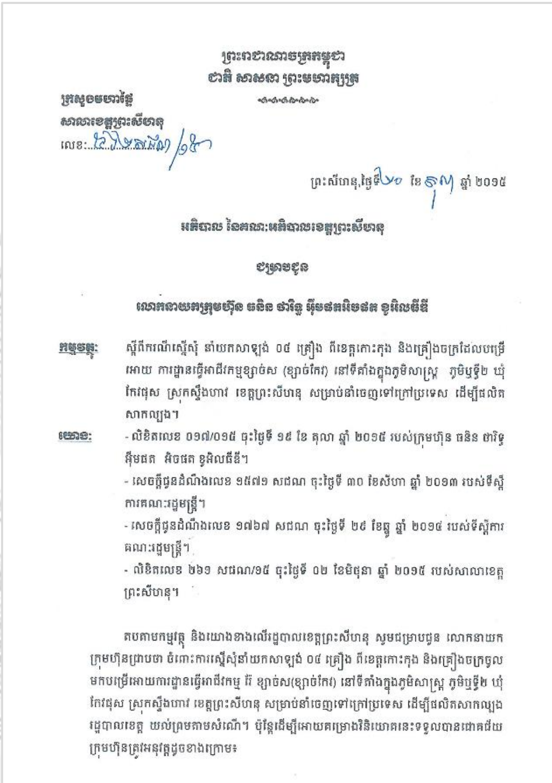
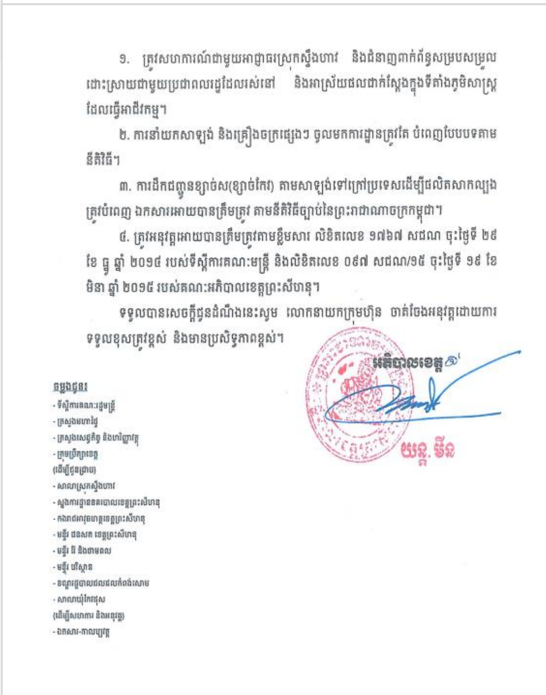

ព្រះរាជាណាចក្រកម្ពុជា

ជាតិ សាសនា ព្រះមហាក្សត្រ




ព្រះរាជាណាចក្រកម្ពុជា

ជាតិ សាសនា ព្រះមហាក្សត្រ

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ

ក្រសួងមហាផ្ទៃ
សាលាខេត្តព្រះសីហនុ
លេខ ០៥៥១ ៣.ស.ស.ក/១៥

ព្រះសីហនុ ថ្ងៃទី ០៩ ខែ មិនា ឆ្នាំ ២០១៥

អភិបាលនៃគណៈអភិបាលខេត្តព្រះសីហនុ
សូមជម្រាបជូន
លោកនាយកក្រុមហ៊ុន ធនិន ថារិទ្ធ អ៊ីមផត អិចផត ខូអិលធីឌី

កម្មវត្ថុ: ស្តីពីលទ្ធផលចុះពិនិត្យស្រាវជ្រាវ និងវាស់វែងទីតាំង គម្រោងស្នើសុំ រ៉ែខ្សាច់ស(ខ្សាច់កែវ) នៅភូមិឬទ្ធី២ ឃុំកែវផុស ស្រុកស្ទឹងហាវ ខេត្តព្រះសីហនុ។

