

**ALTERNATIVE SUPPLIER SOURCING TOWARDS TOTAL PRODUCTION
COST EFFECTIVENESS: A CASE STUDY OF STONE WOOL INSULATION
INDUSTRY**



**AN INDEPENDENT STUDY SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN
MANAGEMENT
INTERNATIONAL COLLEGE
KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG
2017
KMUTL-2017-IC-M-002-004**

**ALTERNATIVE SUPPLIER SOURCING TOWARDS TOTAL PRODUCTION
COST EFFECTIVENESS: A CASE STUDY OF STONE WOOL INSULATION
INDUSTRY**



**AN INDEPENDENT STUDY SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN
MANAGEMENT
INTERNATIONAL COLLEGE
KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG
2017**

KMITL-2017-IC-M-002-004

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

RESEARCH TITLE	ALTERNATIVE SUPPLIER SOURCING TOWARDS TOTAL PRODUCTION COST EFFECTIVENESS: A CASE STUDY OF STONE WOOL INSULATION INDUSTRY
STUDENT NAME	NIPON SARACHAN
STUDENT ID	57610006
DEGREE	MASTER OF SCIENCE
PROGRAM	LOGISTICS AND SUPPLY CHAIN MANAGEMENT
RESEARCH ADVISOR	ASST. PROF. DR. PHAOPHAK SIRISUK



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่ออ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Independent Study Certification
International College
King Mongkut's Institute of Technology Ladkrabang

Independent Study Title Alternative Supplier Sourcing Towards Total Production Cost Effectiveness: A Case Study of Stone Wool Insulation Industry

Student Mr. Nipon Sarachan


Student ID 57610006

Degree Master of Science

Program Logistics and Supply Chain Management (International Program)


Advisor Asst.Prof. Dr. Phaophak Sirisuk

IS Reference Number KMITL-2017-IC-M-002-004

EXAMINERS	SIGNATURES
Dr. Jaruwit Prabnasak	
Asst. Prof. Dr. Wichitsawat Suksawat na Ayudhya	
Asst. Prof. Dr. Phaophak Sirisuk	

Date: May 27th, 2017 **Time** 15.00 – 17.00
Place: International College, 8th floor, 55th Anniversary Chalermpraktiat Building

KING MONGKUT'S INSTITUTE OF TECHNOLOGY LADKRABANG


(Assoc.Prof.Dr. Supat Kittiratsatcha)
Dean of International College
May 27th, 2017

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ABSTRACT

In order to reduce variable production cost, three important steps are needed. These include (1) finding major problem, (2) exploring the problem solution and (3) suggesting decision making guideline. In the first step, after reviewing for current statuses, constraints and assumptions, ABC classification is the powerful technique to find out the major problem to take consider. In this case, the researcher found that reducing cost for coke and raw materials that must be used in the primary process is the most important issues to be concerned in reducing overall cost. The second step is establishing the real problem statements.

After exploring for every possible alternatives or solutions under knowledge on-handed, there are two alternatives left to be compared in this case; using European coke or switch to using Chinese coke. The last step is suggesting the decision making guidelines or monitoring and decision supporting tools for future actions. For this step, cost for both alternatives are simulated simply by excel program. After input the value of parameters; price, percentage of coke usage, percentage of material efficiency and exchange rate, the total production is calculated automatically. According to the past 4 years data, in this case, it is obviously seen that using Chinese coke is the most appropriate solution which could reduce cost for around 15 million THB through the last 4 years.

Since coke and all the materials are completely imported then the different exchange rate and the uncertainty of the exchange rates are other important issue to take concern. According to the last two years data, using “Everest coke” can reduce cost for almost 1 million THB annually due to the different of exchange rate. Moreover, considering the uncertainty of the exchange rates supports changing to use “Everest coke” instead of “Nalon coke” with the possibility to save cost for around 4.8 million THB/year as well.

Keywords: Variable production cost, ABC classification, Pareto, coke, Exchange rate

ACKNOWLEDGEMENT

I would like to express my deepest gratitude toward these people who have contributed to my success in completing this research paper.

First of all, I am grateful to my advisor, Asst. Prof. Dr.Phaophak Sirisuk for his support, guidance, and comment. Besides, I would also like to thank all professors for their knowledge sharing, encouragement, and useful advice. Additionally, I would like to thank all staffs at KMITL for their assistance and motivation.

Most importantly, I would like to say thank you to my family especially my parents for their love, understanding, inspiration, and continuous support. I would not have come to this step of my life without them by my side.

Aside, I would also like to extend my thanks to all of my friends and my colleagues for cheering me up.

Finally, I would like to thank to all the references which I have used throughout this research paper.

Nipon Sarachan

TABLE OF CONTENTS

	Page
ABSTRACT	II
ACKNOWLEDGEMENT	III
TABLE OF CONTENTS	IV
LIST OF TABLES	VII
LIST OF FIGURES.....	VII
CHAPTER 1: INTRODUCTION	1
1.1 Company background.....	1
1.2 Stone wool insulation process.....	2
1.3 Background and problem Statement.....	4
1.4 Objectives of the study	2
1.5 Scope of the study.....	4
1.6 Research methodology.....	4
CHAPTER 2: LITERATURE REVIEW.....	6
2.1 Stone wool insulation Industry	6
2.1.1 Cupola furnace production process (CFPP)	9
2.1.2 Energy consumption for CFPP	11
2.1.2.1 Coking coal production, trade and consumption	13
2.1.2.2 U.S., Chinese, and Global Coke.....	15
2.2 Process key figures in Stone wool Industry.....	16
2.3 Variable production Cost.....	111

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง IV อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

2.4 Applying ABC inventory analysis concept and pareto principle for Stone wool production cost consideration	19
2.5 Benefits of supplier relation management	21
2.6 Impact of foreign exchange	23
2.7 Inco terms rules or international commercial terms	27
2.8 Applying box plot for the consideration of exchange rate and cost uncertainty	30
2.9 Strategic supplier sourcing literature review	34
CHAPTER 3: METHODOLOGY	37
3.1 Product portfolio and cost structure	37
3.2 Bill of materials and materials efficiency analyzing	41
3.3 Applying the tools to the problem	42
3.3.1 Analyze problems of the company	43
3.3.2 Plan ABC classification of all materials consumption	45
3.4 Factors affect cost for coke and raw materials	48
CHAPTER 4: RESULTS	53
4.1 Material efficiency and coke ratios.....	53
4.1.1 AS-IS (Present approach: European Coke)	53
4.1.2 TO-BE (Alternative approach: Chinese Coke).....	54
4.2 Conducting alternative scenarios.	54
4.2.1 AS-IS (Using European coke as an energy)	55
4.2.2 TO-BE (Using Chinese coke as an energy).....	55
4.3 Effect from exchange rates	56
4.4 Box plot analysis.....	60

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

CHAPTER 5: CONCLUSION	63
5.1 Conclusion	63
5.2 Future work.....	64
REFERENCES	65
APPENDIX.....	67
AUTHOR BIOGRAPHY.....	89



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง **VI** ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

LIST OF TABLES

Table	Page
2.1 Compare the properties and characteristics of stone wool insulation and fiberglass.....	7
2.2 Cupola Control Variables	10
2.3 Total world coal production (Metric ton).....	11
2.4 Major coal producers (Metric ton).....	12
2.5 Coking coal exporting volume in 2013-2015.....	14
2.6 A summary of critical success factors for strategic sourcing.....	36
3.1 Production Cost (Benchmarking vs Tons produced).....	38
3.2 Annual cost (2015).....	40
3.3 Melting recipe for this case study.....	42
3.4 Total amount of each class of material.....	46
3.5 Material Type “A” from ABC Classification.....	46
3.6 Material Type “B” from ABC Classification.....	47
3.7 Factors affect to VPC.....	49
4.1 Cost for raw material and coke (European Coke).....	55
4.2 Cost for raw material and coke (Chinese Coke).....	56
4.3 Overall VPC (simulated by quarter).....	57
4.4 Timeline saving.....	58
4.5 Value of minimum, maximum, 1 st quartile, 3 rd quartile and median value from box plot analysis.....	61
4.6 Cost saving from using Chinese coke (THB/month).....	62

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง VII ึ่งอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

LIST OF FIGURES

Figure

1.1 Stone-wool insulation Properties	1
1.2 Applications of stone wool in several parts of industry	2
1.3 An overview of stone wool insulation production processes	2
1.4 Raw materials flow through CFPP process and spinning process	3
2.1 Stone wool insulation market size and growth in Thailand	7
2.2 Insulation Market Size and Growth	8
2.3 Schematic structure of cupola furnace	9
2.4 Proportions of coal produced by ten major source countries	13
2.5 World Coking Coal Consumption (Metric ton)	15
2.6 Key Figures Illustration	16
2.7 Examples of Process Key Figures Calculations	17
2.8 Pareto principle	20
2.9 (a) Historical Foreign Exchange rate for 2 years long (28 Dec 2013 – 28 Dec 2015)	24
2.9 (b) Historical Foreign Exchange rates in 2015	25
2.10 Example of the variations of foreign exchange rates	26
2.11 Structure of box plot	31
2.12 Horizontal box plot	32
2.13 Distribution skewed in box plot	32
2.14 Example for two different box plot A and B	33
2.15 Proposed conceptual model and associated hypotheses	34
3.1 Stone wool manufacturing process	37
3.2 Cost structure of each product	39
3.3 Amount of coke and stones used in melting process	41
3.4 Effect of Coke on Material Efficiency	42
3.5 Process flow and quantities of major materials consumption	44
3.6 Amount of all materials consumption	45

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และ VIII จึงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

3.7 Factor affects VPC	50
4.1 Actual materials efficiency and percentage of coke usage in 2015	54
4.2 Simulated VPC saving by using historical exchange rate	59
4.3 Box plot analysis for monthly exchange rate since 2011 to 2016	60



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง **IX** อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

CHAPTER 1

INTRODUCTION

1.1 Company background

The Company A was founded in 1909 and insulation production started in 1937. The Group's head office is located close to Copenhagen. In 2015, the Group generated net sales of EUR 2,208 million. The company is listed on the Nasdaq Copenhagen stock exchange.

The Company A operations have a large presence in Europe and Russia, a rapidly growing position in North America, and facilities in Asia. With 10,601 employees in 37 countries, Rockwool could support customer world widely.

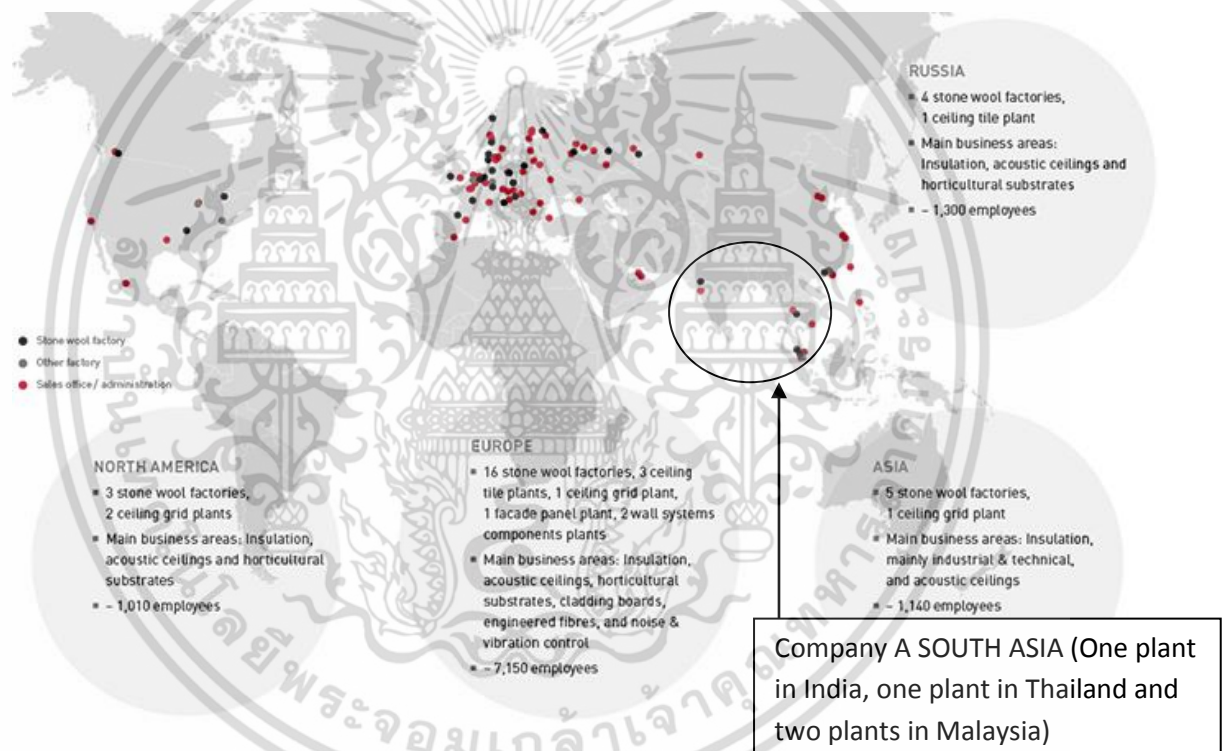


Figure 1.1 Stone-wool insulation Properties. <http://www.rockwool.com>

Stone-wool insulation is an important material to clad the pipe line and machine of many industrial, because it's can withstand more than 1000 degree Celsius without burnt then it is designed to used for protect assets in the factory. Moreover, with several properties such as non-combustible, thermal properties, noise absorbing, water repellent, stone wool is applied in many parts of factory.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ 1 อ่างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

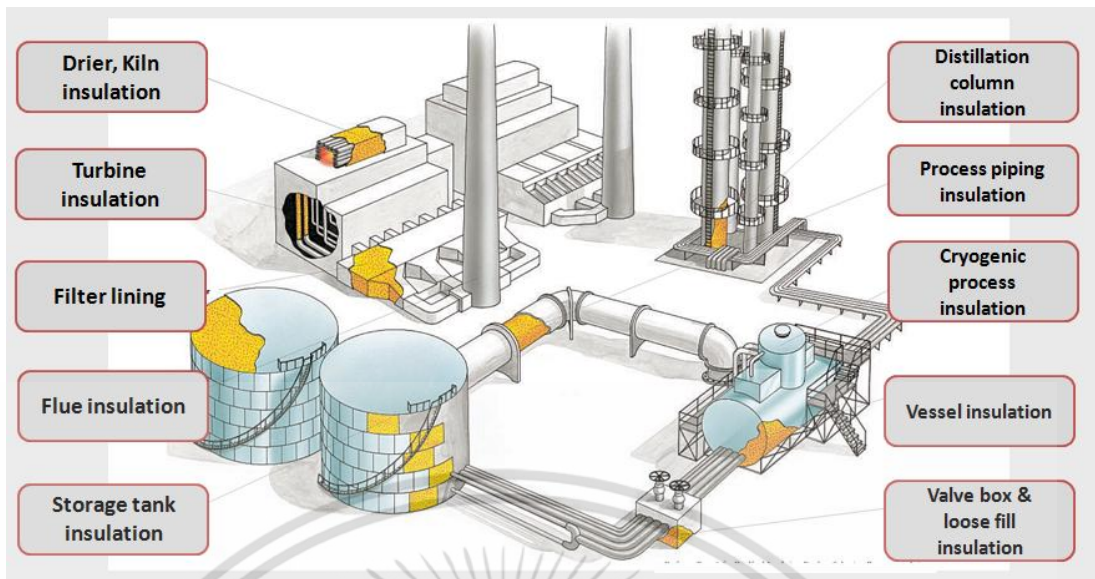


Figure 1.2 Applications of stone wool in several parts of industry. <http://www.rockwool.com>

1.2 Stone wool insulation process

Stone wool insulation products are different in sizes, shape or some application properties which depended on customer's needs. To produce those various products, two main processes have to be done. First process is the primary process that similar for every type of product. Next is the finishing process which is the state of making various products to meet customer's orders. Another important process is recycling process which helpful in reducing production loss and other pollutions. The stone wool insulation production processes are depicted on the following Figure 1.3.

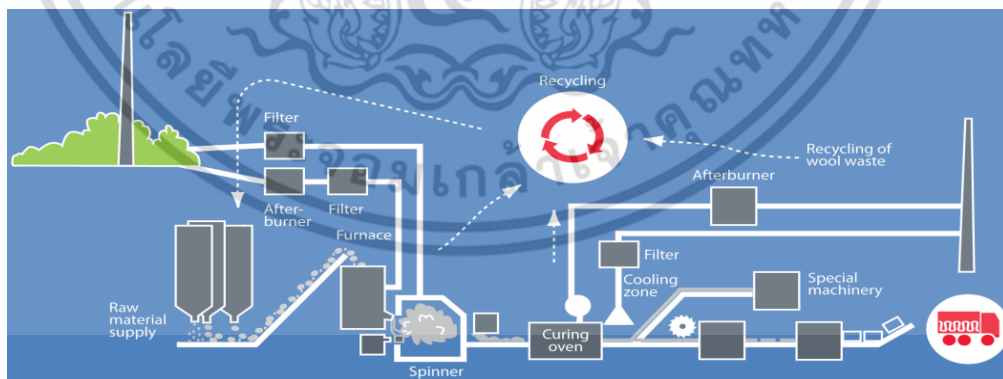


Figure 1.3 An overview of stone wool insulation production processes. <http://www.rockwool.com>

Primary process called Cupola furnace production process (CFPP) is the process that several kinds of material such as various types of stone, slag and other components are melted together in cupola furnace by using energy from foundry coke. After melting state, the secondary

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ 2 ข้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

process called spinning process has to be done. In this process, melted stones are spun together with the specified resin and controlled conditions to formulate product that has specific characteristics, density and dimension designed for unique customer's needs.



Figure 1.4 Raw materials flow through CFPP process and spinning process

Next, stone wool insulations are differently processed to formulated various types of finished products.



Picture 1.1 Finished Products. <http://www.rockwool.com>

As mentioned earlier, CFPP is the primary process that every types of product have to pass. CFPP is then be one of the most important process that consume big portion of cost; materials cost, production cost, procurement cost and last but not least the logistics cost. Look deep inside the total cost of CFPP, founded one big important cost of foundry coke which are procured from several sources with different prices and transportation or shipment costs. Moreover, the cupola model indicate that some source of coke will impact the consumption in cupola process (Miller and Jensen, 2005), and also effect with all material efficiency in furnace.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ3ข้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Many dimensions of research on CFPP had been published; material efficiency, production cost, an impact of foreign exchange. Therefore, relationship among the parameters should be investigated to improve the cost effectiveness of the company.

The purpose of this study is to provide a solution to improve total production cost effectiveness by using the alternative source.

1.3 Background and problem statement

During Group of Company A in South Asia management meeting, the variable production cost taken in Thailand branch is reported, the highest, compare to in other countries. Then this independent study is strongly propelled to find the priority action to reduce the cost of Company A Thailand.

1.4 Objectives of the study

- 1) To apply ABC segmentation technique for raw materials classification in stone wool industry
- 2) To find main parameters that strongly affect to the root problem.
- 3) To provide a guideline for key raw materials in stone wool industry from alternative source.

1.5 Scope of the study

The study focuses on case study of stone wool production. Majority of raw materials is cupola furnace. Besides, it relies upon one-year data collection.

1.6 Research methodology

The project is divided into seven parts namely:

- 1) Applying ABC classification to understand overall consumption of all materials which impact production cost.
- 2) Analysis highest of the group and usage structure.
- 3) Summarize structure of the usage.
- 4) Analysis each element which impact the cost including Exchange rate and efficiency dimension.

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ 4 ข้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

- 5) To generate specific equation for this case study.
- 6) Minimize total cost which related source of material.
- 7) To identify the solution to improve production cost effectiveness.



เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ 5 ข้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

CHAPTER 2

LITERATURE REVIEW

According to the problem reported in the Chapter1 that the production variable cost of Thailand-site is highest compare to of other countries. To solve that problem, clearly understanding of the real situation is necessary. The root problems are needed to find out and related knowledge must be reviewed before consideration for a solution.

In this chapter, several related topics are reviewed. The background of stone wool insulation industry is reviewed first. Stone wool production processes are described. In order to understand the production cost concerned in this problem, cost structure and other related knowledge are reviewed respectively

2.1 Stone wool insulation industry

Fiber materials as generally called in several name as Mineral wool, mineral fiber, mineral cotton, mineral fiber, man-made mineral fiber(MMMF), or man-made vitreous fiber (MMVF), are materials that formed by spinning or drawing molten minerals (or "synthetic minerals" such as slag and ceramics). These fiber materials are named specifically after the raw material in the production such as glass wool (made from glass), stone wool (made from rock) and so on.

As mentioned above, Stone Wool is made from strands of tiny rock or mineral that have been heated up and woven into a wool-like material while Fiberglass on the other hand is produced from fine strands of glass which are wound together to make insulation.

Properties and characteristics of stone wool insulation and fiberglass are comparatively shown in following Table 2.1

Table 2.1 Compare of the properties and characteristics of stone wool insulation and fiberglass.

Properties/ characteristics	Stone wool	Fiberglass
Material	40-75% recycled material, depending on how readily available the raw materials are at the current time	maximum 30% recycled material
Density	1.7 pounds per cubic foot	0.5 to 1.0 pounds per cubic foot
Withstanding in fire	up to 1800 degrees Fahrenheit	Melt at around 1100 degrees Fahrenheit
Sound blocking	10 decibels	4 decibels
Heat transfer	3.0 to 3.3 R-Value per inch	2.2 to 2.7 R-Value per inch
Packing (disposition)	much easier to pack into walls, leaving no gaps	Disposition or gaps may be founded
Hydrophobic	not absorb moisture (water-repellent)	absorb moisture (risked by rot, corrosion, fungi, mold, or bacterial growth)

Stone wool is widely used in Thailand with 9% growth rate of market size since 2008 until present and future forecasting as depicted in Figure 2.1.