យោង: - ពាក្យស្នើសុំលេខ ០០១/១៥ ចុះថ្ងៃទី ២១ ខែ មករា ឆ្នាំ ២០១៥ របស់ក្រុមហ៊ុន ធនិន ថារិទ្ធ អ៊ីមផត អិចផត ខូអិលធីឌី។
- កំណត់ហេតុនិងរបាយការណ៍របស់ក្រុមការងារចម្រុះ ចុះថ្ងៃទី ១៨ ខែ មិនា ឆ្នាំ ២០១៥

តបតាមកម្មវត្ថុ និងយោងខាងលើ រដ្ឋបាលខេត្តព្រះសីហនុសូមជម្រាបជូន លោកនាយកជ្រាបថា: ក្រោយពីទទួលបានពាក្យស្នើសុំរបស់ក្រុមហ៊ុន រដ្ឋបាលខេត្តបានបង្កើតក្រុមការងារចម្រុះចុះត្រួតពិនិត្យ ដល់ទីតាំង លទ្ធផលទទួលបានដូចខាងក្រោម៖

- ទីតាំងនេះស្ថិតនៅក្នុងភូមិឬទ្ធី២ ឃុំកែវផុស ស្រុកស្ទឹងហាវ ខេត្តព្រះសីហនុ ដែលមានផ្ទៃដីសរុបប្រមាណ ១០៤៩ ហិកតា ។
- ជូនភ្ជាប់ផែនទីបង្ហាញទីតាំង និងចំណុចនិយាមកាដូចខាងក្រោម ៖

តារាងនិយាមកានៃចំណុចគោល		
Projection UTM, Zone48N ,Datum WGS 84		
Points.id	Easting (m)	Northing (m)
A	358744.000	1191172.000
B	358793.000	1189621.000
C	357083.000	1188682.000
D	356651.000	1189340.000
E	356058.000	1188226.000
F	353778.000	1188881.000
G	354365.000	1189157.000
H	353977.000	1189652.000
I	353909.000	1190588.000
J	354583.000	1191429.000
K	356777.000	1190884.000

តាមការពិនិត្យ លើប្លង់បង្ហាញទីតាំង និងចំណុចនិយាមកា-កំណត់ហេតុ និងរបាយការណ៍របស់ក្រុមការងារចម្រុះ រដ្ឋបាលខេត្តមិនយល់ទាស់អ្វីឡើយ និងសូមគាំទ្រចំពោះ គម្រោងស្នើសុំអភិវឌ្ឍរ៉ែខ្សាច់ស ព្រមទាំងបង្កើតរោងចក្រ ក្នុងខេត្តព្រះសីហនុ តាមសេចក្តីជូនដំណឹងរបស់ទីស្តីការគណៈរដ្ឋមន្ត្រី។

ដើម្បីអោយគម្រោងនេះ ដំណើរការដោយភាពរលូន និងទទួលបានជោគជ័យ រដ្ឋបាលខេត្ត សុំអោយក្រុមហ៊ុន ធ្វើការសិក្សាផលប៉ះពាល់ បរិស្ថានស្របតាមនិតិវិធីច្បាប់ ដែលបានកំណត់ និងសម្របសម្រួល ដោះស្រាយគោលនយោបាយ ជាមួយប្រជាពលរដ្ឋដែលរស់នៅ និងអាស្រ័យផលជាក់ស្តែងលើទីតាំងនេះ ព្រមទាំងជៀសផ្ទៃដីដែលត្រៀមបម្រុងទុក សាងសង់សាលារៀន និងភូមិប្រជាពលរដ្ឋចេញ។

ទទួលបានសេចក្តីជូនដំណឹងនេះ សូមលោកនាយកចាត់ចែងអនុវត្តស្របទៅនឹងនិតិវិធីនៃច្បាប់តាមការគួរ ។