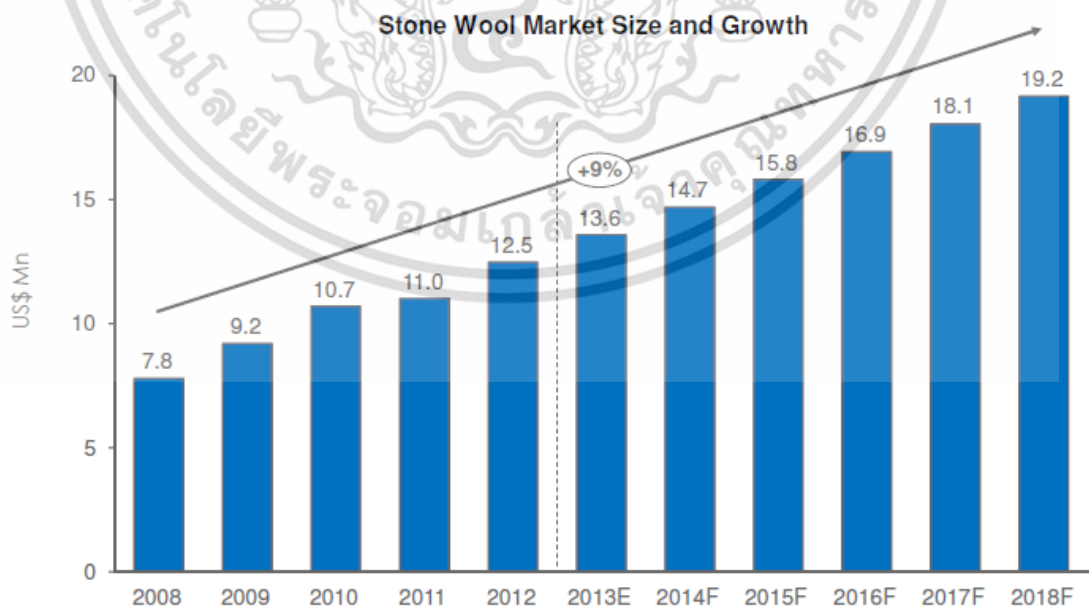


Figure 2.1 Stone wool insulation market size and growth in Thailand. <http://www.rockwool.co.th>

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ 7 ว่าจะอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Stone wool has a variety of different properties which enable it to perform better than fiberglass in many ways, not just R-Value. Market shares of glass wool, stone wool, PU, PE and other insulations in the industry as shown in Figure 2.2 indicates that the market size is 5% growth as a whole. Glass wool holds a large portion of market share but in decreasing trend. Stone wool holds market share with continually growth.

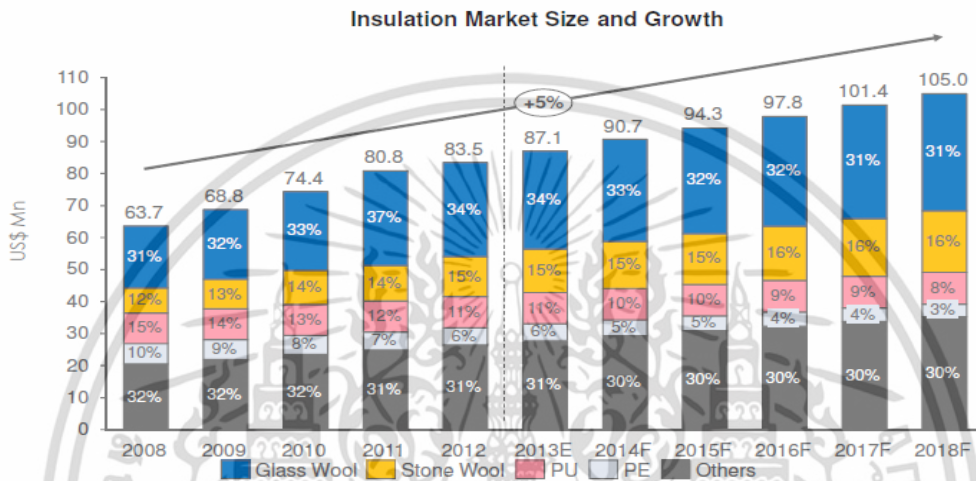


Figure 2.2 Insulation Market Size and Growth. <http://www.rockwool.co.th>

The production of stone wool products involves melting of rock materials and subsequent spinning of the melt into fibers (wool) (Leth-Miller et.,al. 2003) Stone wool is made of a natural volcanic rock called basalt. After re-melted basalt in furnaces at a temperature of 1,500 °C the liquid basalt is then spun into threads in spinning chambers, a binder and surfactant are added to bind the fibers and then the wool is congealed in a hardening kiln using hot air (230 °C). The material is then compressed into wool packets, which are then cut into slabs, blocks or plugs and packaged in film. With factory processing, one cubic meter of basalt can produce approximately fifty cubic meters of stone wool.

2.1.1 Cupola furnace production process (CFPP)

Cupola furnace is usually used in rock melting process (Leth-Miller et.,al. 2003). A cupola furnace is a vertical furnace with a circular cross section as shown in Figure 2.3 Air is blown into bottom part of furnace through a number of nozzles. Coke and raw materials (ie. rocks, basalt, etc.) are fed from the top of furnace. Rocks are melted in the melting zone, and are collected in a melt bath.

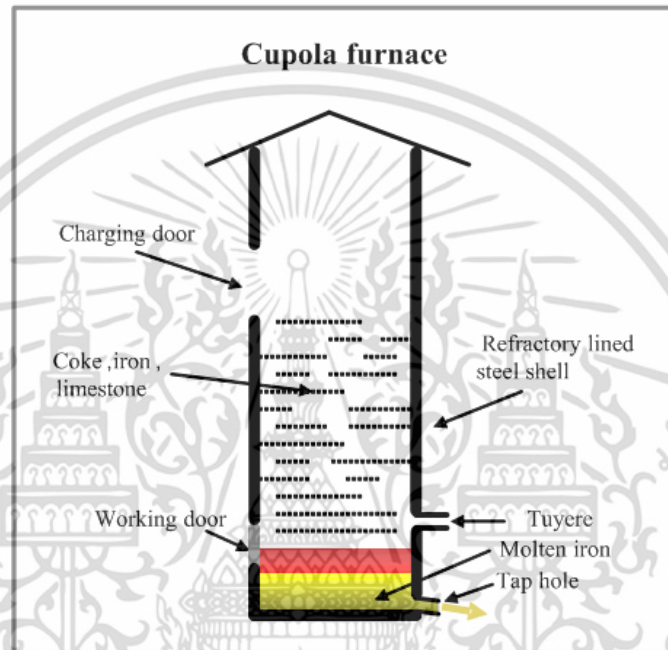


Figure 2.3 Schematic structure of cupola furnace. <http://www.atlasfdry.com/cupolafurnace.htm>

Major variables for cupola control are shown in Table 2.2 Air blast rate is controlled by changing the speed of the blowers, blast temperature by regulating the input to the heaters, and oxygen by regulating the oxygen flow. These variables have short time constants and little delay. The metal charge ratio and the coke ratio, however, are changed by altering what is charged into the top of the cupola. It takes some time, up to an hour, for these changes to propagate with the slowly sinking charge into the active melt zone of the cupola. In current practice, these variables are not automatically controlled. While an independent control loop might be used, for example to maintain constant blast rate, it is up to the operator, based on experience, to select the blast rate and other inputs to reach the required outputs. When the casting line needs no metal, because molds are full, cranes are busy, or it is shut down for a shift or longer, the cupola can be “banked” with a reduced blast rate. There are transient effects associated with this event, which are more

severe for longer shutdowns. A feedback control system would also be desirable during these

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และด้วย 9 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

transient phases, to reduce time and material consumption and to avoid the formation of unusable “transition iron.”

The difficulty of controlling a cupola is due to the fact that the input and output variables are not independent and are cross-linked. For example, to increase the iron temperature, an operator may increase the rate of the blast air. But this would also increase the melting rate, which may be undesirable. Conventional linear control techniques are not very effective at handling control systems with significant cross-linking. Therefore, more intelligent control techniques are needed to control a cupola furnace.

Table 2.2 Cupola Control Variables

Output	Primary Input	Secondary Input
Melting Temperature	Blast Rate	Coke Ratio
	Blast Temperature	
	Oxygen Addition	
Melting composition	Metal Charge Ratio	Coke Ratio
		Oxygen Addition
		Blast Temperature
Melting Rate	Blast Rate	Oxygen Addition
	Coke Ratio	

(E.D. Larsen et .,al. 1997).

From Table 2.2, we found 2 keys parameter (materials charge ratio, and coke ratio) to impact output of CFPP

Cupola control impact costs

- 1) Melting material (STONE)
- 2) Energy for melting (COKE)
- 3) Oxygen
- 4) Blast Air (impact electricity)

Refer Rockwool VPC we found melting materials and energy for melting have a potential to development in Chapter 3.

2.1.2 Energy consumption for CFPP

Foundry coke is the carbonized product remaining after blended bituminous coals are heated in an oven for a period of time. Foundry coke is used primarily in the production of molten iron (e.g., gray iron) by a cupola furnace, both as a fuel and as a source of carbon for the product (Source of data: U.S. international trade commission, 2000).

Table 2.3 Total world coal production (Metric ton)

Coal product	2013	2014	2015
Steam Coal	6,064.1	6,006.2	5,811.4
Coking Coal	1,076.5	1,107.6	1,089.9
Lignite	834.0	815.9	807.4
Total Coal	7,974.6	7,929.7	7,708.7
Peat	19.3	15.2	
Oil Shale/Sands	20.9	21.4	

(Source of data: International Energy Agency, 2016)

Though the world coal production is first declined by 0.6% or 45 Metric tons in 2014 and once again declined by 221 Metric tons, or 2.8% lower in 2015 after 14 years continually growth since 2000 (as presented in Table 2.4 below), the People's Republic of China is still be the world's leading coal producer as it has been since 1985

Ten major sources of coal with more than 100 Metric Tons/year production capacities are listed in Table 2.4.

Table 2.4 Major coal producers (Metric Tons)

Source Countries	2013	2014	2015
PR of China	3,748.5	3,640.2	3,527.2
United State	903.7	918.2	812.8
India	610.0	657.4	691.3
Australia	458.4	488.8	508.7
Indonesia	489.7	484.7	469.3
Russian Federation	326.0	332.9	349.3
South Aferica	256.3	260.5	252.1
Germany	191.0	186.5	184.7
Poland	142.9	137.1	135.8
Kazakhstan	119.6	114.0	107.2
Other	728.5	709.2	670.5
World	7,974.6	7,929.7	7,708.7

(Source of data: International Energy Agency, 2016)

The People's Republic of China is still the world's leading coal producer, as it has been since 1985, with around 46% of total coal production around the world while the United State hold second rank with around 11% production. Figure 2.4 depicted the proportions of coal production volume produced by ten major countries around the world.

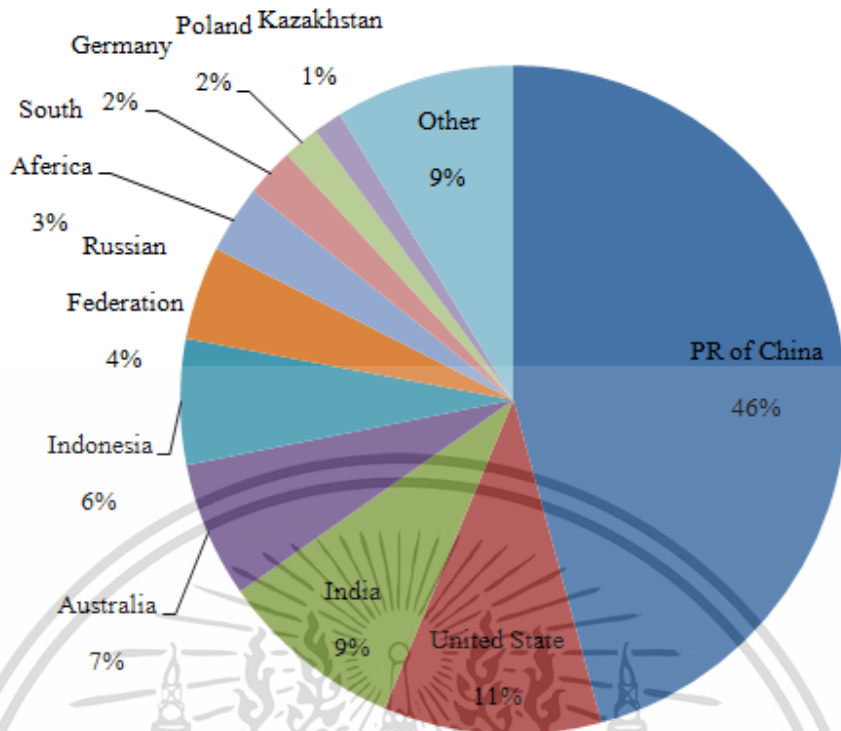


Figure 2.4 Proportions of coal produced by ten major source countries. (Source of data: International Energy Agency, 2016)

2.1.2.1 Coking coal production, trade and consumption

Australia is the world’s second largest producer and the largest exporter of coking coal with 191.1 Metric tons production volume and 182.5 Metric tons exporting volume respectively. While 56.1% of the coking coal (around 611.1 Metric tons) is produced by People’s Republic of China.

Coking Coal exporting volume shown in Table 2.5 indicates that total world coking coal export trade decreased by 3.7% to 299.2 Metric tons in 2015. Australia remained the largest exporter of coking coal at 187.7 Metric tons, accounting for 62.7% of coking coal exports, up from 58.1% in 2014.

Table 2.5 Coking coal exporting volume in 2013-2015

Source Countries	2013	2014	2015
Australia	154.2	180.5	187.7
United States	59.6	54.5	41.7
Canada	35.0	31.1	28.0
Russian Federation	21.5	21.1	18.3
Mongolia	7.7	6.0	7.7
Other	16.7	17.5	15.6
World	294.9	310.7	299.2

(Source of data: International Energy Agency, 2016)

Coking coal consumption by Japan, Organization for Economic Co-operation and Development (OECD), China and World total is depicted in Figure 2.5 Global coking coal consumption is rapidly increased in trend since 2003. Volume of Coking Coal consumed by Japan is quite stable while consumption by OECD is decreasing in trend. On the other hand, coking coal consumption by China is slightly growth since 1978 to 2003, rapidly growth since 2003 until 2014.

Though, in 2015, the global coking coal consumption decreased by 14.1 Metric tons or 1.3% to 1,071.5 Metric tons, the records of coking coal consumption is also represents an increase of 607.8 Metric tons or 131% since 2001. Consumption within the People's Republic of China accounts for 61.4% of global coking coal consumption in 2015.

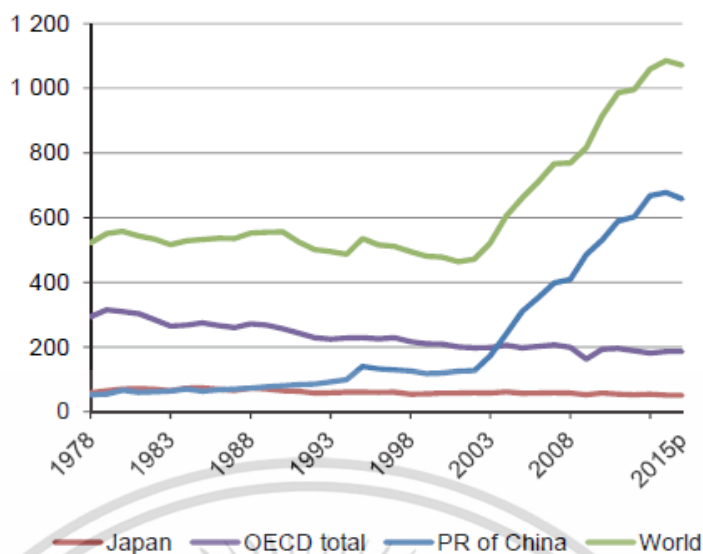


Figure 2.5 World Coking Coal Consumption (Metric ton)

2.1.2.2 U. S., Chinese, and Global Coke

Industry sources estimate world production of foundry coke at approximately 2 percent of total coke production, or about 6.3 million metric tons. As the world’s largest producer of foundry coke, China had a domestic capacity of about 2.6 to 2.7 million metric tons in 1997 (U.S. international trade commission, 2000). Price, quality, environmental regulations, and transportation costs are some of the factors believed to affect foundry coke production and consumption trends as well as overall coke trends. In addition, there are other factors that more specifically affect trends in foundry coke, such as demand in the foundry industry, the dominant end user. The trends in the foundry industry toward electric furnaces and nonferrous castings, as well as larger cupolas, may also affect foundry coke demand in the future.

Generally, U.S. producers reported that imported Chinese foundry coke can be physically used for the same applications as U.S.-produced foundry coke. However, Chinese foundry coke is not substitutable for U.S.-produced foundry coke in all applications. Approximately 75 percent of the importers, brokers, and purchasers who responded to the Commission’s questionnaire stated that the U.S. product is considered to be superior in terms of quality. Although U.S. purchasers of Chinese foundry coke stated that quality (chemical composition and consistency) and price are considered to be the most important factors affecting purchasing decisions, they generally agreed that price was the major factor affecting their decision to purchase Chinese foundry coke. Representatives of the Chinese industry have stated that Chinese producers have been aware of

the concerns about quality held by foreign purchasers and have been working for some time to

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และด้วย 15 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

improve the quality of their coke exports. Over the years, they reportedly have worked to improve product performance, reliability of supply, transportation, and warehousing. Respondents to the Commission’s questionnaires suggested that Chinese and U.S. foundry cokes are generally “comparable” in terms of availability, delivery terms, delivery times, discounts offered, packaging, product consistency, and reliability of supply.

2.2 Process key figures in Stone Wool Industry

This study focuses on production variable cost reduction which is partially influenced by performance and efficiency of production process. Understanding of process performance and efficiency measurement is then necessary. To ensure the consistency of the process performance, the “Process Key Figures” is prepared and used as a manual or KPIs to evaluate how well the production process of an individual line takes place by comparing the actual key figures with the budgeted key figures and a similar production line.

The Key figures only apply to the Company A production line and cannot thus be used as basic for an evaluation of granulation, off-line production or warehouse areas. Separate Key figures can be registered for these areas and definitions of General Key Figures have been established to facilitate a total overview. An overview of process performance measurement system is illustrated Figure 2.6.

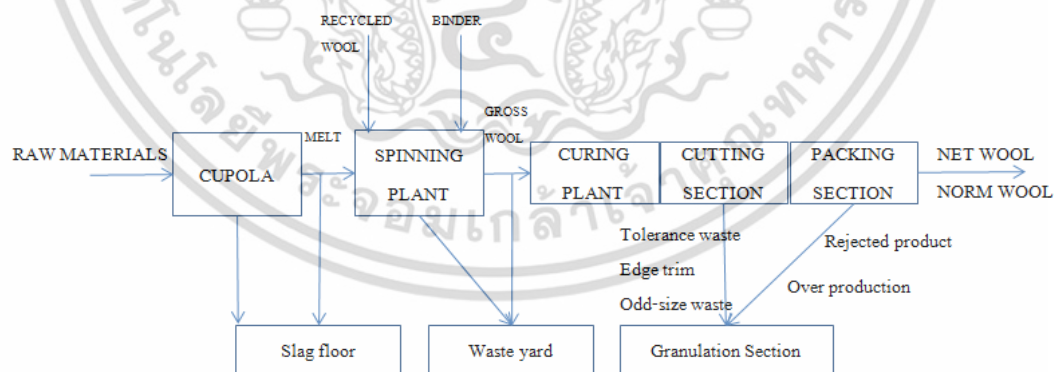


Figure 2.6 Key Figures Illustration (Process Key Figures Manual, Rockwool, 2007)

PROCESS KEY FIGURES

Week Number	1	2
Charging Rate (Kg)	12,584	12,384
Coke Percentage (%)	13.1	12.6
Spinning Efficiency (%)	73.5	73.5
Recycling Percentage (%)	13.4	11.9
Gross Wool 1 (Kg/H)	10,681	10,331
Other Waste Percentage (%)	3.7	4.4
Edge Trim Percentage (%)	3.5	3.5
Odd Size Waste Percentage (%)	0.5	0.7
Volume Efficiency (%)	99.7	99.6
Time Efficiency (%)	96.7	97.5
Material Efficiency (%)	76.7	74.4
Planned Production Time (Hrs)	154.75	131.75
Line Wool2 (Kg/H)	9,564	9,224
Cupola Efficiency (%)	87.1	87.1

Figure 2.7 Examples of Process Key Figures Calculations (Process Key Figures Manual, Rockwool, 2007)

According to this study which is concerned about variable cost, some important key figure calculations such as material efficiency, line wool, coke percentage are described here.

“MATERIAL EFFICIENCY (%)” is calculated as the proportion between the quantity of line wool produced and the quantity of raw material used. This key figure is then indicates the efficiency of material used in the production process. For example, if the material efficiency is reported as 90%, its means that 100 kg of materials used in the production process could produce only 90 kg of line wool output. By this key figure, we could express the amount of line wool produced by the percentage of raw material. “Material efficiency” is not just used in monitoring the efficiency of raw materials using, it can be used in a comparison between actually status and budget-planned target and/or compare to other similar production line also.

The quantity of qualified line wool produced by the process, “LINE WOOL (kg)”, is calculated from NORMWOOL plus ODD SIZEWASTE minus ODD SIZE WASTE RECYCLED added up for all products produced.

“COKE PERCENTAGE (%)” means the quantity of coke consumed in melting 100 kg of RAW MATERIALS. This key figure is expressed as a percentage of RAW MATERIALS.

2.3 Variable Production Cost (VPC)

There are two types of cost comprised in the production total cost; fixed cost and variable cost. Fixed costs are expenses that are not directly related to the production volume such as rental

fee, advertising, insurance and office supplies, which tend to remain the same regardless of เอกสารนี้เป็นเอกสารที่ สงวนลิขสิทธิ์ไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และด้วย 17 ว่าจะอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

production output (Investopedia, 2017). Since the variable cost is a corporate expense that depends on production volume and output, increasing production volume causes raising variable cost and, on the other hand, decreasing production amount causes variable cost reduction. The variable cost is then related to process inefficiency inevitably (King, 2007).

Generally, variable cost is calculated from all the resources that directly related to the production such as cost for direct materials or direct labor. According to the manual for variable production cost written by Rockwool Insulation Company (2008), variable production cost (VPC) is calculated from four groups of variable cost these are wages, materials, maintenance costs and green taxes.

VPC–Wage is like a laboring cost which means to all amounts includes vacation pay, pension payments, other payments to social insurance and other costs which are proportionate to the wages. VPC–Material is an expense related to consumed-materials. This coat is not just a material price but also includes the purchasing cost, freight and other costs in connection with the delivery from the supplier to the factory (acquisition costs). Maintenance Cost is an expense for keeping a production systems work properly as they should be. Green taxes are the costs related directly to consumption of certain raw material in terms of cleaning, waste deposit, environmental costs, internal traffic, etc.

Traditionally, production costs are divided in to four types of cost; direct material cost, direct labor cost, indirect labor cost and overhead cost. Cost for material supplied to the production, called direct material cost is then related to the amount of production and defined as variable cost. Direct labor may not be a variable cost if labor is not added to or subtracted from the production process as production volumes change. This situation arises when a production line must be staffed, irrespective of the amount of production volume. Overhead is not a variable cost, since overhead costs will be incurred, irrespective of production levels. For example, rental cost and machine depreciation are overhead costs will be incurred even if there is no production activity. A company with a high proportion of variable costs can usually generate a profit at a relatively low sales level, since there are few fixed costs that must also be paid for in each accounting period.

According to the manual on material flow cost accounting (ISO14051) written by an Asian Productivity Organization in 2014, costs are may be divided into 4 categories; material cost, energy cost system cost (cost for labor, depreciation, maintenance and transport) and waste management cost (Asian Productivity Organization, 2014).

Material cost for rock wool production is a cost for raw materials such as rocks, briquettes and materials for own production of briquettes. Cost for coke used in cupola furnaces and cost of electricity for melting in electrical ovens are major cost for energy in the stone wool insulation production.

2.4 Applying ABC inventory analysis concept and Pareto principle for stone wool production cost consideration

A manufacturer often keeps inventory of various raw materials and components to meet production needs. Are pair shop needs to ensure availability of different parts for replacement and maintenance work. A retailer usually holds certain amount of various merchandize to satisfy market demand. A hospital must keep sufficient medical supplies of all kinds for its clinical and operational needs. In the above inventory systems, the number of stock keeping units (SKUs) maybe so large that it is often not practical to control them individually (Ernst and Cohen, 1990). One way to manage a large number of SKUs is to aggregate them into different groups, and set common inventory control policies for each group (Chakravarty, 1981). Grouping provides management with more effective means for specifying, monitoring and controlling inventory performance. From the operational perspective, grouping may achieve more efficient inventory management by reducing the overhead of managing each inventory group. Inventory policies also align better with item groups than each individual item. For instance, inventory groups with different service levels often reflect a company's order fulfillment strategy and customer relationship policies, e.g., the service level agreement (SLA). Service levels have a direct impact on the company's revenue and profit. A well-known implementation of the inventory grouping idea is the ABC classification method widely used in industry. It was first developed by GE in the 1950s (cf. Flores and Why bark, 1986; Guvenir and Erel, 1998). In a typical ABC approach, one classifies inventory items according to their transaction volume or value. A small number of items may account for a large share of volume; an intermediate category may have a moderate percentage of volume; and a large number of items may occupy a low proportion of volume. These categories are labeled A, B and C. Taking insights from Pareto (1971), it is often found that a small percentage of the inventory items contribute to the majority of a company's sales and revenue. This has led to the 80–20 rule. That is, the top 20% of items are given the A classification, the next 30% of items the B classification and the bottom 50% the C classification (Flores and

Whybark, 1986). Alternatively, Juran (1954) claims that A-items are the highest 5% of the items in dollar value, C-items are the bottom 75% and B items are the middle 20%. Practitioners often employ the ABC classification scheme in a three-step approach to control inventory. First, SKUs are grouped into categories according to their sales volume. Second, inventory policies, e.g. the target service levels, are determined for each group. A common wisdom to determine the service level is that one should concentrate on the A category to enhance managerial effectiveness. As a rule-of-thumb, the A-class items get the highest service level settings and C-class the lowest (Armstrong, 1985). Finally, inventory managers, in collaboration with sales management and finance, need to make sure that the inventory control policy is feasible within the available inventory and management budget.

The Pareto Principle was propounded by Vilfredo Pareto (1848-1923) when he observed that 20 percent of the people of Italy owned 80 percent of the wealth. This concept of disproportion often holds in many areas. The exact values of 20 and 80 are not significant; they could actually be 10 percent and 60 percent. What is important is that there is a considerable disproportion. The values of 20 and 80 just have a simple symmetry. This principle of concentration, inequality, or inverse proportion can be seen from Figure 2.8, where the smaller first part increases to the larger second part as shown in gray.

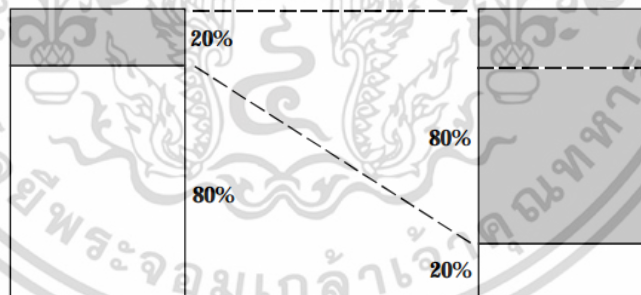


Figure 2.8 Pareto Principle

These Pareto-type observations are not necessarily bad, or good. For example, if only 20% of the roads in a town handle 80% of the traffic, then that could be good for a maintenance crew who can concentrate mainly on the fewer roads; but it could be bad for commuters who take the busy roads. Such Pareto observations could lead to strategies; road crews could try to move commuters off of the busy roads, or commuters could move off on their own.

In case of stone wool production, the concept of ABC inventory group classification (or Pareto concept) could be adopted to be used in cost classification to find the most important point of problem or the most costly consumed. By this concept, costs are analyzed to find out which cost or group of cost is the real serious source of problem.

2.5 Benefits of Supplier Relation Management

In order to maintain profitability and drive efficiencies, these companies are turning to supplier relationship management as a controlled and systematic approach to sourcing the goods and materials they need.

There are several benefits associated with supplier relationship management, and they all culminate in a healthier bottom line.

2.5.1 Reduced cost

There are usually some significant costs involved in setting up deals with new suppliers, but a supplier relationship management program can eliminate many of those costs.

By cooperating in a mutually beneficial relationship with key suppliers, a company can strive for cost savings over the long term.

Good working relationships with suppliers will not only deliver cost savings, they will reduce availability problems, delays and quality issues - and that means a better service for the consumer.

2.5.2 Increased efficiency

As a defined and establish supplier relationship develops, communication improves. Suppliers gain a more complete understanding of the businesses they serve, and this allows them to meet their needs more effectively. Delays in the supply chain will decrease, and the flow of operations will greatly improve.

In addition, when issues in the ordering process do arise, the healthy working relationship between supplier and client will make such issues easier to resolve.

2.5.3 Minimizes price volatility

Nothing spooks consumer more than huge fluctuations in market prices. In some cases, these fluctuations are as a direct result of increase volatility of commodity prices. However, by adopting the principles of supplier relationship management, companies can often take advantage of fixed pricing or scaled increases in exchange for lengthier contract terms, minimum order levels or various other qualifying criteria.

Having a clear and unambiguous cost base allows a business to set its own pricing structures with some certainty, and that often translates to happier, more loyal customers.

2.5.4 Consolidation of the supply chain

As specific areas of both the supplier's and buyer's business work together, this allows both parties to better understand the inner workings of the other. In some cases, both parties will be able to adapt their own working practices and operations to better accommodate the other, and that can lead to further efficiencies and operational advantages.

In addition, consolidation of the supply chain may allow buyers to reduce the number of suppliers they purchase from - streamlining the purchasing process and making budgeting a far simpler task.

2.5.5 Outsourcing certain activities

A successful supplier relationship management program will often create a trusting partnership between a buyer and a supplier. In some cases, this may result in many key activities being transferred to the supplier on a permanent basis. This may include entrusting a supplier with the management of inventory levels and some elements of customer service.

2.5.6 Continual improvement of operations

A long-term relationship between supplier and buyer allows for the free-flow of feedback and ideas. Over time, this will create a more streamlined, effective supply chain that could have a positive impact on both costs and customer service.

The areas of product development, instigating new ordering processes and inventory control can become a joint venture, and that can deliver a range of financial and operational benefits to both parties.

2.6 Impact of Foreign Exchange

Since coke and raw materials are completely imported, their prices are dealt based on source country's currency. For example, if coke is ordered from Everest source (Chinese coke), deal price is made in USD. Or if coke is ordered from Nalon source (European/Spain coke), price is then dealt in EUR as well. Due to the difference of exchange rates, price comparison must be done based on THB currency. Price and cost of any materials is then unavoidably influenced by the exchange rates in two ways; by the value of exchange rate itself and by the uncertainty of those exchange rates.

Since price of imported material is calculated by following equation (2.1) and (2.2). To choose the cheaper one, the prices must be compared in THB currency.

$$\text{Price (THB)} = \text{Price (EUR)} * \text{THB/EUR exchange rate} \quad (2.1)$$

$$\text{Price (THB)} = \text{Price (USD)} * \text{THB/USD exchange rate} \quad (2.2)$$

For example, assume that price of Nalon coke and Everest coke are 58 EUR and 62.5 USD while the exchange rate of THB/EUR and THB/USD are 39.61 and 36.09 respectively. First, it seems like Nalon coke from Europe is cheaper than Everest coke from China. But when consider those prices in THB, it is found that Nalon coke (2,297.38 THB) is more expensive than Everest coke (2,255.62 THB). Rate of exchange is then effect to the real price of material directly.

However, the exchange rate is also unstable. The historical data shown in following figure 2.9 (a) and (b) illustrate the fluctuation of exchange rate through the period of time.

THB per 1 EUR

28 Dec 2013 00:00 UTC - 28 Dec 2015 04:37 UTC
EUR/THB close:39.62000 low:34.43322 high:45.28160



THB per 1 USD

28 Dec 2013 00:00 UTC - 28 Dec 2015 06:23 UTC
USD/THB close:36.09245 low:31.76650 high:36.50500



Figure 2.9 (a) Historical Foreign Exchange rate for 2 years long (28 Dec 2013 – 28 Dec 2015)

(Source: XE.com Inc.)

Figure 2.9 (a) illustrates the 2 years-long recorded data for THB-EUR exchange rate and THB-USD exchange rate on the upper part and lower part of figure respectively. This figure is obviously present the trend of appreciation and depreciation of the currencies. The value of EUR is gradually declined compare to THB while the value of USD is somewhat roughly stable in 2014 but rapidly incline in 2015 compare to THB. This figure illustrates the opposite trends of exchange rate and indicates that the decision making on procurement may needs the revision through time. For example, consider the exchange rate in 2014, the THB-USD exchange rate is

far cheaper than THB-EUR. Its means that decision on importing coke from Europe is may be
เอกสารนี้เป็นเอกสารที่ สงวนลิขสิทธิ์ สำหรับการเรียนการสอนเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และต้องแจ้งถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

more expensive due to the exchange rate. And Everest coke from China is may be not permanently cheaper than European coke in the future. By the way, the price negotiation is may be done due to the gap of expenses from alternative suppliers.



Figure 2.9 (b) Historical Foreign Exchange rates in 2015 (Source: XE.com Inc.)

Not only the value of exchange rate the stability of money currency is also influences on the risk of wrong decision making. Figure 2.9 (b) illustrates the fluctuation of exchange rate in 2015 (28 DEC 2014 – 28 DEC 2015). In 2015, both THB-EUR and THB-USD exchange rates are moving in almost similar trend especially in the last three quarters of the year but the amount of fluctuation is somewhat different. The variation of THB-EUR is seems larger than THB-USD.

Since the transportation of coke needs a long lead time and the payment is done after delivery, the variation of exchange rate through that period of time may cause the different in the total amount the company have to pay and may cause the risk of wrong decision also.

Consider figure 2.10, on 28th Dec 2015, the exchange rates are 39.61 THB/EUR and 36.09 THB/USD. In 2015, the mean of exchange rate of THB:EUR is 37.94 THB/EUR and ranges from 34.43 THB/EUR to 41.45 THB/EUR respectively. While the mean of exchange rate of THB:USD is 34.42 THB/EUR and ranges from 32.34 THB/EUR to 36.51 THB/EUR respectively. The variation of THB:EUR exchange is larger than of THB:USD. This variation is unavoidably affects to the amount of money the company have to pay on the payment date as well.

		1 year (2015)			2 years (2014-2015)		
28/12/2015		Low	Mean	High	Low	Mean	High
THB:EUR	39.61	34.43	37.94	41.45	34.43	39.86	45.28
THB:USD	36.09	32.34	34.42	36.51	31.77	34.14	36.51

Figure 2.10 Example of the variations of foreign exchange rates.

For example, assume that the prices of European coke and Everest coke are 58 EUR and 62.5 USD and the exchange rates on the ordering date are 37.94 THB:EUR and 34.42 THB:USD respectively. On the ordering date, costs for European coke and Everest coke are 2,200.52 (58*37.94=2,200.52) THB and 2,151.25 (62.5*34.42=2,151.25) THB respectively. At this day, the Everest coke is cheaper than European coke for 49.27 THB/ton. But on the payment date, the amount of money, the company have to pay for European coke and Everest coke, may raises up to 2,404.10 (58*41.45=2,404.10) THB and 2,281.87 (62.5*36.51=2,281.87) THB respectively. On the payment date, Everest coke is still cheaper than European coke but larger difference (122.22 THB/ton). But if the movements of exchange rates are on the opposite way, for example, the exchange rates are 34.43 THB/EUR and 36.51 THB/USD, the amount of money that the company have to pay for European coke and Everest coke in this case are 1,996.94 (58*34.43=1,996.94)

THB and 2,281.875 (62.5*36.51=2,281.875) THB respectively. For this situation, the Everest
เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 26 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

coke is more expensive than European coke for 284,935 THB/ton. If on the ordering date, the company decided to import coke from china and the exchange rate changed like in the last situation, the company will lost the money for 284,935 THB/ton as well.

The exchange rate is then effects on costs for imported materials in two ways, the value of exchange rate itself and the stability of the exchange rate also. To reduce cost, the exchange rate is then be one important factor to take consider.

Fortunately, the financial information is easily finds from several sources. For example, Kasikorn bank reports the foreign exchange market news on 01 Sept 2016 that “EUR/USD increased 0.13% to 1.1158. The euro strengthened against the dollar, the euro gaining back the loss after Fed’s chance for rate hike increased. However, the Eurozone’s inflation came out 0.2%, weaker than market expected and well below the ECB target and stronger private job report from the US might help push dollar higher trading later. Asian currencies mostly appreciated against the dollar as the market has been pricing in the stronger chance for Fed’s rate hike this year since the beginning of the week. However, the strong ADP private employment data from the US might help boost dollar again today. USD/THB increased 0.07% to 34.63. The THB depreciated against the dollar as monthly report from the Bank of Thailand suggested that Thai economy might be losing its momentum in July, along with the stronger chance for Fed’s rate hike this year as suggested by strong employment data and hawkish comment from Fed’s Boston. Yesterday, net foreign inflows into Thai stock market were at 1648.5 million THB”. So the company can take it for supporting her decision making.

2.7 Inco terms rules or International Commercial terms

The Inco terms rules or International Commercial terms are a series of pre-defined commercial terms published by the International Chamber of Commerce (ICC) widely used in international commercial transactions (Inco terms, TS Shipping, 2017)

. A series of three-letter trade terms related to common sales practices, the Inco terms rules are intended primarily to clearly communicate the tasks, costs and risks associated with the

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต่อ 27 ว่าจะอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

transportation and delivery of goods. The Inco terms rules are accepted by governments, legal authorities and practitioners worldwide for the interpretation of most commonly used terms in international trade. They are intended to reduce or remove altogether uncertainties arising from different interpretation of the rules in different countries. First published in 1936, the Inco terms rules have been periodically updated, with the eighth version—*Inco terms 2010*—having been published on January 1, 2011. "Inco terms" is a registered trademark of the ICC.

History

The Inco terms rules began development in 1921 with the forming of the idea by the International Chamber of Commerce. In 1936, the first set of the Inco terms rules was published. The first set remained in use for almost 20 years before the second publication in 1953. Additional amendments and expansions followed in 1967, 1976, 1980, 1990 and 2000. The eighth and current version of the Inco terms rules—*Inco terms 2010*—was published on January 1, 2011.

Inco terms 2010

The eighth published set of pre-defined terms, *Inco terms 2010* defines 11 rules, reducing the 13 used in Inco terms 2000 by introducing two new rules ("Delivered at Terminal", DAT; "Delivered at Place", DAP) that replace four rules of the prior version ("Delivered at Frontier", DAF; "Delivered Ex Ship", DES; "Delivered Ex Quay", DEQ; "Delivered Duty Unpaid", DDU). In the prior version, the rules were divided into four categories, but the 11 pre-defined terms of *Inco terms 2010* are subdivided into two categories based only on method of delivery. The larger group of seven rules applies regardless of the method of transport, with the smaller group of four being applicable only to sales that solely involve transportation over water.

Rules for Any Mode(s) of Transport

The seven rules defined by *Inco terms 2010* for any mode(s) of transportation are:

EXW – Ex Works (named place of delivery)

The seller makes the goods available at its premises. This term places the maximum obligation on the buyer and minimum obligations on the seller. The Ex Works term is often used when making an initial quotation for the sale of goods without any costs included. EXW means that a seller has the goods ready for collection at his premises (works, factory, warehouse, plant) on the date agreed upon. The buyer pays all transportation costs and also bears the risks for bringing the goods to their final destination. The seller doesn't load the goods on collecting vehicles and doesn't clear them for export. If the seller does load the good, he does so at buyer's

to bear the risk and all costs of such loading, this must be made clear by adding explicit wording to this effect in the contract of sale.

FCA – Free Carrier (named place of delivery)

The seller hands over the goods, cleared for export, into the disposal of the first carrier (named by the buyer) at the named place. The seller pays for carriage to the named point of delivery, and risk passes when the goods are handed over to the first carrier.

CPT - Carriage Paid To (named place of destination)

The seller pays for carriage. Risk transfers to buyer upon handing goods over to the first carrier.

CIP – Carriage and Insurance paid to (named place of destination)

The containerized transport/multimodal equivalent of CIF. Seller pays for carriage and insurance to the named destination point, but risk passes when the goods are handed over to the first carrier.

DAT – Delivered at Terminal (named terminal at port or place of destination)

Seller pays for carriage to the terminal, except for costs related to import clearance, and assumes all risks up to the point that the goods are unloaded at the terminal.

DAP – Delivered at Place (named place of destination)

Seller pays for carriage to the named place, except for costs related to import clearance, and assumes all risks prior to the point that the goods are ready for unloading by the buyer.

DDP – Delivered Duty Paid (named place of destination)

Seller is responsible for delivering the goods to the named place in the country of the buyer, and pays all costs in bringing the goods to the destination including import duties and taxes. This term places the maximum obligations on the seller and minimum obligations on the buyer.

Rules for Sea and Inland Waterway Transport

The four rules defined by Inco terms 2010 for international trade where transportation is entirely conducted by water are:

FAS – Free Alongside Ship (named port of shipment)

The seller must place the goods alongside the ship at the named port. The seller must clear the goods for export. Suitable only for maritime transport but NOT for multimodal sea transport in containers (see *Inco terms 2010*, ICC publication 715). This term is typically used for heavy-lift or bulk cargo.

FOB – Free on Board (named port of shipment)

The seller must load themselves the goods on board the vessel nominated by the buyer. Cost and risk are divided when the goods are actually on board of the vessel (this rule is new!). The seller must clear the goods for export. The term is applicable for maritime and inland waterway transport only but NOT for multimodal sea transport in containers (see *Inco terms 2010*, ICC publication 715). The buyer must instruct the seller the details of the vessel and the port where the goods are to be loaded, and there is no reference to, or provision for, the use of a carrier or forwarder. This term has been greatly misused over the last three decades ever since *Inco terms 1980* explained that FCA should be used for container shipments.

CFR – Cost and Freight (named port of destination)

Seller must pay the costs and freight to bring the goods to the port of destination. However, risk is transferred to the buyer once the goods are loaded on the vessel (this rule is new!). Maritime transport only and Insurance for the goods is NOT included. This term is formerly known as CNF (C&F).

CIF – Cost, Insurance and Freight (named port of destination)

Exactly the same as CFR except that the seller must in addition procure and pay for the insurance. Maritime transport only.

http://court-inter.us/sites/default/files/users/user8/incoterms_2010.pdf

2.8 Applying box plot for the consideration of exchange rate and cost uncertainty.

Since cokes are all imported whether from Europe or China, exchange rate is then unavoidably affects to variable production cost. The exchange rate affects to costs by two reasons, the stability of the currency (the certainty of exchange rate) and the difference of exchange rate among EU:THB rate and USD:THB rate. Basically, to compare cost for coke from different country (different exchange rate), the prices have to be calculated back to THB currency. However, the exchange rate on the ordering date and the payment date might be different due to an uncertainty. The supplier selection under variability of exchange rates is risky. The forecasting for exchange rate and risk control are necessary to be concerned. We have to keep concern on different exchange rates and their uncertainties for comparison. Consideration on the variation they have at

specific period of payment time is needed. Actually, we can use standard deviations for the consideration, but for this time, to ease up the understanding, The box plot is used as a pictorial tool to describe the consideration scenarios. <http://stattrek.com/statistics/charts/boxplot.aspx>

This section presents an applying of statistic tool, box plot, on an investigating of an exchange rate.