អភិបាលខេត្ត

ឈិត សុខុន

ចម្លងជូន
- ក្រសួងមហាផ្ទៃ "ដើម្បីជូនជ្រាប"
- រដ្ឋបាលជលផល
- មន្ទីរ ដនស ខេត្ត
- មន្ទីររ៉ែនិងថាមពលខេត្ត
- មន្ទីរបរិស្ថានខេត្ត
- សាលាស្រុកស្ទឹងហាវ
  "ដើម្បីសហការអនុវត្ត"
  "ឯកសារ-កាលប្បវត្តិ"

ព្រះរាជាណាចក្រកម្ពុជា

ទីស្តីការគណៈរដ្ឋមន្ត្រី　　ជាតិ សាសនា ព្រះមហាក្សត្រ

លេខ: ១៧៨៦ ស.ជ.ណ

រាជធានីភ្នំពេញ,ថ្ងៃទី ៣១ ខែ ធ្នូ ឆ្នាំ ២០១៤

ឧបនាយករដ្ឋមន្ត្រី រដ្ឋមន្ត្រីទទួលបន្ទុកទីស្តីការគណៈរដ្ឋមន្ត្រី
គោរពជូន
ឯកឧត្តម ចេសរដ្ឋមន្ត្រី រដ្ឋមន្ត្រីក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម

កម្មវត្ថុ ៖ ករណីសំណើសុំនាំចេញខ្សាច់ស (Salica Sand) របស់ក្រុមហ៊ុនធនិនថារិទ្ធអ៊ីមផតអិចផត ខូអិលធីឌី (THAKNIN THARITH IMPORT EXPORT Co.,LTD)នៅតំបន់នៅឃុំជើងគោ ស្រុកព្រៃនប់ និងស្រុកស្រែអំបិល ខេត្តព្រះសីហនុ ចំនួន ២៩.៥០០ម៣ សម្រាប់យកទៅធ្វើការផលិតសាកល្បងជាផលិតផលសម្រេច និងធ្វើការសិក្សាវាយតម្លៃគុណភាពនៅប្រទេសថៃ កូរ៉េខាងត្បូង សិង្ហបុរី ម៉ាឡេស៊ី សាធារណរដ្ឋប្រជាមានិតចិន អាល្លឺម៉ង់ និងនៅកោះតៃវ៉ាន់។

យោង ៖ -លិខិតលេខ២០៨៨ MIH/2014 ចុះថ្ងៃទី១៧ ខែធ្នូ ឆ្នាំ២០១៤ របស់ក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម
-ចំណាររបស់សម្តេចអគ្គមហាសេនាបតីតេជោ នាយករដ្ឋមន្ត្រីចុះ ថ្ងៃទី២៦ ខែធ្នូ ឆ្នាំ២០១៤។

សេចក្តីដូចមានចែងក្នុងកម្មវត្ថុ និងយោងខាងលើ ទីស្តីការគណៈរដ្ឋមន្ត្រី សូមជំរាបជូនឯកឧត្តមមេត្តាជ្រាបថា ចំពោះករណីសុំនាំចេញខ្សាច់ស (Salica Sand) របស់ក្រុមហ៊ុនធនិនថារិទ្ធអ៊ីមផតអិចផត ខូអិលធីឌី (THAKNIN THARITH IMPORT EXPORT Co.,LTD)នៅតំបន់នៅឃុំជើងគោ ស្រុកព្រៃនប់ និងស្រុកស្រែអំបិល ខេត្តព្រះសីហនុ ចំនួន ២៩.៥០០ម៣ សម្រាប់យកទៅធ្វើការផលិតសាកល្បងជាផលិតផលសម្រេច និងធ្វើការសិក្សាវាយតម្លៃគុណភាពនៅប្រទេសថៃ កូរ៉េខាងត្បូង សិង្ហបុរី ម៉ាឡេស៊ី សាធារណរដ្ឋប្រជាមានិតចិន អាល្លឺម៉ង់ និងនៅកោះតៃវ៉ាន់នោះ រាជរដ្ឋាភិបាលបានសម្រេចយល់ព្រមតាមសំណើរបស់ក្រសួងឧស្សាហកម្ម និងសិប្បកម្មដូចខាងក្រោម ៖