According to the concept of box plot, the distribution of data is described in pictorial way. Box plot splits the data set into quartiles. The body of the box plot consists of a "box", which goes from the first quartile (Q1) to the third quartile (Q3). The median of the data set is expressed as a vertical line at the second quartile (Q2) within the box. Two horizontal lines, called whiskers, extend from the front and back of the box. The front whisker goes from Q1 to the smallest non-outlier in the data set, the minimum point of the distribution (the maximum value among the lowest data point and $Q1-1.5(Q3-Q1)$). And the back whisker goes from Q3 to the largest non-outlier, the maximum point of the distribution (the minimum value among the highest data point and $Q3+1.5(Q3-Q1)$). One or more outliers will be plotted separately as point on the chart.

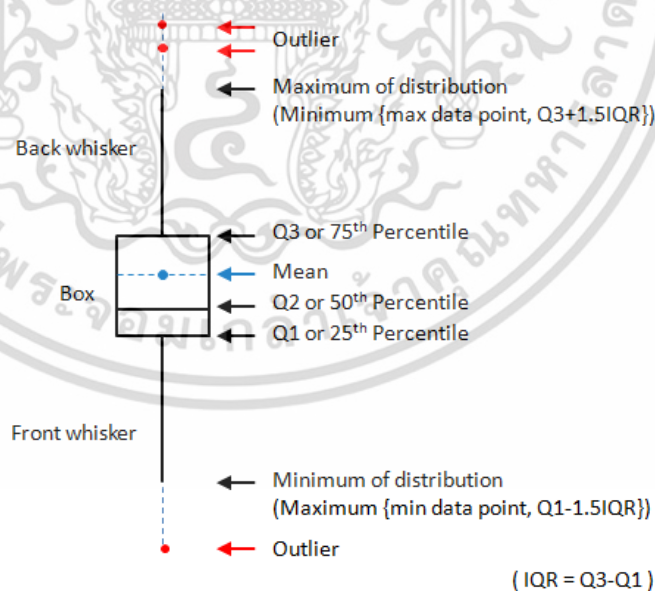


Figure 2.11 Structure of box plot

Box plot can be drawn even on the vertical and horizontal direction as shown in Figure 2.11 above and Figure 2.12 below.

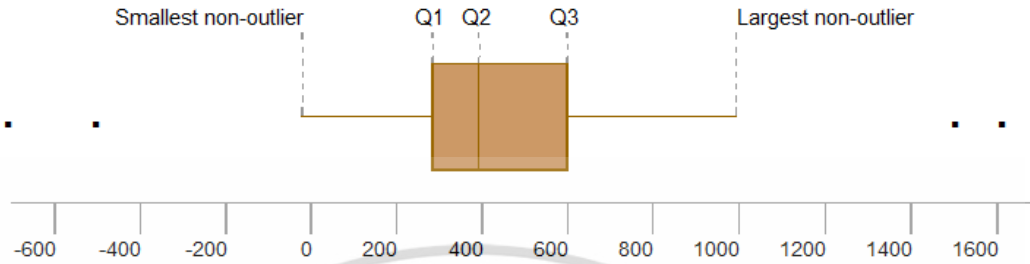


Figure 2.12 Horizontal box plot

Box plot illustrates the variation or distribution of data. Various statistical-information could be read box plot. Median is the data at Q2. Maximum data point and minimum data point are depicted as a point at the end most of the box plot. The distribution of data set is described by the range of data which expressed by the distance between maximum data and minimum data or the distance between ended points of front and back whiskers. Another way to describe the variation of data set is the inter-quartile range (IQR) which could be calculated from following equation.

$$IQR = Q3 - Q1$$

The range of whiskers or width of box illustrates the variability of the data set. The more width, the more widely spread. Wide spread data mention to the data uncertainty or high variance as well.

The position of Q1, Q2 and Q3 in the box plot indicates the distribution characteristic or skewed of data set as presented in Figure 2.12.

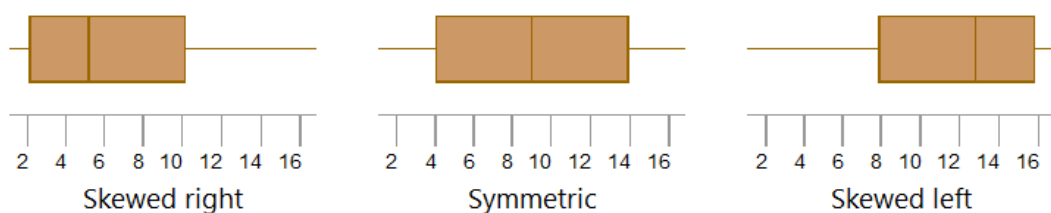


Figure 2.13 Distribution skewed in box plot

Each of the above box-plot illustrates three patterns of data skewed. If the data is symmetrical distribute around median the box-plot is balance and no skewed found as shown in the middle part of Figure 2.13 above. If the observed data are concentrated on the low end of the scale, the distribution is skewed right; and vice versa.

Applying the box plot as a pictorial tool for cost consideration in the environment of uncertain exchange rates is then be the simple way to understand the comparison scenarios for decision making by

$$Cost = Price * Exchange Rate \quad (2.1)$$

Where the exchange rate is a forecast at payment

If the exchange rate is uncertain, cost is uncertain also. The wider range of exchange rate, the more variation cost. The different ranges of cost cause the risk from wrong decision making as well. An example of case comparison is depicted as Figure 2.14 below.

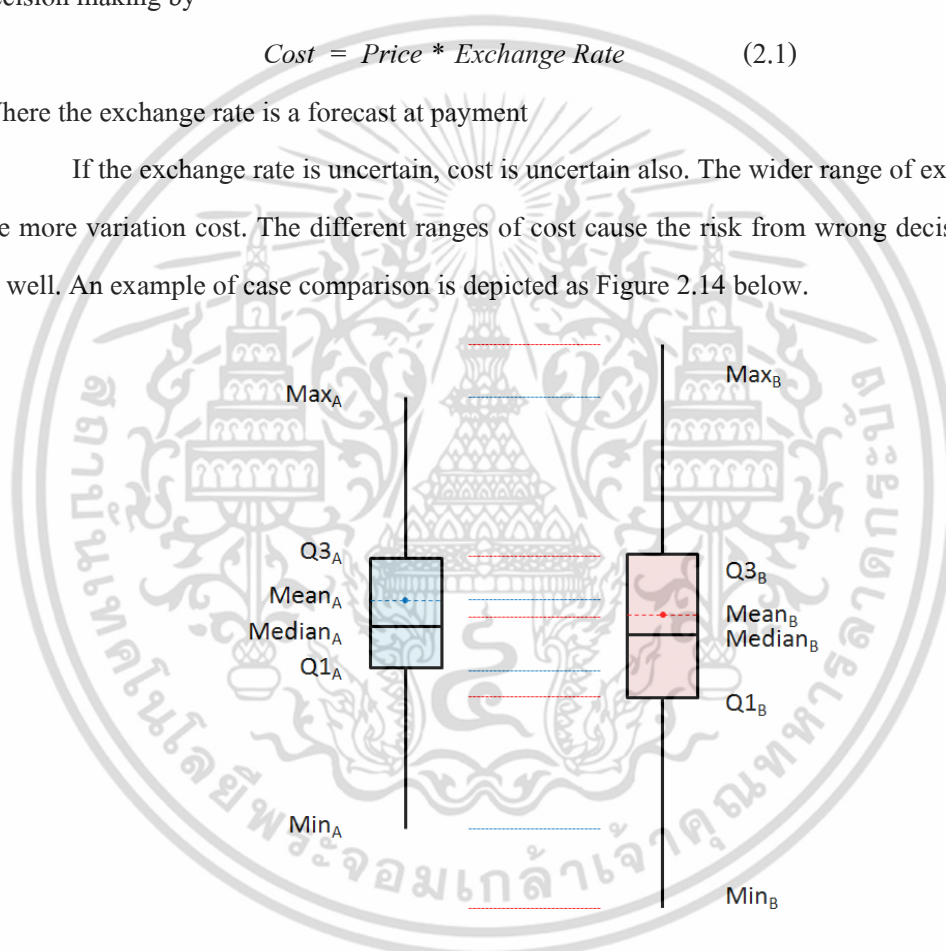


Figure 2.14 Example for two different box plot A and B

According to the example shown in Figure 2.14, assume that box plot A and B illustrate cost for case A and B respectively. It seems like case B is the better choice compare to case A since mean cost from case B is lower than from case A. However, box plot A is smaller than box plot B, its mean that the variation of cost from case A is lower than cost from case B. Under uncertainty, wrong forecasting is possible. The situation that cost from case B is higher than case

A is may be happen. So there are several scenarios to be considered before decision making. By เอกสารนี้เป็นเอกสารที่สงวนลิขสิทธิ์ไว้เพื่อการศึกษาเท่านั้น เมื่อผู้ใดเห็นว่าเป็นประโยชน์สามารถ
 ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ตัดแปลงเนื้อหา และด้อย 33 ำงอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

the way, since mean cost for case B is lower, if we decide to use this case as a major choice, reducing the uncertainty or reducing the variation of exchange rate by some financial approach is a good suggestion. Or price negotiation for case A is may be taken place.

2.9 Strategic supplier sourcing literature review

Divesh Kumar et.,al. 2016 study buyer relationship and supply chain sustainability supplier to figure out the framework of supplier relation to evaluate sustainability (economical , social, and environment) by investigating the relationship among various factors leading to sustainability performance. The results indicate that external influence and expected sustainability benefits positively affect top management’s commitment towards flexibility of sustainable practices.

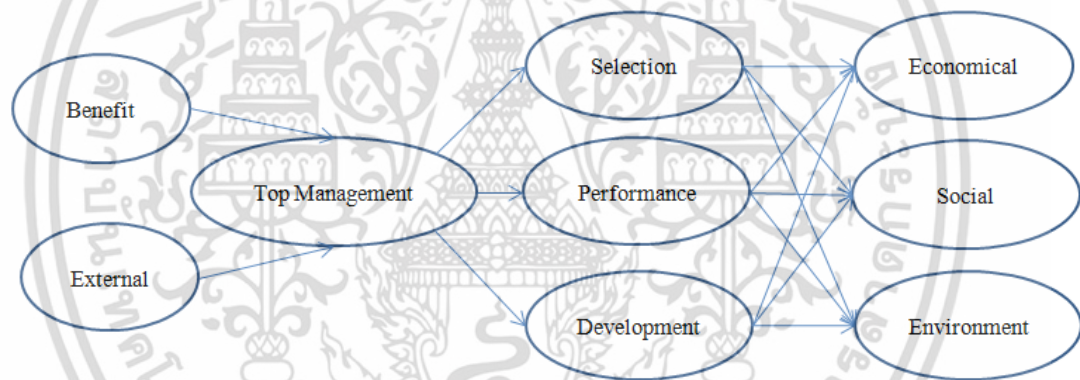


Figure 2.15 Proposed conceptual model and associated hypotheses (Divesh Kumar et.,al. 2016)

Lena Silbermayr et.,al 2016 identify dual sourcing under the risks of supply disruptions due to e.g. labor strikes, natural disasters, supplier bankruptcy, and business fail-ures. They perform sensitivity analysis and find that increasing certainty about supplier reliability, and increasing risk aversion of a buyer yield more balanced supply volume allocations among the available sup-pliers and that the advantage of dual sourcing decreases with uncertainty about supplier reliability.

This model of Lena Silbermayr et.,al 2016 for the first step toward understanding the operational implications of disruption risk and learning effect and also offers numerous

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 34 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

opportunities for future work, but still not go to the detail of impact from the consumption of down-stream customer.

While Hui-Shung Chang et.,al 1997 identify Coking coal procurement policy and base on the history and development trend of Coking coal. By provides an overview of the Japanese integrated steel mills' procurement policies for coking coal during the past three decades and the economic rationale underpinning them. Such as Japan has been experiencing in recent years, pressures have mounted for policies aimed at supply security to be modified in order to cut costs. Technological and institutional changes also provide the impetus for change in the coking coal procurement policies.

Martin Kotula et.,al 2015 study the Strategic sourcing supplier selection misalignment with critical success factors, mention that there is no research on critical success factors for strategic sourcing specific to industry and country. his research aims to qualitatively evaluate and understand the current role of strategic sourcing,

As papers review of supplier sourcing, we found that the research consider about sustainability, tread of material price, the risk of supply disruption, and study many factor to impact the strategic sourcing supplier selection misalignment to summary of critical success factors for strategic sourcing, such as delivery and process, volume-change and modification capabilities, information sharing with key suppliers, supplier collaboration, supplier development etc.

However nobody explains about supplier source related toward the analysis of production performance and materials consumption which impact the total production cost which is the best impact with operations cost and to increase the benefit of the company.

Table 2.6 A summary of critical success factors for strategic sourcing. (Martin Kotula et.,al 2015)

Authors	Critical success factors
Anderson and Katz (1998)	Total cost of ownership, sourcing process excellence, annual plan, develop requirements, devise sourcing strategies, procurement materials and services, evaluate suppliers, and manage supplier relationships.
Narasimhan and Das (1999)	Suppliers should have strong delivery performance, volume-change and modification capabilities.
Kocabasoglu and Suresh (2006)	Status of purchasing, internal coordination, information sharing with key suppliers and key supplier development. The authors argue to empower the sourcing function with relevant tools to make strategic decisions and to manage the supplier relationships. Besides, the cross- functional team collaboration should be improved with sales or R&D departments.
Chan and Chin (2007)	The fourteen success factors (from most important to least important) are : people management, linking sourcing strategy to corporate strategy, supplier evaluation and selection, system improvement, supplier collaboration, supplier development, supplier monitoring, sourcing strategy, learning organization, process improvement, leadership in strategic sourcing planning, competitive analysis, proficiency focus, life cycle costs.
Khan and Pillania (2008)	Strategic supplier partnership, sourcing flexibility, supplier evaluation and trust.
Chiang et al. (2012)	Strategic purchasing, supplier development, internal integration, and information sharing.
Su (2013)	Sourcing 's long-range plan is reviewed and adjusted to match changes in the company's strategic plans on a regular basis, sourcing 's long- range plan includes developing relationships with key suppliers, and top management of the company emphasis the strategic role of sourcing function.

CHAPTER 3

RESEARCH METHODOLOGY

According to the objectives of this research, processes for finding the answers start with clarified the production cost structure. Considering the major problems as the alternatives for cost reduction has to be done next. After choosing core problem for this study, the solving has to be explored. The methodology for this research is described in this chapter.

3.1 Product portfolio and cost structure.

Since the stone wool manufacturing process runs as a line production and since the products from the process are obviously categorized into two groups: product from mainline process and products from secondary process, the cost structure is then considered as two separated parts also.

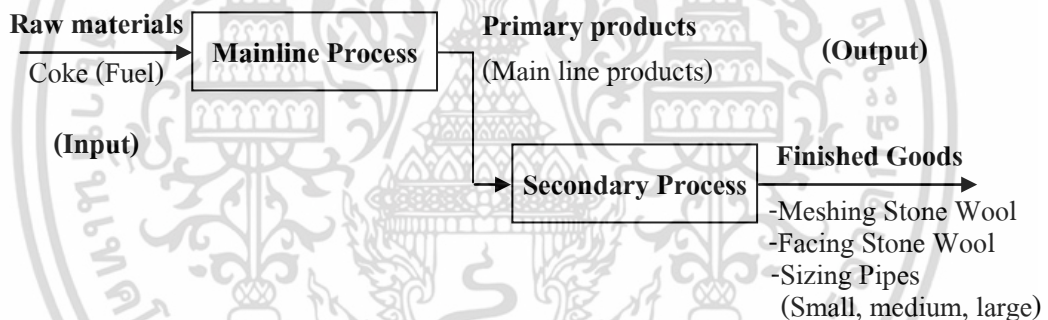


Figure 3.1 Stone wool manufacturing process.

From the conceptual production process depicted in Figure 3.1, raw material and coke (as a fuel) are fed to the primary production process called “Mainline process” and then return as the primary products such as blanket and board at the end of production line. Part of those primary products are sold as a goods and remains are input to the secondary process to produce finished goods like meshing stone wool, facing stone wool and pipes. In 2015, around 54% of totally 14,103 tons of main line products (around 7,623 tons) are sold to customers and 46% (around 6,480 tons) left are fed as work in process for the secondary process.

Cost for stone wool manufacturing consists of cost for melt raw materials, energy for melting, binder, gas/oil, off-line materials, packaging, wages, electricity and others. Table 3.1

indicates the VPCs per ton of product occur in the primary process (for producing the main line

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 37 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

product) and in secondary process (for producing other product lines). Table 3.1 shows the VPC structure for each type of product. Overall, VPCs per ton of product are 16,569 THB. VPC for main line product are 12,430 THB/ton. As mentioned earlier that main line product is the basic product used as work-in-process for the secondary processes, to produce finished goods, the additional costs are required.

$$VPC_{\text{Finished Goods}} = VPC_{\text{Main Line Product}} + VPC_{\text{Secondary Process}} \quad (3.1)$$

Additional VPC consumed along the secondary process for producing each ton of Fiber Mesh, Facing, Small Pipe, Medium Pipe and Large Pipe are also shown in Table 3.1.

Table 3.1 Variable Production Cost (Benchmarking vs Tons produced)

Variable Production Cost (THB/Ton) (YTD 2015)	Secondary Process						
	Overall	Main line	Fiber mesh	Facing	Pipe		
					Small	Medium	Large
Melt raw materials	2,110	2,110	-	-	-	-	-
Energy for melting	3,078	3,078	-	-	-	-	-
Binder, impr. Oil etc	1,930	1,876	-	-	523	272	503
Gas/oil	1,031	715	79	144	2,780	1,697	2,204
Off-line materials	1,385	6	3,809	6,567	9	6	25
Packing materials	1,160	560	770	1,444	2,135	2,751	1,642
Wages	3,149	1,423	1,056	4,037	8,854	5,672	8,311
Electricity	1,502	1,198	54	25	2,251	2,327	1,597
Others	1,224	1,465	-	-	-	-	-
Total	16,569	12,430	5,767	12,217	16,553	12,727	14,282
Ton Produced	14,103	14,103	3,780	765	456	936	543

Data in Table 3.1 are graphically depicted as Figure 3.2 for more clearly illustration of cost structure for each product. Since cost structures for each product are different, the problem or improvement approaches are different too. For example, the major VPC for S-pipe is wages then issue about productivity should be considered. Interesting issue for fiber production is “Off-line

Materials” as well. To choose the most important issue for improvement, more information is in concerned.

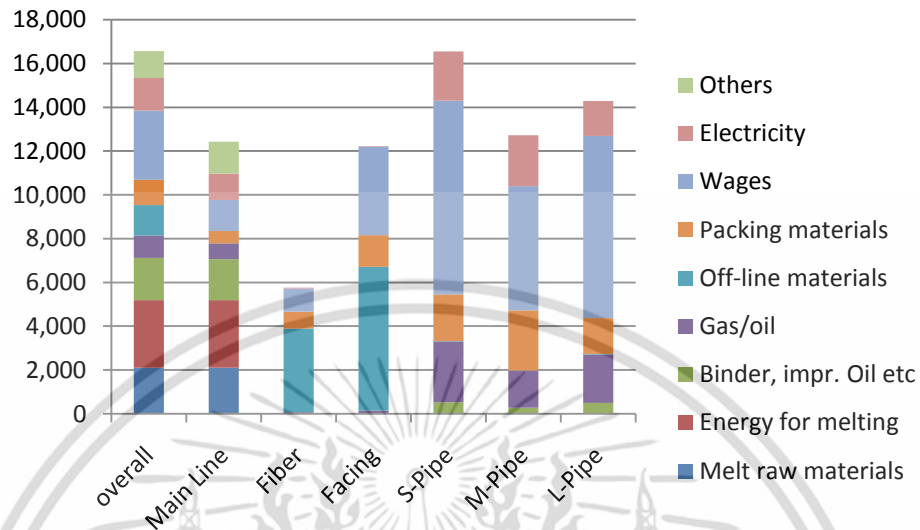


Figure 3.2 Cost structure of each product.

Table 3.2 shows variable production costs paid in 2015. Around 75 percent of total cost (175 million THB) was paid for main line production. Cost for the secondary process was 25% or 58.3 million THB. Consider VPC for main line production, the major cost is cost for energy used in melting process with 24.8% or around 43.4 million THB. Next biggest cost is cost for raw materials used in melting process with the amount of 29.75 million THB. Every resource except Gas/Oil and Off-line Materials were used in main line production.

Table 3.2 Annual cost (2015)

Annual Cost (THB) (2015)	Secondary Process						
	Overall	Main line	Fiber mesh	Facing	Pipe		
					Small	Medium	Large
Melt raw materials	29,750,081	29,750,081	-	-	-	-	-
Energy for melting	43,406,107	43,406,107	-	-	-	-	-
Binder, impr.oil etc	27,223,835	26,457,414	-	-	238,244	254,907	273,270
Gas/oil	14,545,735	10,084,278	299,388	109,857	1,267,056	1,588,437	1,196,719
Off-line materials	19,528,466	86,150	14,396,359	5,022,172	4,260	5,762	13,763
Packing materials	16,353,450	7,900,633	2,908,940	1,104,343	973,020	2,574,686	891,828
Wages	44,412,194	20,068,719	3,991,281	3,087,361	4,034,940	5,307,914	4,513,080
Electricity	21,182,451	16,890,836	202,894	18,819	1,025,581	2,177,260	867,061
Others	17,262,117	20,658,097	-	-	-	-	-
Total	233,664,437	175,302,315	21,798,863	9,342,551	7,543,101	11,908,966	7,755,722

When consider the unit cost, wage seems like problem issues but due to the low production volume compare to other products this problem is found not quite important. Cost for “melt raw materials” and “Energy for melting” used in main line production became more interesting issues instead when consider annually cost.

There are relationships between energy for melting and melt raw materials. Obviously seen in Figure 3.3, cost of energy used in melting process is related to coke usage directly. And the ratio of Coke usage and quality of Coke affect to material efficiency of melt raw material also. In 2015, the value of coke usage is around 43 million THB while around 15 million THB comes from Basalt and remains 15 million THB comes from other types of stone.