១-អនុញ្ញាតជាគោលការណ៍ឲ្យក្រុមហ៊ុនធនិនថារិទ្ធអ៊ីមផតអិចផត ខូអិលធីឌី បាននាំចេញខ្សាច់ស ចំនួន ២.៥០០ម៣ តែមួយលើកនេះគត់ ទៅកាន់គោលដៅដូចបានលើកឡើងខាងលើ សម្រាប់ការយកទៅសាកល្បងផលិតជាកែវ ឬកញ្ចក់តែប៉ុណ្ណោះ ។

២-សាមីក្រុមហ៊ុនត្រូវមានកាតព្វកិច្ចធ្វើសេចក្តីរាយការណ៍ជូនក្រសួងឧស្សាហកម្ម និងសិប្បកម្ម ដើម្បីក្រសួងមានមូលដ្ឋានរាយការណ៍បន្តជូនរាជរដ្ឋាភិបាល អំពីលទ្ធផលជាក់ស្តែងនៃការផលិតសាកល្បងរួមទាំងការវាយតម្លៃអំពីគុណភាពផលិតផល គុណភាពវត្ថុធាតុដើមខ្សាច់សកម្ពុជា ដែលកើតចេញពីការធ្វើកិច្ចសហប្រតិបត្តិការជាមួយរោងចក្រនៅបណ្តាប្រទេស ឬនៅទីតាំងដែលក្រុមហ៊ុនបានជ្រើសរើសធ្វើជាដៃគូផលិត ដូចបានលើកឡើងក្នុងកម្មវត្ថុខាងលើ ។ ផ្តើមចេញពីនេះ ក្រុមហ៊ុនត្រូវផ្តល់ព័ត៌មានបន្ថែមទៀតអំពីលទ្ធភាព និងសក្តានុពលនៃការវិនិយោគបង្កើតរោងចក្រផលិតជាផលិតផលកែវ ដប ឬកញ្ចក់ ឬផលិតផលផ្សេងៗទៀតនៅក្នុងប្រទេសកម្ពុជា។

៣-ឯកភាពឲ្យមានគោលការណ៍ហាមការនាំចេញខ្សាច់សមុទ្រប្រភេទនេះតទៅទៀត ដើម្បីទុកទាក់ទាញអ្នកវិនិយោគឲ្យមកបង្កើតរោងចក្រផលិតកែវ ឬកញ្ចក់នៅក្នុងប្រទេសយើងវិញ។

សេចក្តីដូចបានជំរាបជូនខាងលើ សូមឯកឧត្តមមេត្តាជ្រាប និងចាត់ចែងអនុវត្តតាមការគួរ ។

ឧ.រដ្ឋមន្ត្រីទទួលបន្ទុកទីស្តីការគណៈរដ្ឋមន្ត្រី
រដ្ឋលេខាធិការ

ប៊ុន អ៊ុយ

ចម្លងជូន:
- ក្រសួងមហាផ្ទៃ
- ក្រសួងសេដ្ឋកិច្ច និងហិរញ្ញវត្ថុ
- ក្រសួងពាណិជ្ជកម្ម
- ក្រសួងធនធានទឹក និងឧតុនិយម
- ក្រសួងបរិស្ថាន
- ខុទ្ទកាល័យសម្តេចនាយករដ្ឋមន្ត្រី
- ក្រុមហ៊ុនធនិនថារិទ្ធអ៊ីមផតអិចផត ខូអិលធីឌី
- ឯកសារ-កាលប្បវត្តិ

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ

ទីស្តីការគណៈរដ្ឋមន្ត្រី
លេខ: ១៥៧១ សជណ

រាជធានីភ្នំពេញ ថ្ងៃទី ៣០ ខែ សីហា ឆ្នាំ ២០១៣

ឧបនាយករដ្ឋមន្ត្រី រដ្ឋមន្ត្រីទទួលបន្ទុកទីស្តីការគណៈរដ្ឋមន្ត្រី
ជំរាបជូន
ឯកឧត្តម រដ្ឋមន្ត្រី ក្រសួងឧស្សាហកម្ម រ៉ែ និងថាមពល

កម្មវត្ថុ ៖ ករណីការផ្តល់មតិលើសំណើសុំគោលការណ៍សាងសង់ រោងចក្រផលិតកែវ និងកញ្ចក់ សំរាប់ផ្គត់ផ្គង់ទីផ្សារក្នុងស្រុក និងនាំចេញផលិតផលសម្រេចដែលលើសពីតម្រូវការក្នុងស្រុក របស់ក្រុមហ៊ុនធនិន ថារិទ្ធ អ៊ីមផតអិចផត ខូអិលធីឌី ។

យោង ៖ -លិខិតលេខ២១៨៨ ឧរថ.កឧ ចុះថ្ងៃទី២៨ ខែ សីហា ឆ្នាំ ២០១៣ របស់ក្រសួងឧស្សាហកម្ម រ៉ែ និងថាមពល
-ចំណាររបស់សម្តេចអគ្គមហាសេនាបតីតេជោ នាយករដ្ឋមន្ត្រី ចុះថ្ងៃទី២៩ ខែសីហា ឆ្នាំ២០១៣ ។

សេចក្តីដូចមានចែងក្នុងកម្មវត្ថុ និងយោងខាងលើ ទីស្តីការគណៈរដ្ឋមន្ត្រី សូមជំរាបជូនឯកឧត្តម មេត្តាជ្រាបថា ៖ ចំពោះករណីសំណើរបស់ក្រសួងឧស្សាហកម្ម រ៉ែ និងថាមពលសុំអនុញ្ញាតឲ្យក្រុមហ៊ុនធនិន ថារិទ្ធ អ៊ីមផតអិចផត ខូអិលធីឌី ធ្វើការសាងសង់រោងចក្រផលិតកែវ និងកញ្ចក់ សំរាប់ផ្គត់ផ្គង់ទីផ្សារក្នុងស្រុក និងនាំចេញផលិតផលសម្រេចដែលលើសពីតម្រូវការក្នុងស្រុក ដោយតម្រូវមុននឹងចាប់ផ្តើមធ្វើការសាងសង់រោងចក្រសូមឲ្យក្រុមហ៊ុនបំពេញបែបបទសុំអាជ្ញាប័ណ្ណធ្វើអាជីវកម្មខ្សាច់ស និងបែបបទពាក់ព័ន្ធនានាផ្សេងទៀតស្របទៅតាមច្បាប់ជាធរមាន នោះ រាជរដ្ឋាភិបាលបានសំរេចដូចតទៅ ៖

១-យល់ព្រមតាមសំណើ
២-ត្រូវបំពេញបែបបទតាមនីតិវិធីជាធរមាន ។

សេចក្តីដូចបានជំរាបជូនខាងលើ សូមឯកឧត្តម មេត្តាជ្រាប និងចាត់ចែងអនុវត្តតាមការគួរ ។

ជ.រដ្ឋមន្ត្រីទទួលបន្ទុកទីស្តីការគណៈរដ្ឋមន្ត្រី
រដ្ឋលេខាធិការ

ប្រាក់ សុខុន

ចម្លងជូន:
-ក្រសួងមហាផ្ទៃ
-ក្រសួងសេដ្ឋកិច្ច និងហិរញ្ញវត្ថុ
-ក្រសួងរៀបចំដែនដី នគរូបនីយកម្ម និងសំណង់
-ក្រសួងបរិស្ថាន
-ក្រសួងធនធានទឹក និងឧតុនិយម
-ក្រុមប្រឹក្សាអភិវឌ្ឍន៍កម្ពុជា
-ខុទ្ទកាល័យសម្តេចនាយករដ្ឋមន្ត្រី
-ក្រុមហ៊ុន ធនិន ថារិទ្ធ អ៊ីមផតអិចផត ខូអិលធីឌី
-ឯកសារ-កាលប្បវត្តិ