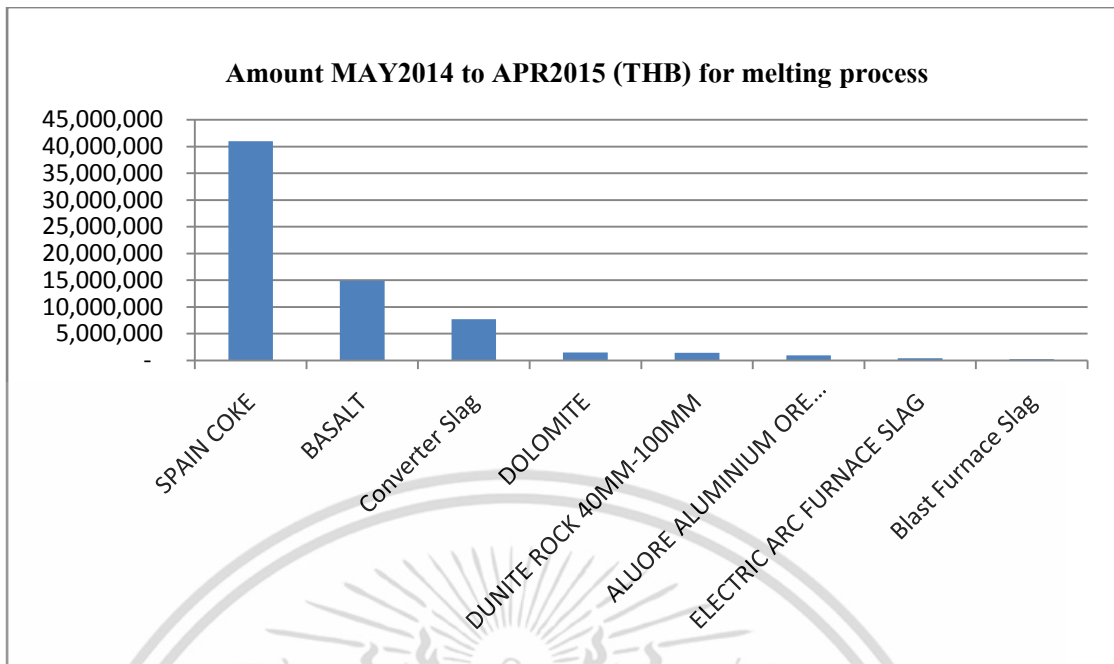


Figure 3.3 Amount of coke and stones used in melting process (May 2014 to April 2015).

Since melting ratio of all stone affected by coke ratio (E..D. Larsen et .,al., 1997), to looking for the cost reduction of these, we need to deeply understand with the current ratio on melting raw material, bill of materials and current materials as well.

3.2 Bill of Materials, and Materials Efficiency Analyzing

Chemical composition and the quality of stone wool product is compliance with the European Certification Board for Mineral Wool Product (EUCEB)'s standard for mineral wool product. To achieve EUCEB's standard, raw materials, stone and slag, are meticulously selected and controlled to meet required chemical composition.

Since this study refers only to data in 2015, the existing bill of materials (BOM) for melting process in this study is then Basalt 67% formula as shown in Table 3.3.

Table 3.3 Melting recipe for this case study

Melting material	Percentage of Raw Materials
Basalt Stone	67%
Dolomite Stone	5%
Dunite Stone	5%
Electric Arc Furnace Slag	8%
Converter slag	15%
Total	100%

Regarding to this recipe, it appears that the material efficiency is approximately 78%. It means that, refers to this BOM, we have to use 100 kg of melting material to produce stone wool 78 kg. However, the material efficiency may increase or decrease by the impact of energy used in melting process, coke, in this case. Coke ratio affects to melting composition, melting rate, and melting temperature (E..D. Larsen et. al. 1997). However, Leth-Miller et.,al. (2004) proved that coke quality affects to coke consumption (coke ratio). Cost for melting process is then affected by quality and efficiency of raw materials and coke as well. Refer to data in 2015, material efficiency is 78% and coke usage is 11.7% (single source from Europe) of charged melting materials.



Figure 3.4 Effect of Coke on Material Efficiency

For this section, we can conclude that raw materials and energy (coke) have a great impact on product quality, production efficiency and variable production cost. To reduce the VPC, the company should pay attention on the recipe, the quality of raw materials and coke and cost of those things altogether. Sourcing is then one important activity for this case.

3.3 Applying analysis tools to solve the problem

Current status, product portfolio, cost structures and materials are already explored in the previous section. We found that there are several factors affects to the VPC. And there might

be several approaches to reduce the VPC also. To choose the most effective approach, root problems of stone wool production will be more deeply analyzed in this section.

The variable production cost is reminded again in Section 3.3.1 before applying the ABC classification to declare the classes for each type of material as presented in Section 3.3.2. The real problem for this study is identified by this process.

After analyze VPC with ABC technique, the researcher found that cost for material and coke used in the melting process (or in primary process or in wool manufacturing process) is the most interesting point to explore since it has the highest affect to total variable production cost (VPC). The next step for problem analysis, as will present in Section 3.4 is then exploring factors affect cost for coke and raw materials.

Material efficiency and coke ratio are reviewed by production history as reported in Section 4.1 Cost from two scenarios with different source of coke (coke from Europe and China) are compared in this section.

Recipe, material efficiency, coke ratio, cost for material and cost for coke are explored in detail and presented in Section 4.2 Cost for coke and raw materials from those two scenarios are compared here.

In Section 4.3, Effect from exchange rate stabilities are included in consideration of selecting alternative scenarios.

3.3.1 Analysis problems of the company

As mentioned in previous section that big portion of VPC comes from cost of materials and cost of energy used in the production process, for more clearly understanding those costs are depicted along the process as shown in Figure 3.5.

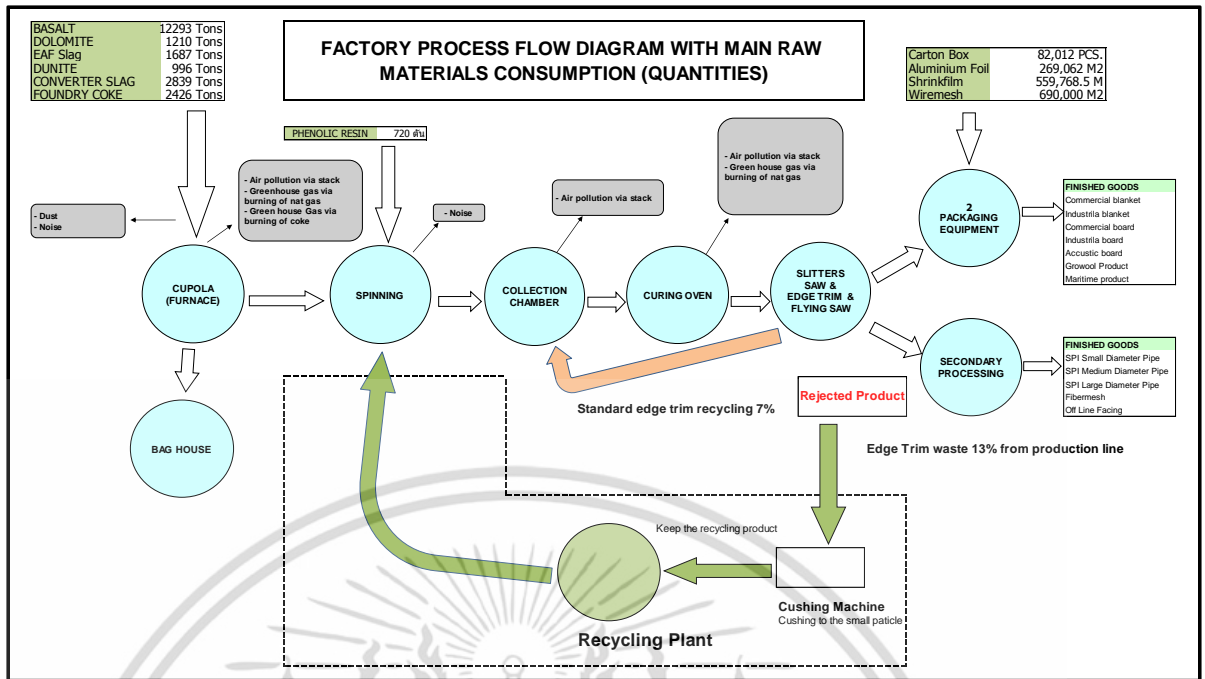


Figure 3.5 Process flow and quantities of major materials consumption (one year).

Considering annual amount of VPCs occur in 2015 from list of costs presented in Figure 3.6, it is obviously seen that coke consumption is the biggest amount compare to others. It is such interesting since coke affects to VPC both by amount of usage and price itself as mentioned in the previous section.

Amount MAY2014 to APR2015 (THB)

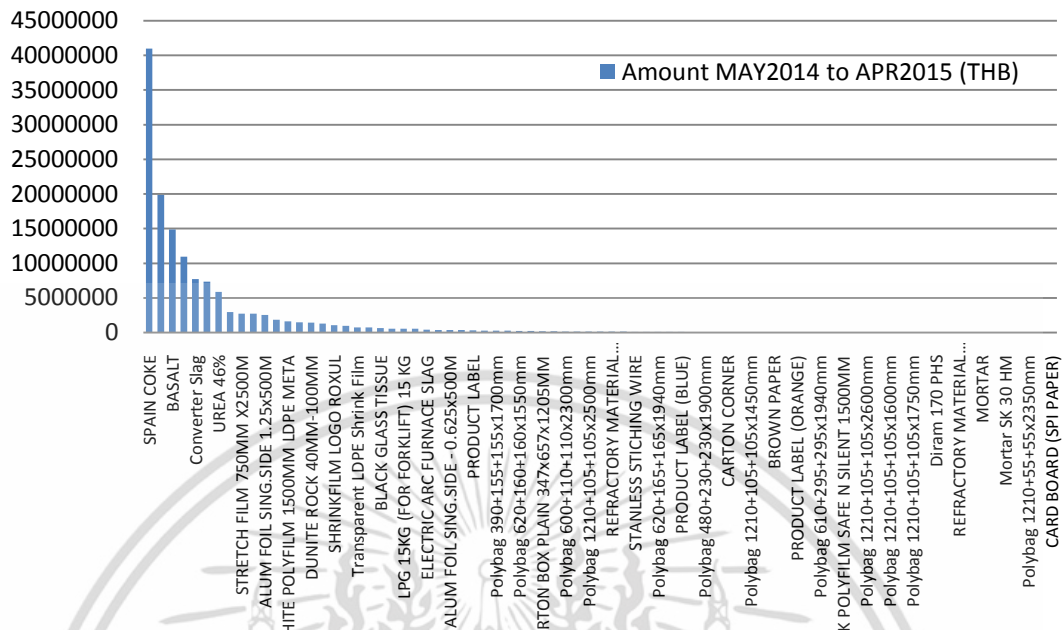


Figure 3.6 Amount of all materials consumption (one year)

3.3.2 Applying ABC classification to all materials consumption.

Total VPC covers costs for several materials consumed along the process. Costs or values of those materials come from volume multiply by price. In order to find out the important material consumption cost, ABC classification technique is applied in this study.

By the ABC technique and Pareto's concept, the materials used along the process are classified into three groups. The group of materials (around 5% by type) which hold 63% of total value is declared as "A" type. The next 20% of number of material which hold 32% of total value is declared as "B" type and the 75% of number of material which frequently hold just only around 5% of total cost is declared as "C" type. Since the total cost for material is 137.87 million THB, the value of material type "A", "B" and "C" are calculated as shown in Table 3.4.

Table 3.4 Total amount of each class of material

Class	Amount (THB)	Percentage
A	86,663,345.09	63%
B	44,329,183.17	32%
C	6,872,523.80	5%
Total	137,865,052.10	100%

According to these calculations, values of material sorted in the descendent list are considered and classified as “A”, “B” and “C” type also. The materials with highest most consumption values which hold cumulative value of around 86 million THB are tagged as type “A”. The materials which are the next highest most consumption values and hold cumulative value of around 44 million THB are tagged as type “B”. And the remaining materials are tagged as type “C” respectively.

Table 3.5 Material Type “A” from ABC Classification

Process	Materials	Amount MAY2014 to APR2015 (THB)	ABC Classification
Melting Materials	SPAIN COKE	40,997,878.24	A
Binder Materials	PHENOLIC RESIN	19,844,865.68	A
Melting Materials	BASALT	14,886,870.48	A
Materials for secondary process	WIRE MESH	10,933,730.69	A

Material type “A”, a few types of material that cover big portion of total variable production cost, as presented in Table 3.5, 63% of total VPC (or 86.6 million THB) cover 4 materials these are Spain Coke (40 million THB), Phenolic Resin (19 million THB), Basalt (14 million THB) and Wire Mesh (10 million THB). Phenolic Resin and Wire Mesh are used in the secondary process while Spain Coke and Basalt are used in the primary process (Cupola process). It indicates that Spain coke hold the biggest portion of total cost both for stone wool production process and for primary process.

Material type “B” is group of material that cover around 30% of total variable production cost. As presented in Table 3.6, 32% of total VPC (or 44.3 million THB) covers 17 materials.

Table 3.6 Material Type “B” from ABC Classification

Process	Materials	Amount MAY2014 to APR2015 (THB)	ABC Classification
Packing materials	SHRINKFILM WITH ROCKWOOL LOGO	7,325,888.72	B
Binder Materials	UREA 46%	5,874,813.62	B
Binder Materials	INSULCOTE SE95	2,971,600.00	B
Materials for secondary process	STRETCH FILM 750MM X2500M	2,731,847.56	B
Packing materials	CARTONS BOX ROCKWOOL LOGO	2,711,160.00	B
Materials for secondary process	ALUM FOIL SING.SIDE 1.25x500M	2,551,170.33	B
Materials for secondary process	STITCHING WIRE	1,828,400.4	B
Packing materials	##WHITE POLYFILM 1500MM LDPE META	1,641,062.85	B
Melting Materials	DOLOMITE	1,502,907.56	B
Melting Materials	DUNITE ROCK 40MM-100MM	1,456,316.42	B

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 47 ว่าจะอ้างถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Materials for secondary process	STANLESS STEEL WIREMESH	1,290,525.82	B
Packing materials	SHRINKFILM LOGO ROXUL	1,051,606.58	B
Melting Materials	ALUORE ALUMINIUM ORE (BAUXITE)	957,000.39	B
Packing materials	Transparent LDPE Shrink Film	751,923.82	B
Materials for secondary process	PRESSURESENSITIVEADHESIVE	747,198.00	B
Materials for secondary process	BLACK GLASS TISSUE	656,560.00	B
Materials for secondary process	SILICON EMULSION	571,769.84	B

Material type “C” is big group of remained materials that cover just around 5% of total variable production cost. In this case, total value of material in type “C” is around 6 million THB.

After considering the production variable cost, we have found that almost half of the total cost (around 68 million THB from total cost 137 million THB) is cost for cupola process. According to ABC classification, we have found that coke and stone (melting materials) holds the biggest portion of total cost. Cost for coke and stone is the most important cost for the production and be the most significant problem for this study. Reduce cost for coke and stone is then the most effective approach to reduce total cost. This study is then focus on this issue.

3.4 Factors affect cost for coke and raw materials.

Stone wool made of several types of stone melted in the cupola using coke as a source of energy. To produce the stone wool with standard grade, the amount of each material are strictly

followed the melting recipe. However, different coke leads to different coke usage and material efficiency. And material efficiency affects to material consumptions consequently.

In this study, Stone-Wool-company considers coke from Europe and China as major sources with different qualities. Though the melting process runs under similar recipe but amount of materials and coke are different due to material efficiency and coke ratio (as will present later in Table 3.8 and 3.9). Production cost is then varied by the material consumptions and their prices also.

Table 3.7 Factors affect to VPC.

Factor affects to VPC	Quality	Cost	Delivery
Coke	Effect from Coke Quality (% Coke Usage)	Volume of coke used Coke Price Exchange rate (stability)	-No issue-
Raw Materials	Material Efficiency	Volume of raw material used Price of raw materials Exchange rate (stability)	-No issue-

Table 3.7 show factors affect to VPC. In this table, coke and raw materials are considered in three perspectives; quality, cost and delivery. Quality of supplies affects to yield of the production or production efficiency which affects to amount of required supplies consequently. While cost for delivery activities are not in concerned since it is included in the price of coke and raw materials already (CIF price). And costs for transporting those supplies from sea port to the factory are the same value though where they are ordered.

In summary, qualities of materials and coke affect to amount of supplies used in the production. Quality of coke is directly affects to coke ratio (% coke usage) which affects to volume of coke used in the production consequently. Moreover, quality of coke is affect to the material efficiency which affects to volume of raw material used in the production also. Since cost for material is already cover transportation cost then no different in transportation cost have to be concerned in this study. (Actually, we can explore this cost for price negotiation in the future.)

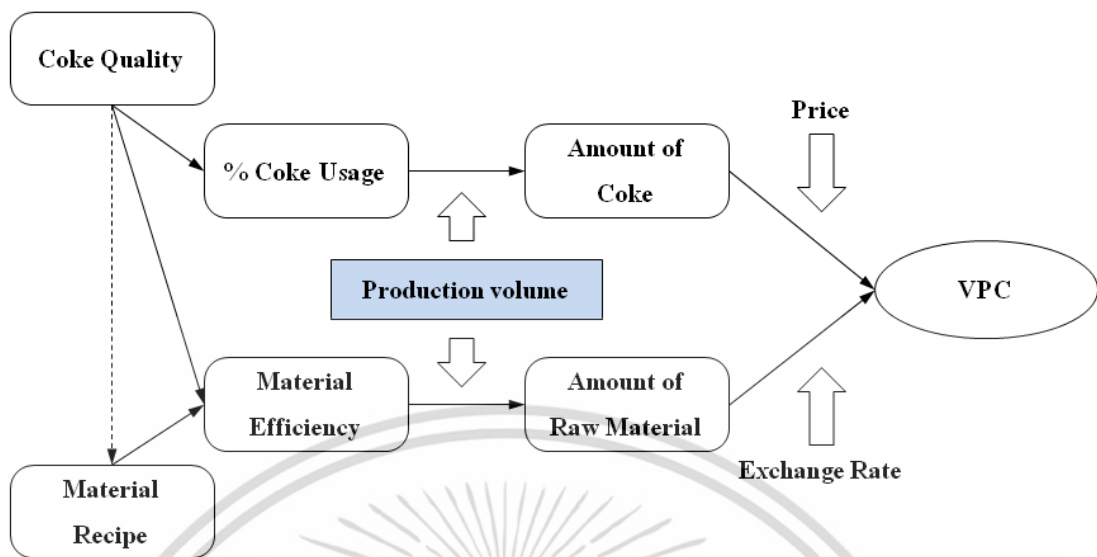


Figure 3.7 Factor affects VPC

According to Pareto’s concept as mentioned earlier that coke and raw materials are classified as type “A” priority. Moreover coke and raw material are influence to each other. Then we have to concern both these two cost altogether in this study.

Factors affect to variable production cost concerned in this study are (1) yield of melting material (Material Efficiency) and coke ratio (Percentage of coke usage), (2) coke and material prices, (3) exchange rate, (4) alternative sources with difference price, quality and exchange rate.

VPC construct for this study is calculated from several variables depicted in Figure 3.7. Coke quality is specified by source of coke. Choosing Source of coke affects to % coke usage directly and affect to material efficiency through the recipe. After the amount of coke and materials used in the production are calculated by following equations.

Material efficiency: Material efficiency is a ratio of volume of output product per volume of stone input to the process.

$$ME = W_{Output} / S_{Input} \quad (3.1)$$

Where ME is Material Efficiency

W_{Output} is Output Line Wool (or production volume: tons)

S_{Input} is Input Stone Materials (or volume of raw materials: tons)

Volume of raw material (stone): Volumes of raw materials input to the process is then calculate from production volume (tons) divided by material efficiency. According to the recipe, volumes of each material could be calculated as well.

$$S_{Input} = W_{Output} / ME \quad (3.2)$$

Volume of coke: Volume of coke used in the melting process V_{Coke} is calculated by the multiplication of coke ratio (or % coke usage) and volumes of raw materials.

$$V_{Coke} = S_{Input} * Coke\ ratio \quad (3.3)$$

Cost for material: In this study, cost for material used in the production covers cost for stone materials and cost for coke

$$C_M = C_C + C_S \quad (3.4)$$

Where C_M is Cost for melting material and energy for melting process per ton of wool product (THB/ton)

C_C is Cost of coke used per ton of wool product (THB/ton)

C_S is Cost for stone materials per ton of wool product (THB/ton)

Cost for stone materials: Cost for stone material is the summation of cost for each material in the recipe. (C_s) Cost for stone materials per ton of wool product is then cover cost for Basalt, Dolomite, EAF, Converter slag and Dunite.

$$C_s = C_{Basalt} + C_{Dolomite} + C_{EAF} + C_{C\ Slag} + C_{Dunite} \quad (3.5)$$

C_{Basalt} is Cost of Basalt used per ton of wool product (THB/ton)

$C_{Dolomite}$ is Cost of Dolomite used per ton of wool product (THB/ton)

C_{EAF} is Cost of EAF used per ton of wool product (THB/ton)

$C_{C\ Slag}$ is Cost of Converter Slag used per ton of wool product (THB/ton)

C_{Dunite} is Cost of Dunite used per ton of wool product (THB/ton)



CHAPTER 4

RESULTS

Since this study is focused on reducing variable production cost, cost structure is then must be explored. Applying ABC technique can help classifying costs as a source of problem into classes and useful for finding the most impactful problem to be concerned. Four main problem issues, classified as “A” type by ABC technique, are Spain coke, Phenolic Resin, Basalt and Wire mesh. Those problems cover around 63% of total VPC cost or around 86,663,345.09 THB. Melting material and coke are the most important costs to be concerned in this study.

According to the production efficiency key figure and recipe in stone wool industry, the parameters that related to Melting material and coke are Material Efficiency, Coke ratio, Price and Rate of Exchange as mentioned in chapter 3.

The detailed results of this study are described in this chapter.