ក្រសួងឧស្សាហកម្ម រ៉ែ និង ថាមពល
Ministry of Industry, Mines and Energy
លេខ: ២១៤៤ ឧរថ.កឧ.

ព្រះរាជាណាចក្រកម្ពុជា
ជាតិ សាសនា ព្រះមហាក្សត្រ
Kingdom of Cambodia
Nation Religion King

រាជធានីភ្នំពេញ, ថ្ងៃទី២៨ ខែ សីហា ឆ្នាំ២០១៣

រដ្ឋមន្ត្រី ក្រសួងឧស្សាហកម្ម រ៉ែ និងថាមពល
សូមគោរពជូន
សម្តេចអគ្គមហាសេនាបតីតេជោ ហ៊ុន សែន នាយករដ្ឋមន្ត្រី
នៃព្រះរាជាណាចក្រកម្ពុជា ជាទីគោរពដ៏ខ្ពង់ខ្ពស់

កម្មវត្ថុ: ការផ្តល់មតិលើសំណើសុំគោលការណ៍សាងសង់ រោងចក្រផលិតកែវ និងកញ្ចក់ សំរាប់ផ្គត់ផ្គង់ទីផ្សារក្នុងស្រុក និងនាំចេញផលិតផលសម្រេចដែលលើសពីតម្រូវការក្នុងស្រុក របស់ក្រុមហ៊ុន ធនិន ថារិទ្ធ អ៊ីមផតអិចផត ខូអិលធីឌី

យោង: លិខិតលេខ 1010 ខន/០១៣ ចុះថ្ងៃទី 22 ខែ ឧសភា ឆ្នាំ ២០១៣ របស់ខុទ្ទកាល័យសម្តេចអគ្គមហាសេនាបតីតេជោ ហ៊ុន សែន នាយករដ្ឋមន្ត្រី

សេចក្តីដូចបានចែងក្នុងកម្មវត្ថុ និងយោងខាងលើ ខ្ញុំបាទមានកិត្តិយសសូមអនុញ្ញាតគោរពជម្រាបជូន សម្តេចអគ្គមហាសេនាបតីតេជោ ហ៊ុន សែន នាយករដ្ឋមន្ត្រី នៃព្រះរាជាណាចក្រកម្ពុជា មេត្តាជ្រាបដ៏ខ្ពង់ខ្ពស់ថា ក្រសួងឧស្សាហកម្ម រ៉ែ និងថាមពល ឯកភាពជាគោលការណ៍លើសំណើសុំសាងសង់រោងចក្រផលិត កែវ និងកញ្ចក់ពីខ្សាច់ ស សំរាប់បម្រើទីផ្សារក្នុងស្រុក និងនាំចេញផលិតផលសម្រេច កែវ និងកញ្ចក់ ដែលលើសពីតម្រូវការទីផ្សារក្នុងស្រុក របស់ក្រុមហ៊ុន ធនិន ថារិទ្ធ អ៊ីមផតអិចផត ខូអិលធីឌី ។ ការបង្កើតរោងចក្រនេះ បានផ្តល់តម្លៃបន្ថែមលើវត្ថុធាតុដើមខ្សាច់ក្នុងស្រុក នាំមកនូវការផ្ទេរបច្ចេកវិទ្យា បង្កើតការងារ និងផលប្រយោជន៍ផ្សេងទៀត ហើយចំពោះ ការនាំចេញផលិតផលសម្រេចកែវ-កញ្ចក់នេះក៏ពុំមានច្បាប់ហាមឃាត់ដែរ។

៤៥ មហាវិថីព្រះនរោត្តម ខណ្ឌដូនពេញ ភ្នំពេញ ទូរស័ព្ទ (៨៥៥)-២៣-២១១១៤១ , ទូរសារ : ៨៥៥-២៣-៤២៨២៦៣
45 Preah Norodom Boulevard, Khan Daun Penh, Phnom Penh, Phone : 855-23-211141 , Fax : 855-23-428263

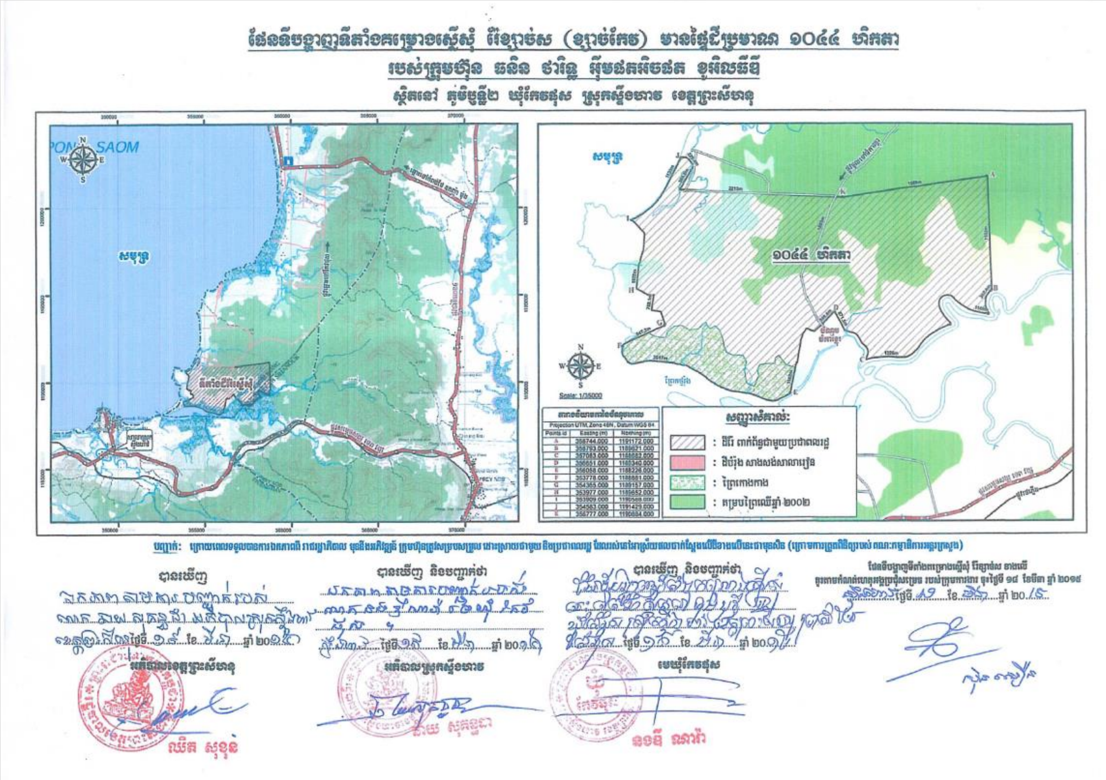
ក៏ប៉ុន្តែ មុននឹងចាប់ផ្តើមធ្វើការសាងសង់រោងចក្រ សូមឱ្យក្រុមហ៊ុនបំពេញបែបបទសុំ អាជ្ញាប័ណ្ណធ្វើអាជីវកម្មខ្សាច់ ស និងបែបបទពាក់ព័ន្ធនានាផ្សេងទៀត ស្របទៅតាមច្បាប់ជាធរមាន។

សេចក្តីដូចបានគោរពជម្រាបជូនខាងលើសូម សម្តេចតេជោ នាយករដ្ឋមន្ត្រី មេត្តាជ្រាប និងផ្តល់អនុសាសន៍ណែនាំដ៏ខ្ពង់ខ្ពស់។