4.1 Material efficiency and coke ratios

Since the composition of stone wool product is controlled by the recipe, each material is then mixed with fixed ratio. The volume of material used in the production is related to stone wool production volume and material efficiency.

As mentioned earlier that quality of coke affect material efficiency, cost for stone material is then affected by coke from different source also. Since coke from Europe, Spain coke or “Nalon coke” was used in 2015 while coke from China named “Everest coke” has been studied as another alternative, costs for these two alternatives are compared in this study.

4.1.1 AS-IS (Present approach: European Coke)

European Coke (Spain Coke) was input to the production line through 2015. Recorded data shown in Figure 4.1 indicates that material efficiency (%ME) and Coke Ratio (% Coke usage) are somewhat stable, average material efficiency (%ME) and Coke Ratio (% Coke usage) are around 77.7% and 11.7% (of stone charging) respectively.

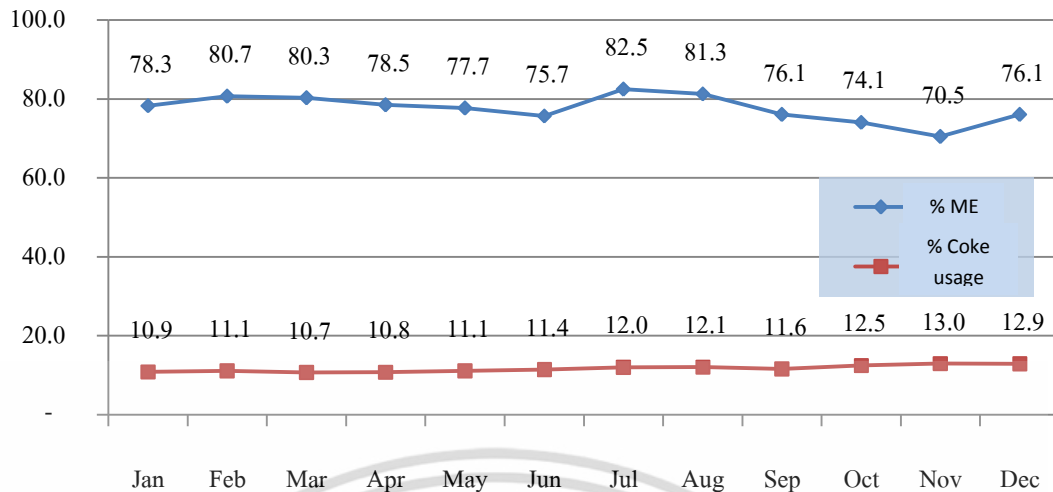


Figure 4.1 Actual materials efficiency and percentage of coke usage in 2015

4.1.2 TO-BE (Alternative approach: Chinese Coke)

Production with coke imported from China is considered as an alternative in this study. Referring to the trial report (see Appendix), under the similar condition, using Chinese coke instead of Spain Coke can yields only 69% material efficiency. But after adjust the velocity of blast air by tuning tuyere to meet suitable condition, the highest material efficiency available from using Chinese Coke in the production is estimated as 75% while coke ratio is around 13%. This trial test result is congruence with research of Leth-Miller et.,al. (2004) which mentioned that using coke from China caused higher consumption in the production process.

4.2 Conducting alternative scenarios

Since the CIF price for European Coke and Chinese Coke are 397 EU/metric ton and 361 USD/metric ton respectively in 2015. While the exchange rates are estimated 39.72 THB per 1 EU and 35.25 THB per 1 USD respectively. Costs for these two alternatives are calculated as following. (Estimated Coke Inland Transportation from port to bunker in the factory (495 THB/metric ton) is equal for both European Coke and Chinese Coke because they will be transported on the similar root route and method. Then the inland transportation cost is unnecessary to be concerned in this study.)

4.2.1 AS-IS

For the first alternative, using European coke as energy, is summary in Table 4.1 the cost for Raw material is 1,705.71 THB per ton of finish good, cost for Coke is 2,450.90 THB per ton of finish good. Total cost for Raw materials and Coke is 4,156.60 THB per ton of finish good.

Table 4.1 Cost for raw material and coke (European Coke)

Raw material and coke	Recipe	Composition (kg)	Material consumption	Price per ton (THB)	Cost (THB)
	%Raw mat	per ton of finished good	(kg) - with ME % 77.65%		
Raw Materials					
Basalt	67%	670	862.85	1,079	931.01
Dolomite	5%	50	64.39	770	49.58
EAF	8%	80	103.03	250	25.76
Converter slag	15%	150	193.17	2,291	442.56
Dunite	5%	50	64.39	3,988	256.79
Total (material)	100%	1,000	1,287.83		1,705.71
Coke	11.7% of material consumption (11.7%*1287.83)		150.68	16,266	2,450.90
Total Cost					4,156.60

Exchange Rate THB: EU = 39.72 THB: 1 EU (updated 22/6/2016: source Bank of Thailand)

4.2.2 TO-BE

Using Chinese coke as energy is summary in Table 4.2 the cost for Raw material is 1,765.97 THB per ton of finish good, cost for Coke is 2,291.64 THB per ton of finish good. Total cost for Raw materials and Coke is 4,057.61 THB per ton of finish good.

Table 4.2 Cost for raw material and coke (Chinese Coke)

Raw material and coke	Recipe %Raw mat	Composition (kg)	Material consumption	Price per ton (THB)	Cost (THB)
		per ton of finished good	(kg) - with ME % 75.00%		
Raw Materials					
Basalt	67%	670	893.33	1,079	963.91
Dolomite	5%	50	66.67	770	51.33
EAF	8%	80	106.67	250	26.67
Converter slag	15%	150	200.00	2,291	458.20
Dunite	5%	50	66.67	3,988	265.87
Total (material)	100%	1,000	1,333.33		1,765.97
Coke	13% of material consumption		173.33	13,221	2,291.64
	(13%*1287.83)				
Total Cost					4,057.61

Exchange Rate THB: USD = 35,25 THB: 1 USD (updated 22/6/2016: source Bank of Thailand)

4.3 Effect from different exchange rates

According to the assumption and price mentioned in Table 4.1 and 4.2, costs for European coke (price in EU currency) and for Chinese coke (price in USD currency) are multiplied by their exchange rate (THB:US and THB:EU) and presented in following Table 4.3. Cost saving by using Chinese coke instead of European coke is simulated and presented in this table also.

Table 4.3 Overall VPC (simulated by quarter). (Quarterly exchange rate Ref: Bank of Thailand)

Period of Time		Exchange Rate		VPC Diff
Year	Quarter	THB:EUR	THB:USD	(THB/TON)
2016	Q3	38.9	34.8	71
	Q2	39.8	35.3	101
	Q1	39.3	35.7	46
2015	Q4	39.2	35.8	31
	Q3	39.2	35.2	66
	Q2	36.8	33.3	47
	Q1	36.8	32.6	83
2014	Q4	40.9	32.7	323
	Q3	42.5	32.1	462
	Q2	44.5	32.5	556
	Q1	44.7	32.7	558
2013	Q4	43.2	31.7	522
	Q3	41.7	31.5	451
	Q2	39	29.9	390
	Q1	39.4	29.8	415

According to Table 4.3, when “VPC Diff” which refers to the difference of cost generated by using European coke that exceeds cost generated by using Chinese coke shows positive values, it means that using European coke is more expensive compared to Chinese coke. In 2013 and 2014 (from the 1st quarter of 2013 to the 4th quarter of 2014), we found that cost saving from using Chinese Coke is around 460 THB/Ton by average. But in 2015 and 2016 (from the 1st quarter of 2015 to the 3rd quarter of 2016), though costs generated by using coke from Europe and China are not far different, cost of using Chinese Coke is still save for around 64 THB/Ton by average.

Since total volume of Rockwool production is approximately 1200 Ton/month.

It means that if in 2013 and 2014, Rockwell company decided to use Chinese coke instead of European coke, the company will save cost for around 460THB/Tons*1,200 Tons/month =

552,000 THB/month (or 6,624,000 THB/year). While in 2015 and 2016, the company can save

cost by using Chinese coke for around 64THB/Tons*1,200 Tons/month = 76,800 THB/month (or around 921,600 THB/year),

Table 4.4 Timeline saving

Timeline	Average Saving (THB/Ton)	Average Saving (THB/Month)	Average Saving (THB/Year)
Q1 13 to Q4 14	460	552,000	6,624,000
Q1 15 to Q3 16	64	76,800	921,600

For more understanding, these data are depicted again as following figure 4.2. In figure 4.2, it is obviously seen that, with fixed prices, cost differences are affected by the difference of exchange rate. The more difference in exchange rate the more difference in costs. In 2013 and 2014, THB:USD is somewhat stable while THB:EUR grow higher. This situation causes the production by using European coke to get higher cost also.

This phenomenon introduces the issue about the difference of exchange rates that affects to cost for coke imported from different country. Moreover when the exchange rate is unstable, it is also risky for supplier selection as well. Then it is worthy to keep concern on the risk from stability of exchange rate (THB: EU and USD) to support long term decision making for selecting source of Coke.

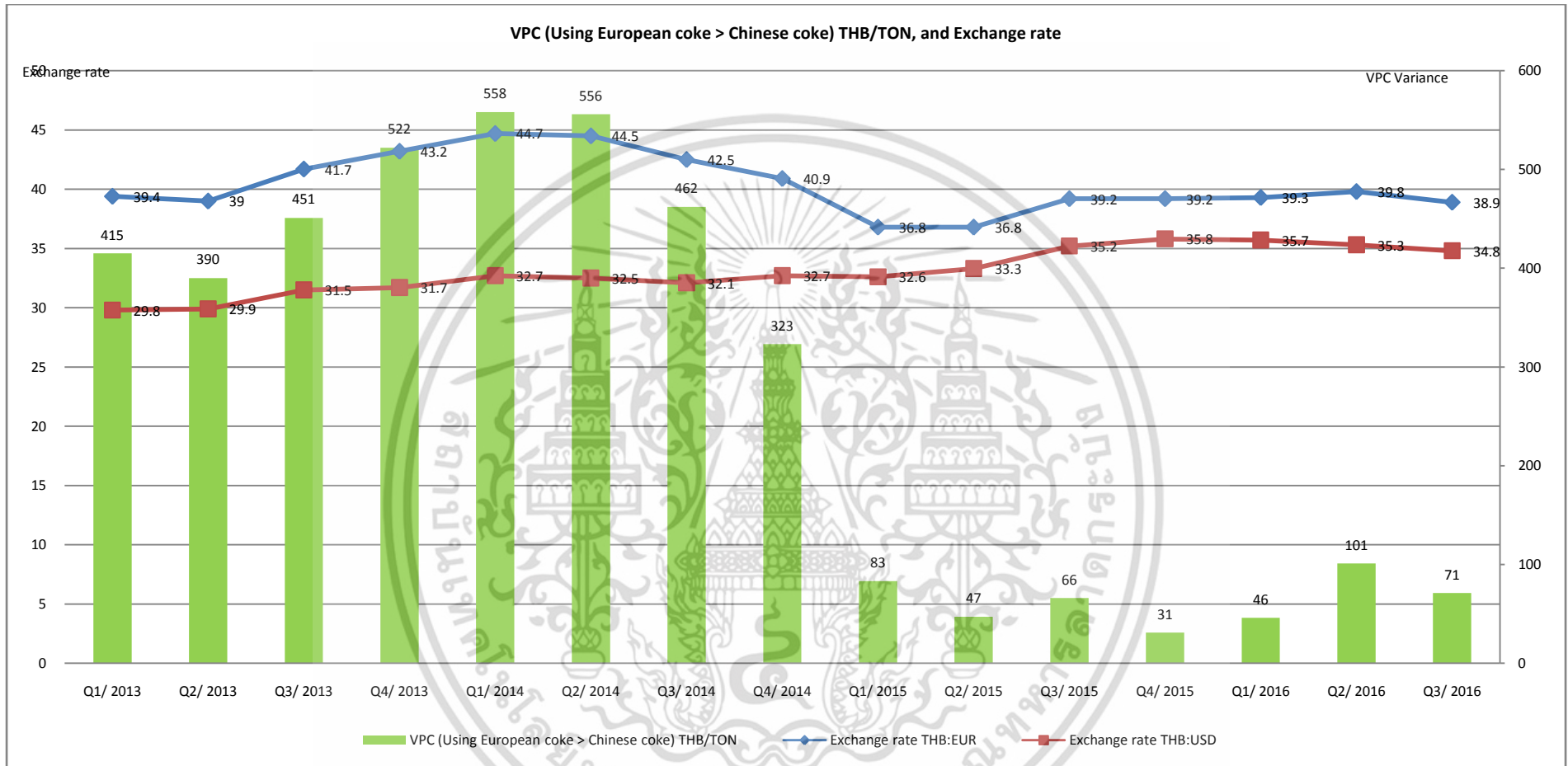


Figure 4.2 Simulated VPC saving by using historical exchange rate

4.4 Box Plot Analysis

Cost consideration under an uncertainty of exchange rate

According to historical data in 6 latest years (72 months since 2011 to 2016), EU:THB and USD:THB exchange rates are presented as box plots in following Figure 4.3.

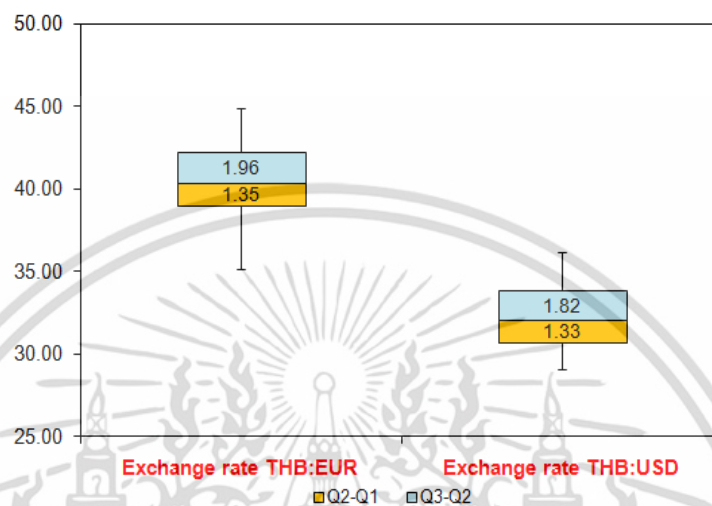


Figure 4.3 Box plot analysis for monthly exchange rate since 2011 to 2016.

According to Figure 4.3, the variation of exchange rate for THB: USD is lower than for THB: EUR. Exchange rate for THB: EUR range from 35.16 to 44.87 THB/EUR. While the exchange rate for THB: USD range from 29.07 to 36.16 THB/USD. The exchange rates in both cases are likely symmetrically distributed around their median as illustrated in Figure 4.3. Summary exchange rate from box plot analysis both THB: EU and THB: USD is also presented in Table 4.5.

Table 4.5 Value of minimum, maximum, 1st quartile, 3rd quartile and median value from box plot analysis

Labels	Exchange rate	Exchange rate
	THB:EUR	THB:USD
Min	35.16	29.07
Q ₁	38.98	30.73
Median	40.33	32.06
Q ₃	42.29	33.87
Max	44.87	36.16

Scenarios comparison

Price for Spain coke (in EUR currency) and for Chinese coke (in USD currency) are converted into THB currency by five important values (minimum, maximum, 1st quartile, 3rd quartile and median) from each box plot. Then there are 25 scenarios of cost to be compared. Price and cost (in THB currency) are calculated by following equation.

$$\text{Price (THB)} = \text{Price (EUR or USD)} * \text{Exchange rate} \quad (4.1)$$

$$\text{Cost (THB)} = \text{Price (THB/ton)} * \text{Coke Amount (ton)} \quad (4.2)$$

Assume that production volume is 1,200 tons/month while price of Chinese coke and European coke are 62.5 USD and 58 EUR respectively. Cost for using Chinese coke and European coke are calculated and compared in 25 scenarios. Monthly saving from using Chinese coke for each scenario is then calculated and reported as in Table 4.6.

Table 4.6 Cost saving from using Chinese coke (THB/month)

Saving from using Chinese coke (THB/Month, 25 conditions)					
THB:EUR	THB:USD				
	Min	Q1	Median	Q3	Max
Min	252,271.31	127,812.95	28,133.63	(108,338.81)	(280,102.61)
Q1	526,123.14	401,664.78	301,985.46	165,513.02	(6,250.78)
Median	623,145.96	498,687.60	399,008.28	262,535.84	90,772.04
Q3	763,568.99	639,110.63	539,431.31	402,958.87	231,195.07
Max	948,826.98	824,368.62	724,689.30	588,216.86	416,453.06

According to the historical data (2011–2016), using Chinese coke can save cost in almost every case except in the case that THB currency is weak compare to USD currency and strong compare to EUR currency which is not easily occur. If the exchange rates are still in the area of median rate (both THB:USD and THB:EUR), using Chinese coke may save cost for 399,008.28 THB/month or around 4.9 million THB annually.

In the middle area that the exchange rates hold in the range of 1st quartile to 3rd quartile, using Chinese coke may save cost at least 165,513.02 THB/month (or around 1.99 million THB annually) and up to 639,110.63 THB/month (or around 7.67 million THB annually).

Whenever THB weaken down to meet 33.87 THB/USD, the decision making may need more concerned especially when the THB:EUR meet 38.98 THB/EUR at the same time the decision making may needed to be revised, said that this is the area of change.

As mention earlier that cost for coke is related to coke price also. It's mean that, refer to this decision framework, we can get the range of price for negotiation with other supplier for lower price. Or we can get the scope of budget able to be prepared for stabilizing the exchange rate as well.

This analysis supports an idea that the variation of exchange rate may affects to cost also. Simulating the cost under uncertainty exchange rate is reasonable and beneficial. However, it is worthy to suggest about more precisely forecasting techniques for the future research.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The main objective of this study is to reduce production variable cost for the stone-wool manufacturing process. The study is then composed of three important steps; finding major problem, exploring the problem solution and suggesting decision making guideline.

In the first step, three sub-processes have been done; manufacturing process reminding, cost allocating and defining real problem to be solved. After reminding the manufacturing process, it has been found that stone-wool production is composed of two consequently groups of process; the primary process and the secondary process. The primary process is the process of producing stone-wool from raw materials. And secondary process is to shape those stone-wools to meet customer's requirements. Every type of stone-wool product is then must be produce by the similar primary process. Reducing cost that occurs in the primary process is then high potential to reduce overall total cost. Cost allocation is then explored concerning process key figures and the real data of costs in the history. Since costs of the primary process is mainly due to cost for materials and coke (as an energy) which hold the very big costs for inventory, ABC classification is then appropriately applied in this stage to find out what are the major important costs for the manufacturing. Applying the ABC technique have revealed the major problems with highest potential to reduce the overall production cost are cost for coke and cost for materials respectively. According to Pareto concept, costs for coke and cost for materials are declared as major problems to be concerned in this study.

The process key figures and recipes are explored to find out the parameters that strongly related to the major costs; cost for coke and cost for material. The results from this stage indicate four important parameters these are material efficiency, coke ratio, price and exchange rate.

For the second step, coke and raw materials consumptions are explored to find out the alternative of solutions. In this step, it has been found that coke quality is influence on the consumption of coke (% coke usage) and stone materials (% material efficiency).

According to the past trials, there are only two alternative solutions left to be concerned whether using Everest Coke from China or using Nalon Coke from Spain. Since Nalon coke and Everest coke are different in price and quality (different coke consumption and stone material consumption), costs for these alternatives are different also. Moreover, since Nalon coke and Everest coke are imported from different country, the impact of different exchange rate have to be concerned also.

To compare these alternatives of solution, the total production cost was calculated using excel-simulator. In the simulation, only input the value of parameters; price, percentage of coke usage, percentage of material efficiency and exchange rate, the total production is calculated automatically. Then we could easily find out the most appropriate solution as well. For example, according to the past 4 years data, right choosing source of coke can reduce cost for around 15 million THB through the pass 4 years.

This excel simulator is then could be the simple decision supporting tool to choose the appropriate source. Choosing the right supplier is not only help reducing cost but it is helpful in the business negotiation, in the procurement policy establishment and in the supplier relationship management especially when applied this idea in the long termed sourcing plan.

5.2 Future Works

- 1) To try alternative source of COKE In other areas.
- 2) Due to source of stone also impact %material efficiency because composition of each source and purity of each source, next step we should also Consider main stone material such as Basalt.
- 3) Forecasting COKE price analysis which coming from Coal market by review situation of worldwide Coal market.
- 4) Negotiation after deeply understand the Coal market situation, and projection the Coke price with supplier in the future of each Vendor.

REFERENCES

- Armstrong, D.J., 1985. Sharpening inventory management. *Harv. Bus. Rev.*63(6), 42–58.
- Chakravarty, A.K., 1981. Multi-item inventory aggregation into groups. *J.Oper.Res. Soc.* 32,19–36.
- Divesh Kumar, Zillur Rahman., 2016. Buyer supplier relationship and supply chain sustainability: empirical study of Indian automobile industry. *Journal of Cleaner Production* 131, 836–848.
- E.D. Larsen, D.E. Clark, K.L. Moore, P.E. King, Intelligent control of cupola melting. INEL/CON-97-00018.
- Ernst, R., Cohen, M., 1990. Operations Related Groups (ORG): a clustering procedure for production/inventory systems. *J. Oper. Manage.* 9 (4),574–598.
- Flores, B.,Whybark, C.,1986. Multiple criteria ABC analysis. *Int. J. Oper. Prod. Manage.* 6(3), 38–46.
- Foundry Coke: A Review of the Industries in the United States and China, U.S. International Trade Commission, July 2000.
- Güvenir, H., Erel, E., 1998. Multi-criteria inventory classification using a genetic algorithm. *Eur.J.Oper.Res.*105,29–37.
- Hui-Shung Chang., 1997. Coking coal procurement policies of the Japanese steel mills: changes and implications. *Resources Policy.* 23(3), 125-135.
- Juran, J., 1954. *Universals in Management Planning and Control.* Management Review. 1954. American Management Association, New York, NY, pp.748–761 (November).
- Key Coal Trends, International Energy Agency, 2016.
- King, D. W. (2007). The cost of journal publishing: a literature review and commentary. *Learned Publishing*, 20(6), 85–106. <http://dx.doi.org/10.1087/174148507X183551>
- Lena Sibermayr, Stefan Miner., 2016. Dual sourcing under disruption risk and cost improvement through learning. *European Journal of Operational Research.* 250, 226-238.
- Martin Kotula, William Ho, Prasanta Kumar Dey, Carman Ka Man Lee., 2015. Strategic sourcing supplier selection misalignment with critical success factors: Finding from multiple case studies in Germany and the United Kingdom. *Int.J. Production Economics.* 166, 238-247.
- Pareto, V., 1971. (English Translation) *Manual of Political Economy.* AM Kelley, New York.
- Process Key Figures Manual, Rockwool, 2007.