សូម សម្តេចអគ្គមហាសេនាបតីតេជោ ហ៊ុន សែន នាយករដ្ឋមន្ត្រី នៃព្រះរាជាណាចក្រកម្ពុជា មេត្តាទទួលនូវគារវកិច្ច និងការគោរពដ៏ខ្ពង់ខ្ពស់បំផុតពីខ្ញុំបាទ។

ស៊ុយ សែម

29.8.13



Expenditure Operation cost

Table 5-1: List of equipment and plant installation

No	List	Size (mm)	Power	Working	Unit	Price (baht)/unit	Value (baht)
1	Hopper	4000x4000x2500		100	1	300000	300000
2	Belt feeder	4000x600	7.5Kw	100	1	140000	140000
3	Belt conveyor	18000x600	7.5Kw	30	7	360000	2520000
4	Trommel	#20	7.5 KW	50	3	587400	1762200
5	Hydro-cyclone	Ø375		20	6	190000	1140000
6	Spiral Concentrator	4x4 Spirals		20	4	800000	3200000
7	Pumping	8-inch x 6 inch	24Kw	300m3	3	140000	420000
8	Magnetic Separator	2000x1000	5KW	0.5	1	915000	915000
9	Attrition scrubber				1	310000	310000
10	Tank classifier	Ø2500x7000			3	467400	1402200
11	Other						
Installation and construction						THB	23,250,000.00
Total						THB	35,359,400.00
Road Construction						THB	57,640,600.00
Total consumption						THB	93,000,000.00

Table 5-2: Employment expend

LABOR COST	UNIT	BAHT/UNIT	TOTAL	PER YEAR
PLANT MANGER	1	50,000.00	50,000.00	600,000.00
ENGINEER	2	30,000.00	60,000.00	720,000.00
ACCOUNTANT	1	16,000.00	16,000.00	192,000.00
SALE MANAGER	1	20,000.00	20,000.00	240,000.00
MARKETING MANAGER	1	20,000.00	20,000.00	240,000.00
FOREMAN	2	16,000.00	32,000.00	384,000.00
WORKER	15	9,000.00	135,000.00	1,620,000.00
SECURITY	1	9,000.00	9,000.00	108,000.00
HOUSEKEEPER	1	9,000.00	9,000.00	108,000.00
MINE MANAGER	1	30,000.00	30,000.00	360,000.00
SURVEYOR	1	20,000.00	20,000.00	240,000.00
MECHANIC	1	20,000.00	20,000.00	240,000.00
TRUCK DRIVER	6	15,000.00	90,000.00	1,080,000.00
EXCAVATOR DRIVER/WHEELER LOADER DRIVER	5	17,000.00	85,000.00	1,020,000.00
FUEL/WATER OPERATOR	3	9,000.00	27,000.00	324,000.00
TOTAL			623,000.00	7,476,000.00

VITA

NAME	Ros Sochea
DATE OF BIRTH	05 September 1993
PLACE OF BIRTH	Kompong Chhnang Province, Cambodia
INSTITUTIONS ATTENDED	1. Department of Geo-resources and Geo-Technical Engineering, Institute of Technology of Cambodia, Phnom Penh City 2. Department of Geo-resources and Petroleum Engineering, Chulalongkorn University
HOME ADDRESS	Phetchaburi 18 Alley, Khwaeng Thanon Phetchaburi, Khet Ratchathewi, Krung Thep Maha Nakhon 10400
PUBLICATION	Study on Beneficiation of silica sand by Wet High-Intensity Magnetic Separators (WHIMS) and Reverse flotation technique for glass application: A case study in Sihanoukville province, Cambodia at National Geoscience Conference (NGC 2018): Geo-resources Development for Sustainable Future in Penang City, Malaysia
AWARD RECEIVED	ASEAN scholarship