R. Leth-Miller, A. D. Jensen, P. Glarborg, L. M. Jensen, P. B. Hansen and S. B. Jørgensen,
Investigation of a Mineral Melting Cupola Furnace. Part I. Experimental Work, Industrial
Engineering Chemistry Res., Vol. 42, No. 26, 2003.

Box plot, website, <http://stattrek.com/statistics/charts/boxplot.aspx>

Cupola furnace, website, <http://www.atlasfdry.com/cupolafurnace.htm>

Cupola furnace, website,

<http://temperaturedetectors.com/www.meltingtemperatures.com/Cupola%20Furnace1.png>

Fiber glass, website, <http://nationalstonewool.com/products/mw-vs-fiberglass>

Inco-terms, website, <http://www.tf-shipping.com/info/incoterms/>

International Energy Agency, website, <http://www.iea.org/>

Mineral wool, website, https://en.wikipedia.org/wiki/Mineral_wool

Stone wool insulation production, website,

<http://www.grodan.com/sustainability/certificates/stone+wool+production>

Stone wool insulation details, website, <http://www.rockwool.com>

Stone wool insulation details, website, <http://www.rockwool.co.th>

U.S. international trade commission, website,

<https://www.usa.gov/federal-agencies/u-s-international-trade-commission>

Variable cost, website, <http://www.investopedia.com/terms/v/variablecost.asp#ixzz4Gcul9tml>

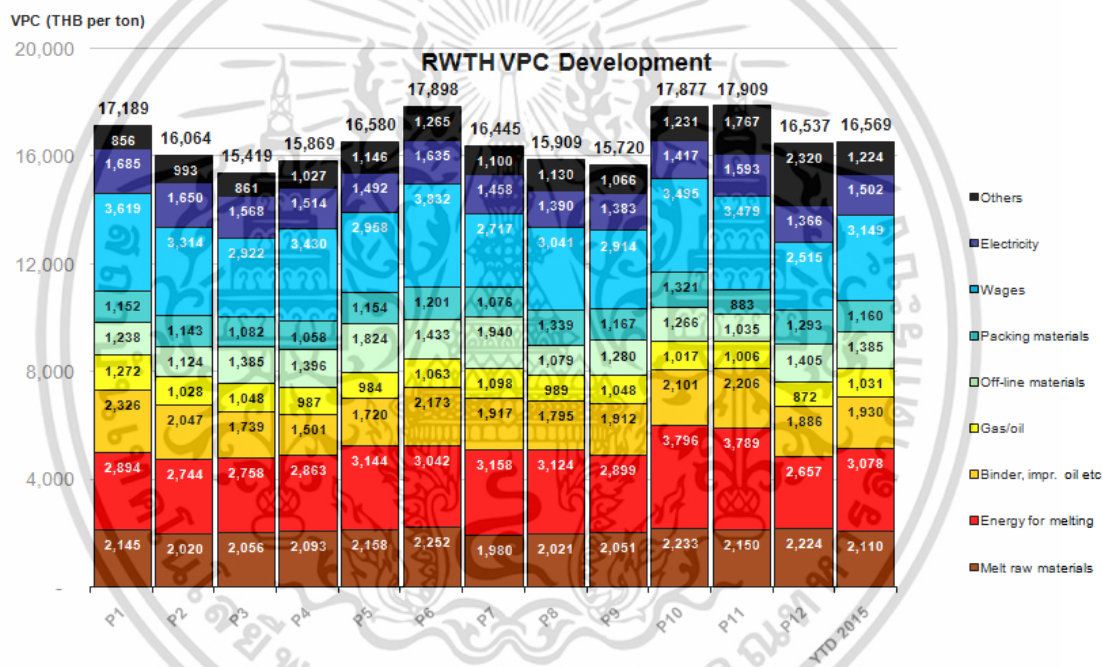
APPENDIX

Variable production cost

Year 2015 16,569 THB/Tons product (Mainline + Secondary process)

	2015												YTD 2015
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
Melt raw materials	2,145	2,020	2,056	2,093	2,158	2,252	1,980	2,021	2,051	2,233	2,150	2,224	2,110
Energy for melting	2,894	2,744	2,758	2,863	3,144	3,042	3,158	3,124	2,899	3,796	3,789	2,657	3,078
Binder, impr. oil etc	2,326	2,047	1,739	1,501	1,720	2,173	1,917	1,795	1,912	2,101	2,206	1,886	1,930
Gas/oil	1,272	1,028	1,048	987	984	1,063	1,098	989	1,048	1,017	1,006	872	1,031
Off-line materials	1,238	1,124	1,385	1,396	1,824	1,433	1,940	1,079	1,280	1,266	1,035	1,405	1,385
Packing materials	1,152	1,143	1,082	1,058	1,154	1,201	1,076	1,339	1,167	1,321	883	1,293	1,160
Wages	3,619	3,314	2,922	3,430	2,958	3,832	2,717	3,041	2,914	3,495	3,479	2,515	3,149
Electricity	1,685	1,650	1,568	1,514	1,492	1,635	1,458	1,390	1,383	1,417	1,593	1,366	1,502
Others	856	993	861	1,027	1,146	1,265	1,100	1,130	1,066	1,231	1,767	2,320	1,224
Total	17,189	16,064	15,419	15,869	16,580	17,898	16,445	15,909	15,720	17,877	17,909	16,537	16,569
Total stone wool	916	1,024	1,223	987	1,357	1,038	1,439	1,377	1,394	1,177	1,059	1,112	14,103

Overall variable production cost (both mainline and secondary process)



VPC Mainline

	2015												YTD 2015
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
Melt raw materials	2,145	2,020	2,056	2,093	2,158	2,252	1,980	2,021	2,051	2,233	2,150	2,224	2,110
Energy for melting	2,894	2,744	2,758	2,863	3,144	3,042	3,158	3,124	2,899	3,796	3,789	2,657	3,078
Binder, impr. oil etc	2,288	1,995	1,683	1,466	1,670	2,124	1,846	1,733	1,863	2,028	2,127	1,856	1,876
Gas/oil	995	790	807	731	685	758	779	631	643	622	683	534	715
Off-line materials	7	4	7	5	6	5	3	8	3	7	11	7	6
Packing materials	576	642	487	470	510	497	482	640	587	692	426	711	560
Wages	1,701	1,517	1,243	1,595	1,258	1,651	1,165	1,318	1,256	1,530	1,781	1,362	1,423
Electricity	1,379	1,335	1,287	1,280	1,242	1,297	1,168	1,094	1,085	1,028	1,156	1,131	1,198
Others	1,225	1,309	1,127	1,327	1,353	1,537	1,276	1,322	1,239	1,439	2,048	2,547	1,465
Total	13,212	12,356	11,456	11,829	12,026	13,162	11,859	11,892	11,627	13,375	14,171	13,028	12,430
Ton Produced	916	1,024	1,223	987	1,357	1,038	1,439	1,377	1,394	1,177	1,059	1,112	14,103

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
 ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

VPC Secondary Process

1) Meshing the stone wool

	2015												YTD 2015	
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12		
Melt raw materials	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy for melting	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Binder, impr. oil etc	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gas/oil	75	78	53	70	71	75	61	86	107	72	100	115	79	
Off-line materials	3,330	3,934	3,293	2,853	4,308	4,537	5,043	3,317	3,674	3,229	4,031	4,300	3,809	
Packing materials	770	642	737	689	757	891	742	1,111	646	764	441	926	770	
Wages	959	1,144	874	1,111	953	1,652	966	1,067	1,115	1,079	1,196	867	1,056	
Electricity	52	60	48	44	48	57	62	54	58	55	77	40	54	
Others	13,823	12,179	12,490	12,147	12,152	12,057	12,010	12,360	12,150	12,196	12,199	12,418	12,311	
Total	19,009	18,037	17,496	16,914	18,290	19,269	18,883	17,994	17,751	17,395	18,044	18,666	18,078	
Ton Produced	209	211	405	350	428	215	375	379	349	320	229	311	3,780	

2) Facing the stone wool

	2015												YTD 2015
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
Melt raw materials	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy for melting	-	-	-	-	-	-	-	-	-	-	-	-	-
Binder, impr. oil etc	-	-	-	-	-	-	-	-	-	-	-	-	-
Gas/oil	103	113	122	157	210	184	124	108	26	246	456	-	144
Off-line materials	4,348	6,819	6,055	5,710	8,195	5,706	7,338	8,271	7,554	7,604	6,797	5,955	6,567
Packing materials	1,088	1,359	1,112	1,268	1,277	1,676	1,567	2,309	1,275	2,156	758	1,725	1,444
Wages	2,691	4,367	3,938	3,586	3,955	3,391	3,261	9,375	4,859	5,496	8,114	2,280	4,037
Electricity	86	18	13	14	13	14	14	22	16	16	39	13	25
Others	13,820	13,465	13,537	13,036	13,083	13,075	13,301	14,877	13,088	14,079	13,356	13,644	13,438
Total	22,135	26,141	24,779	23,771	26,733	24,046	25,605	34,962	26,817	29,597	29,520	23,617	25,655
Ton Produced	99	46	58	65	76	89	122	26	65	59	24	36	765

3) Pipe Small Size

	2015												YTD 2015
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
Melt raw materials	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy for melting	-	-	-	-	-	-	-	-	-	-	-	-	-
Binder, impr. oil etc	350	511	314	173	578	232	614	939	435	605	961	468	523
Gas/oil	2,442	1,922	2,491	2,721	2,246	2,048	2,584	3,137	2,939	3,065	4,363	4,033	2,780
Off-line materials	16	-	7	-	16	10	-	-	27	27	-	-	9
Packing materials	1,489	1,789	1,837	1,899	2,180	2,107	1,642	3,318	2,848	2,045	2,203	1,850	2,135
Wages	10,889	10,540	9,748	10,417	7,314	8,626	7,511	9,712	7,371	9,622	8,979	7,519	8,854
Electricity	2,179	2,185	2,490	2,054	1,588	2,085	1,936	2,049	1,717	3,807	4,225	1,082	2,251
Others	18,480	19,091	19,277	19,455	22,822	24,814	20,595	19,616	18,463	19,360	19,786	19,214	20,294
Total	35,846	36,036	36,164	36,718	36,743	39,924	34,883	38,771	33,800	38,532	40,516	34,166	36,846
Ton Produced	32	32	35	25	47	48	50	41	47	37	33	29	456

4) Pipe Medium Size

	2015												YTD 2015
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
Melt raw materials	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy for melting	-	-	-	-	-	-	-	-	-	-	-	-	-
Binder, impr. oil etc	192	223	496	134	328	331	381	212	209	283	227	212	272
Gas/oil	1,642	1,220	1,286	1,856	1,843	1,332	1,768	1,907	2,227	2,261	900	1,915	1,697
Off-line materials	4	9	7	5	16	4	5	10	10	-	-	-	6
Packing materials	2,839	2,597	3,158	3,038	3,080	2,933	2,438	2,550	2,525	2,545	3,152	2,466	2,751
Wages	6,089	4,928	5,350	6,954	7,868	6,424	4,875	6,020	5,465	6,109	5,010	3,225	5,672
Electricity	2,413	2,194	2,162	2,437	2,189	2,279	2,317	2,169	2,271	2,420	2,586	2,670	2,327
Others	17,405	17,038	18,573	17,301	17,129	18,217	18,657	16,838	16,820	21,570	17,191	16,937	17,794
Total	30,583	28,209	31,033	31,725	32,452	31,518	30,442	29,706	29,527	35,188	29,066	27,426	30,520
Ton Produced	64	82	76	51	80	69	91	104	98	78	74	67	936

5) Pipe Large Size

	2015												YTD 2015
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	
Melt raw materials	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy for melting	-	-	-	-	-	-	-	-	-	-	-	-	-
Binder, impr. oil etc	638	614	481	1,245	287	281	670	436	528	520	668	178	503
Gas/oil	2,429	2,097	1,950	2,998	2,077	1,543	2,382	2,295	3,300	1,761	1,838	2,932	2,204
Off-line materials	-	18	25	27	30	21	28	9	39	13	19	92	25
Packing materials	1,668	1,502	1,448	2,914	2,036	1,439	1,498	1,406	2,339	1,226	1,134	2,412	1,642
Wages	11,811	11,282	9,668	14,899	6,678	7,709	7,319	7,736	9,422	7,290	6,946	7,572	8,311
Electricity	2,000	2,018	1,752	2,100	1,321	1,332	1,538	1,370	1,762	1,433	2,148	1,182	1,597
Others	17,448	21,502	17,213	17,746	19,920	16,523	16,246	16,378	20,695	16,314	16,217	16,536	17,518
Total	35,994	39,032	32,536	41,929	32,349	28,847	29,681	29,630	38,084	28,556	28,969	30,904	31,800
Ton Produced	18	28	41	19	50	60	55	56	51	78	53	33	543

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และต้องอ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

All materials consumption (Amount THB)

Process	Materials	Amount MAY2014 to APR2015 (THB)	ABC Classification
Melting Materials	SPAIN COKE	40,997,878.24	A
Binder Materials	PHENOLIC RESIN	19,844,865.68	A
Melting Materials	BASALT	14,886,870.48	A
Materials for secondary process	WIRE MESH	10,933,730.69	A
Melting Materials	Converter Slag	7,707,431.26	B
Packing materials	SHRINKFILM WITH ROCKWOOL LOGO	7,325,888.72	B
Binder Materials	UREA 46%	5,874,813.62	B
Binder Materials	INSULCOTE SE95	2,971,600.00	B
Materials for secondary process	STRETCH FILM 750MM X2500M	2,731,847.56	B
Packing materials	CARTONS BOX ROCKWOOL LOGO	2,711,160.00	B
Materials for secondary process	ALUM FOIL SING.SIDE 1.25x500M	2,551,170.33	B
Materials for secondary process	STITCHING WIRE	1,828,400.40	B
Packing materials	##WHITE POLYFILM 1500MM LDPE META	1,641,062.85	B
Melting Materials	DOLOMITE	1,502,907.56	B
Melting Materials	DUNITE ROCK 40MM-100MM	1,456,316.42	B
Materials for secondary process	STANLESS STEEL WIREMESH	1,290,525.82	B
Packing materials	SHRINKFILM LOGO ROXUL	1,051,606.58	B
Melting Materials	ALUORE ALUMINIUM ORE (BAUXITE)	957,000.39	B
Packing materials	Transparent LDPE Shrink Film	751,923.82	B

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 69 ำงอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Materials for secondary process	PRESSURESENSITIVEADHESI VE	747,198.00	B
Materials for secondary process	BLACK GLASS TISSUE	656,560.00	B
Materials for secondary process	SILICON EMULSION	571,769.84	B
Liquid Fuel	LPG 15KG (FOR FORKLIFT) 15 KG	564,593.66	C
Packing materials	YELLOW SHRINKFILM W.LOGO	543,454.91	C
Melting Materials	ELECTRIC ARC FURNACE SLAG	418,603.13	C
Packing materials	Polybag 1210+105+105x2250mm	380,113.74	C
Materials for secondary process	ALUM FOIL SING.SIDE - 0.625x500M	375,000.00	C
Liquid Fuel	DIESEL	359,660.11	C
Packing materials	PRODUCT LABEL	321,078.21	C
Materials for secondary process	CSR THERMOFOIL 730 ALUM FOIL 1.35MX60M	296,342.72	C
Packing materials	Polybag 390+155+155x1700mm	290,121.44	C
Melting Materials	Blast Furnace Slag	259,363.53	C
Packing materials	Polybag 620+160+160x1550mm	228,767.30	C
Packing materials	PRODUCT LABEL (YELLOW)	223,452.86	C
Packing materials	CARTON BOX PLAIN 347x657x1205MM	172,960.00	C
Packing materials	PRODUCT LABEL (RED)	171,051.80	C
Packing materials	Polybag 600+110+110x2300mm	152,950.58	C
Packing materials	Polybag 600+130+130x1900mm	148,164.28	C
Packing materials	Polybag 1210+105+105x2500mm	135,864.00	C
Materials for secondary process	SPRAY ADHESIVE	129,772.90	C

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และด้วย 70 ว่าจะถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Auxiliary Materials	REFRACTORY MATERIAL (GREY)230x114x60	119,664.56	C
Packing materials	Polybag 660+320+320x1940mm	117,901.24	C
Materials for secondary process	STANLESS STICHING WIRE	114,924.10	C
Packing materials	OPPTAPE-BROWN 309 48MM.X100M.	105,383.18	C
Packing materials	Polybag 620+165+165x1940mm	97,327.02	C
Packing materials	PRODUCT LABEL (PINK)	89,281.82	C
Packing materials	PRODUCT LABEL (BLUE)	86,236.36	C
Packing materials	OPPTAPE-CLEAR 309 48MM.X100M.	65,960.00	C
Packing materials	Polybag 480+230+230x1900mm	64,075.86	C
Packing materials	PRODUCT LABEL (CSR)	63,407.87	C
Packing materials	CARTON CORNER	57,060.50	C
Liquid Fuel	GASOHOL 91	56,939.81	C
Packing materials	Polybag 1210+105+105x1450mm	53,635.20	C
Auxiliary Materials	##Firewood	49,869.00	C
Packing materials	BROWN PAPER	39,782.80	C
Auxiliary Materials	REFRACTORY MATERIAL (GREY)230x114x30	38,334.38	C
Packing materials	PRODUCT LABEL (ORANGE)	37,806.41	C
Packing materials	Polybag 420+210+210x1550mm	37,296.00	C
Packing materials	Polybag 610+295+295x1940mm	33,386.58	C
Materials for secondary process	BLACK GLASS FIBER CLOTH	32,760.00	C
Packing materials	SHRINK POLYFILM SAFE N SILENT 1500MM	32,543.68	C
Packing materials	Polybag 610+155+155x1680mm	32,367.60	C
Packing materials	Polybag 1210+105+105x2600mm	29,370.60	C

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และด้วย 71 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Auxiliary Materials	Fine sand	28,816.57	C
Packing materials	Polybag 1210+105+105x1600mm	28,706.07	C
Packing materials	Polybag 600+130+130x1080mm	24,021.14	C
Packing materials	Polybag 1210+105+105x1750mm	22,253.28	C
Materials for secondary process	BLACK POLYESTER	21,875.00	C
Auxiliary Materials	Diram 170 PHS	20,860.95	C
Packing materials	Polybag 610+105+105x2250mm	20,357.40	C
Auxiliary Materials	REFRACTORY MATERIAL (WHITE)230x114x30	19,869.79	C
Packing materials	Polybag 1210+105+105x1950mm	16,315.52	C
Auxiliary Materials	MORTAR	16,019.86	C
Packing materials	Polybag 1200+55+55x2600mm	7,474.74	C
Auxiliary Materials	Mortar SK 30 HM	6,816.00	C
Materials for secondary process	CSR THERMOFOIL 730 PERFORATED 1.2MX60M	5,124.32	C
Packing materials	Polybag 1210+55+55x2350mm	3,703.70	C
Auxiliary Materials	Diram 170	2,099.47	C
Packing materials	CARD BOARD (SPI PAPER)	1,580.25	C

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า ไม่ว่าจะกรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และด้วย 72 ว่าจะอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

Monthly Exchange Rate 2011 to 2016

Exchange rate Year													Min	Max
2016	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	2016	2016
Exchange rate														
THB:EUR	39.28	39.53	39.16	39.80	40.04	39.65	38.78	38.91	38.92	38.68	38.16	37.73	37.73	40.04
Exchange rate														
THB:USD	36.16	35.60	35.24	35.09	35.45	35.31	35.08	34.73	34.73	35.05	35.32	35.81	34.73	36.16
Exchange rate Year													Min	Max
2015	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	2015	2015
Exchange rate														
THB:EUR	38.03	36.99	35.32	35.16	37.43	37.86	37.72	39.46	40.47	40.13	38.45	39.16	35.16	40.47
Exchange rate														
THB:USD	32.73	32.57	32.63	32.51	33.55	33.73	34.30	35.42	36.02	35.72	35.78	36.01	32.51	36.02

Exchange rate Year													Min	Max
2014	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	2014	2014
Exchange rate														
THB:EUR	44.87	44.57	44.77	44.62	44.65	44.19	43.46	42.61	41.56	41.15	40.89	40.54	40.54	44.87
Exchange rate														
THB:USD	32.94	32.65	32.39	32.32	32.53	32.51	32.10	32.01	32.18	32.45	32.78	32.90	32.01	32.94
Exchange rate Year													Min	Max
2013	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	2013	2013
Exchange rate														
THB:EUR	39.94	39.88	38.26	37.80	38.62	40.67	40.71	42.08	42.31	42.54	42.67	44.27	37.80	44.27
Exchange rate														
THB:USD	30.07	29.82	29.52	29.07	29.78	30.83	31.12	31.60	31.71	31.22	31.63	32.34	29.07	32.34

Exchange rate Year	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Min	Max
2012													2012	2012
Exchange rate														
THB:EUR	40.71	40.63	40.57	40.71	40.07	39.72	38.94	38.99	39.86	39.78	39.40	40.19	38.94	40.71
Exchange rate														
THB:USD	31.58	30.73	30.69	30.89	31.34	31.65	31.65	31.43	31.00	30.70	30.71	30.64	30.64	31.65
Exchange rate Year	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Min	Max
2011													2011	2011
Exchange rate														
THB:EUR	40.83	41.97	42.51	43.43	43.30	43.91	42.99	42.86	41.90	42.28	41.99	41.03	40.83	43.91
Exchange rate														
THB:USD	30.58	30.72	30.37	30.05	30.24	30.51	30.08	29.88	30.42	30.89	30.95	31.21	29.88	31.21

ROCKWOOL PROCESS KEY FIGURE JAN 2015

1a PKF report

Line: 01 Month: 1 Year: 2015

[Print](#)

[Return](#)

PKF				%
EAF SLAG	kg	92,670		7.9
Coke	kg	127,987		10.9
BF SALG	kg	3,528		0.3
BAUXITE	kg	6,916		0.6
DOLOMITE	kg	85,070		7.3
BASALT	kg	761,582		65.1
CONVERTER SLAG	kg	162,680		13.9
DUNITE	kg	56,628		4.8
LIME STONE	kg	0		0.0
Raw material	kg	1,169,074		
Corr. raw materials	kg	1,114,877		
Total fuel	kg	127,987		
Secondary Combustion Materials	kg	0		
Net wool	kg	895,438		
Odd size waste	kg	0		
Odd size waste Recl.	kg	0		
Edge trim	kg	67,030		
Waste	kg	49,631		
Gross wool	kg	1,012,098		
Recycling	kg	128,726		
Norm wool	kg	915,687		
Line wool	kg	915,687		
Time available	hour	287.80		
Melting time	hour	286.60		
Effective time	hour	266.78		
Stand still	hour	477.22		
No. of stops		111		
No. of series		241		
				Budget
Charging rate	kg/hour	4,079		4,300
Coke	%	10.9		11.7
Secondary Combustion Materials	%	0.0		0.0
Spinning efficiency	%	81.2		74.0
Recycling	%	12.7		12.5
Gross wool 1	kg/hour	3,794		3,500
Other waste	%	4.9		4.5
Edge trim	%	6.6		4.5
Odd size waste	%	0.0		0.0
Volume efficiency	%	102.3		102.0
Time efficiency	%	92.7		96.0
Material efficiency	%	78.3		76.0
Line wool 2	kg/hour	3,182		3,300
Cupola efficiency	%	95.4		99.0
Cupola time efficiency	%	99.6		99.0
Melting time efficiency	%	93.1		97.0
Corrected charging rate	kg/hour	3,890		4,189
Corrected coke	%	11.5		11.8
Corrected spinner efficiency	%	85.1		87.0
Corrected material efficiency	%	82.1		-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 76 ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE FEB 2015

1a PKF report

Line: 01 Month: 2 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	118,653	9.4
Coke	kg	140,436	11.1
BF SALG	kg	9,529	0.8
BAUXITE	kg	9,221	0.7
DOLOMITE	kg	96,737	7.6
BASALT	kg	810,954	63.9
CONVERTER SLAG	kg	164,269	12.9
DUNITE	kg	59,517	4.7
LIME STONE	kg	0	0.0
Raw material	kg	1,268,880	
Corr. raw materials	kg	1,208,106	
Total fuel	kg	140,436	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,002,001	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	79,066	
Waste	kg	52,210	
Gross wool	kg	1,133,276	
Recycling	kg	145,540	
Norm wool	kg	1,023,998	
Line wool	kg	1,023,998	
Time available	hour	313.80	
Melting time	hour	312.45	
Effective time	hour	304.65	
Stand still	hour	367.35	
No. of stops		91	
No. of series		270	
			Budget
Charging rate	kg/hour	4,061	4,300
Coke	%	11.1	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	79.8	74.0
Recycling	%	12.8	12.5
Gross wool 1	kg/hour	3,720	3,500
Other waste	%	4.6	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	102.2	102.0
Time efficiency	%	97.1	96.0
Material efficiency	%	80.7	76.0
Line wool 2	kg/hour	3,263	3,300
Cupola efficiency	%	95.2	99.0
Cupola time efficiency	%	99.6	99.0
Melting time efficiency	%	97.5	97.0
Corrected charging rate	kg/hour	3,867	4,189
Corrected coke	%	11.6	11.8
Corrected spinner efficiency	%	83.9	87.0
Corrected material efficiency	%	84.8	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 77 ำงอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE MAR 2015

1a PKF report

Line: 01 Month: 3 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	132,291	8.7
Coke	kg	163,117	10.7
BF SALG	kg	0	0.0
BAUXITE	kg	5,900	0.4
DOLOMITE	kg	83,624	5.5
BASALT	kg	991,650	65.1
CONVERTER SLAG	kg	226,505	14.9
DUNITE	kg	82,842	5.4
LIME STONE	kg	0	0.0
Raw material	kg	1,522,812	
Corr. raw materials	kg	1,464,358	
Total fuel	kg	163,117	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,198,929	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	94,537	
Waste	kg	61,564	
Gross wool	kg	1,355,030	
Recycling	kg	176,743	
Norm wool	kg	1,223,356	
Line wool	kg	1,223,356	
Time available	hour	371.13	
Melting time	hour	369.45	
Effective time	hour	358.37	
Stand still	hour	385.63	
No. of stops		118	
No. of series		274	
			Budget
Charging rate	kg/hour	4,122	4,300
Coke	%	10.7	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	79.8	74.0
Recycling	%	13.0	12.5
Gross wool 1	kg/hour	3,781	3,500
Other waste	%	4.5	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	102.0	102.0
Time efficiency	%	96.6	96.0
Material efficiency	%	80.3	76.0
Line wool 2	kg/hour	3,296	3,300
Cupola efficiency	%	96.2	99.0
Cupola time efficiency	%	99.5	99.0
Melting time efficiency	%	97.0	97.0
Corrected charging rate	kg/hour	3,964	4,189
Corrected coke	%	11.1	11.8
Corrected spinner efficiency	%	83.0	87.0
Corrected material efficiency	%	83.5	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 78 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE APR 2015

1a PKF report

Line: 01 Month: 4 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	102,337	8.1
Coke	kg	136,193	10.8
BF SALG	kg	0	0.0
BAUXITE	kg	9,888	0.8
DOLOMITE	kg	72,170	5.7
BASALT	kg	816,464	64.9
CONVERTER SLAG	kg	183,843	14.6
DUNITE	kg	73,539	5.8
LIME STONE	kg	0	0.0
Raw material	kg	1,258,241	
Corr. raw materials	kg	1,207,316	
Total fuel	kg	136,193	
Secondary Combustion Materials	kg	0	
Net wool	kg	968,033	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	78,110	
Waste	kg	73,440	
Gross wool	kg	1,119,584	
Recycling	kg	130,329	
Norm wool	kg	987,132	
Line wool	kg	987,132	
Time available	hour	279.92	
Melting time	hour	278.47	
Effective time	hour	269.53	
Stand still	hour	450.47	
No. of stops		92	
No. of series		217	
			Budget
Charging rate	kg/hour	4,518	4,300
Coke	%	10.8	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	81.2	74.0
Recycling	%	11.6	12.5
Gross wool 1	kg/hour	4,154	3,500
Other waste	%	6.6	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	102.0	102.0
Time efficiency	%	96.3	96.0
Material efficiency	%	78.5	76.0
Line wool 2	kg/hour	3,527	3,300
Cupola efficiency	%	96.0	99.0
Cupola time efficiency	%	99.5	99.0
Melting time efficiency	%	96.8	97.0
Corrected charging rate	kg/hour	4,336	4,189
Corrected coke	%	11.3	11.8
Corrected spinner efficiency	%	84.7	87.0
Corrected material efficiency	%	81.8	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 79 ำงอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE MAY 2015

1a PKF report

Line: 01 Month: 5 Year: 2015

[Print](#)

[Return](#)

PKF				%
EAF SLAG	kg	140,759		8.1
Coke	kg	194,094		11.1
BF SALG	kg	0		0.0
BAUXITE	kg	11,596		0.7
DOLOMITE	kg	100,705		5.8
BASALT	kg	1,145,814		65.6
CONVERTER SLAG	kg	254,960		14.6
DUNITE	kg	92,858		5.3
LIME STONE	kg	0		0.0
Raw material	kg	1,746,692		
Corr. raw materials	kg	1,676,881		
Total fuel	kg	194,094		
Secondary Combustion Materials	kg	0		
Net wool	kg	1,336,320		
Odd size waste	kg	0		
Odd size waste Recl.	kg	0		
Edge trim	kg	105,606		
Waste	kg	71,756		
Gross wool	kg	1,513,682		
Recycling	kg	184,549		
Norm wool	kg	1,357,467		
Line wool	kg	1,357,467		
Time available	hour	394.73		
Melting time	hour	392.53		
Effective time	hour	375.87		
Stand still	hour	368.13		
No. of stops		163		
No. of series		334		
				Budget
Charging rate	kg/hour	4,450		4,300
Coke	%	11.1		11.7
Secondary Combustion Materials	%	0.0		0.0
Spinning efficiency	%	79.5		74.0
Recycling	%	12.2		12.5
Gross wool 1	kg/hour	4,027		3,500
Other waste	%	4.7		4.5
Edge trim	%	7.0		4.5
Odd size waste	%	0.0		0.0
Volume efficiency	%	101.6		102.0
Time efficiency	%	95.2		96.0
Material efficiency	%	77.7		76.0
Line wool 2	kg/hour	3,439		3,300
Cupola efficiency	%	96.0		99.0
Cupola time efficiency	%	99.4		99.0
Melting time efficiency	%	95.8		97.0
Corrected charging rate	kg/hour	4,272		4,189
Corrected coke	%	11.6		11.8
Corrected spinner efficiency	%	82.8		87.0
Corrected material efficiency	%	81.0		-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 80 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE JUNE 2015

1a PKF report

Line: 01 Month: 6 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	111,479	8.1
Coke	kg	155,779	11.4
BF SALG	kg	0	0.0
BAUXITE	kg	7,812	0.6
DOLOMITE	kg	78,459	5.7
BASALT	kg	897,524	65.5
CONVERTER SLAG	kg	200,331	14.6
DUNITE	kg	74,132	5.4
LIME STONE	kg	0	0.0
Raw material	kg	1,369,737	
Corr. raw materials	kg	1,315,288	
Total fuel	kg	155,779	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,020,808	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	81,433	
Waste	kg	64,967	
Gross wool	kg	1,167,208	
Recycling	kg	135,537	
Norm wool	kg	1,037,527	
Line wool	kg	1,037,527	
Time available	hour	318.77	
Melting time	hour	316.27	
Effective time	hour	301.15	
Stand still	hour	418.85	
No. of stops		149	
No. of series		242	
			Budget
Charging rate	kg/hour	4,331	4,300
Coke	%	11.4	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	79.1	74.0
Recycling	%	11.6	12.5
Gross wool 1	kg/hour	3,876	3,500
Other waste	%	5.6	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.6	102.0
Time efficiency	%	94.5	96.0
Material efficiency	%	75.7	76.0
Line wool 2	kg/hour	3,255	3,300
Cupola efficiency	%	96.0	99.0
Cupola time efficiency	%	99.2	99.0
Melting time efficiency	%	95.2	97.0
Corrected charging rate	kg/hour	4,159	4,189
Corrected coke	%	11.8	11.8
Corrected spinner efficiency	%	82.4	87.0
Corrected material efficiency	%	78.9	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 81 บ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE JULY 2015

1a PKF report

Line: 01 Month: 7 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	138,050	7.9
Coke	kg	208,578	12.0
BF SALG	kg	0	0.0
BAUXITE	kg	16,800	1.0
DOLOMITE	kg	115,233	6.6
BASALT	kg	1,139,193	65.3
CONVERTER SLAG	kg	254,795	14.6
DUNITE	kg	80,922	4.6
LIME STONE	kg	0	0.0
Raw material	kg	1,744,993	
Corr. raw materials	kg	1,668,968	
Total fuel	kg	208,578	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,416,025	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	111,643	
Waste	kg	72,547	
Gross wool	kg	1,600,214	
Recycling	kg	238,344	
Norm wool	kg	1,438,764	
Line wool	kg	1,438,764	
Time available	hour	429.08	
Melting time	hour	425.35	
Effective time	hour	415.37	
Stand still	hour	328.63	
No. of stops		174	
No. of series		306	
			Budget
Charging rate	kg/hour	4,102	4,300
Coke	%	12.0	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	79.9	74.0
Recycling	%	14.9	12.5
Gross wool 1	kg/hour	3,853	3,500
Other waste	%	4.5	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.6	102.0
Time efficiency	%	96.8	96.0
Material efficiency	%	82.5	76.0
Line wool 2	kg/hour	3,353	3,300
Cupola efficiency	%	95.6	99.0
Cupola time efficiency	%	99.1	99.0
Melting time efficiency	%	97.7	97.0
Corrected charging rate	kg/hour	3,924	4,189
Corrected coke	%	12.5	11.8
Corrected spinner efficiency	%	83.6	87.0
Corrected material efficiency	%	86.2	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 82 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE AUG 2015

1a PKF report

Line: 01 Month: 8 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	137,797	8.1
Coke	kg	204,140	12.1
BF SALG	kg	0	0.0
BAUXITE	kg	4,500	0.3
DOLOMITE	kg	94,227	5.6
BASALT	kg	1,121,296	66.2
CONVERTER SLAG	kg	253,306	15.0
DUNITE	kg	82,755	4.9
LIME STONE	kg	0	0.0
Raw material	kg	1,693,881	
Corr. raw materials	kg	1,629,377	
Total fuel	kg	204,140	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,353,352	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	106,659	
Waste	kg	68,763	
Gross wool	kg	1,528,774	
Recycling	kg	205,549	
Norm wool	kg	1,377,477	
Line wool	kg	1,377,477	
Time available	hour	394.48	
Melting time	hour	391.03	
Effective time	hour	378.23	
Stand still	hour	365.77	
No. of stops		152	
No. of series		241	
			Budget
Charging rate	kg/hour	4,332	4,300
Coke	%	12.1	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	80.8	74.0
Recycling	%	13.4	12.5
Gross wool 1	kg/hour	4,042	3,500
Other waste	%	4.5	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.8	102.0
Time efficiency	%	95.9	96.0
Material efficiency	%	81.3	76.0
Line wool 2	kg/hour	3,492	3,300
Cupola efficiency	%	96.2	99.0
Cupola time efficiency	%	99.1	99.0
Melting time efficiency	%	96.7	97.0
Corrected charging rate	kg/hour	4,167	4,189
Corrected coke	%	12.5	11.8
Corrected spinner efficiency	%	84.0	87.0
Corrected material efficiency	%	84.5	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 83 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE SEPT 2015

1a PKF report

Line: 01 Month: 9 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	155,611	8.5
Coke	kg	212,988	11.6
BF SALG	kg	0	0.0
BAUXITE	kg	12,180	0.7
DOLOMITE	kg	106,156	5.8
BASALT	kg	1,201,029	65.6
CONVERTER SLAG	kg	265,829	14.5
DUNITE	kg	91,379	5.0
LIME STONE	kg	0	0.0
Raw material	kg	1,832,184	
Corr. raw materials	kg	1,759,327	
Total fuel	kg	212,988	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,373,321	
Odd size waste	kg	270	
Odd size waste Recl.	kg	246	
Edge trim	kg	111,045	
Waste	kg	107,012	
Gross wool	kg	1,591,648	
Recycling	kg	214,848	
Norm wool	kg	1,393,959	
Line wool	kg	1,393,983	
Time available	hour	439.30	
Melting time	hour	435.80	
Effective time	hour	417.85	
Stand still	hour	302.15	
No. of stops		190	
No. of series		308	
			Budget
Charging rate	kg/hour	4,204	4,300
Coke	%	11.6	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	78.4	74.0
Recycling	%	13.5	12.5
Gross wool 1	kg/hour	3,809	3,500
Other waste	%	6.7	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.5	102.0
Time efficiency	%	95.1	96.0
Material efficiency	%	76.1	76.0
Line wool 2	kg/hour	3,173	3,300
Cupola efficiency	%	96.0	99.0
Cupola time efficiency	%	99.2	99.0
Melting time efficiency	%	95.9	97.0
Corrected charging rate	kg/hour	4,037	4,189
Corrected coke	%	12.1	11.8
Corrected spinner efficiency	%	81.6	87.0
Corrected material efficiency	%	79.2	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 84 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE OCT 2015

1a PKF report

Line: 01 Month: 10 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	121,945	7.7
Coke	kg	198,881	12.5
BF SALG	kg	0	0.0
BAUXITE	kg	6,445	0.4
DOLOMITE	kg	93,158	5.9
BASALT	kg	1,052,217	66.2
CONVERTER SLAG	kg	232,389	14.6
DUNITE	kg	83,380	5.2
LIME STONE	kg	0	0.0
Raw material	kg	1,589,534	
Corr. raw materials	kg	1,525,913	
Total fuel	kg	198,881	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,158,599	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	94,394	
Waste	kg	99,981	
Gross wool	kg	1,352,974	
Recycling	kg	183,287	
Norm wool	kg	1,177,265	
Line wool	kg	1,177,265	
Time available	hour	370.93	
Melting time	hour	367.18	
Effective time	hour	350.50	
Stand still	hour	393.50	
No. of stops		184	
No. of series		279	
			Budget
Charging rate	kg/hour	4,329	4,300
Coke	%	12.5	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	77.1	74.0
Recycling	%	13.5	12.5
Gross wool 1	kg/hour	3,860	3,500
Other waste	%	7.4	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.6	102.0
Time efficiency	%	94.5	96.0
Material efficiency	%	74.1	76.0
Line wool 2	kg/hour	3,174	3,300
Cupola efficiency	%	96.0	99.0
Cupola time efficiency	%	99.0	99.0
Melting time efficiency	%	95.5	97.0
Corrected charging rate	kg/hour	4,156	4,189
Corrected coke	%	13.0	11.8
Corrected spinner efficiency	%	80.3	87.0
Corrected material efficiency	%	77.2	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 85 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE NOV 2015

1a PKF report

Line: 01 Month: 11 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	122,475	8.2
Coke	kg	195,052	13.0
BF SALG	kg	0	0.0
BAUXITE	kg	6,767	0.5
DOLOMITE	kg	97,944	6.5
BASALT	kg	988,331	65.8
CONVERTER SLAG	kg	215,944	14.4
DUNITE	kg	70,808	4.7
LIME STONE	kg	0	0.0
Raw material	kg	1,502,269	
Corr. raw materials	kg	1,438,313	
Total fuel	kg	195,052	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,039,002	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	86,259	
Waste	kg	111,124	
Gross wool	kg	1,236,385	
Recycling	kg	169,499	
Norm wool	kg	1,058,554	
Line wool	kg	1,058,554	
Time available	hour	353.22	
Melting time	hour	348.77	
Effective time	hour	333.15	
Stand still	hour	386.85	
No. of stops		190	
No. of series		240	
			Budget
Charging rate	kg/hour	4,307	4,300
Coke	%	13.0	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	74.3	74.0
Recycling	%	13.7	12.5
Gross wool 1	kg/hour	3,711	3,500
Other waste	%	9.0	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.9	102.0
Time efficiency	%	94.3	96.0
Material efficiency	%	70.5	76.0
Line wool 2	kg/hour	2,997	3,300
Cupola efficiency	%	95.7	99.0
Cupola time efficiency	%	98.7	99.0
Melting time efficiency	%	95.5	97.0
Corrected charging rate	kg/hour	4,124	4,189
Corrected coke	%	13.6	11.8
Corrected spinner efficiency	%	77.7	87.0
Corrected material efficiency	%	73.6	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 86 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE DEC 2015

1a PKF report

Line: 01 Month: 12 Year: 2015

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	104,013	7.1
Coke	kg	187,872	12.9
BF SALG	kg	0	0.0
BAUXITE	kg	7,378	0.5
DOLOMITE	kg	105,722	7.2
BASALT	kg	960,710	65.8
CONVERTER SLAG	kg	218,132	14.9
DUNITE	kg	64,544	4.4
LIME STONE	kg	0	0.0
Raw material	kg	1,460,499	
Corr. raw materials	kg	1,393,770	
Total fuel	kg	187,872	
Secondary Combustion Materials	kg	0	
Net wool	kg	1,088,395	
Odd size waste	kg	433	
Odd size waste Recl.	kg	0	
Edge trim	kg	88,437	
Waste	kg	90,336	
Gross wool	kg	1,267,601	
Recycling	kg	175,075	
Norm wool	kg	1,111,187	
Line wool	kg	1,111,620	
Time available	hour	342.77	
Melting time	hour	338.87	
Effective time	hour	327.68	
Stand still	hour	416.32	
No. of stops		159	
No. of series		259	
			Budget
Charging rate	kg/hour	4,310	4,300
Coke	%	12.9	13.0
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	77.4	78.0
Recycling	%	13.8	12.5
Gross wool 1	kg/hour	3,868	3,500
Other waste	%	7.1	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	102.1	102.0
Time efficiency	%	95.6	96.0
Material efficiency	%	76.1	78.0
Line wool 2	kg/hour	3,243	3,300
Cupola efficiency	%	95.4	99.0
Cupola time efficiency	%	98.9	99.0
Melting time efficiency	%	96.7	97.0
Corrected charging rate	kg/hour	4,113	4,189
Corrected coke	%	13.5	11.8
Corrected spinner efficiency	%	81.1	87.0
Corrected material efficiency	%	79.8	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 87 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

ROCKWOOL PROCESS KEY FIGURE (Trial Chinese Coke 19/OCT/2015- 17/NOV/2015)

1a PKF report

Line: 01 Period: 2015-10-19 00:00 to: 2015-11-17 00:00

[Print](#)

[Return](#)

PKF			%
EAF SLAG	kg	115,755	8.2
Coke	kg	183,845	13.1
BF SALG	kg	0	0.0
BAUXITE	kg	3,753	0.3
DOLOMITE	kg	78,753	5.6
BASALT	kg	928,807	66.0
CONVERTER SLAG	kg	201,445	14.3
DUNITE	kg	78,040	5.5
LIME STONE	kg	0	0.0
Raw material	kg	1,406,553	
Corr. raw materials	kg	1,351,831	
Total fuel	kg	183,845	
Secondary Combustion Materials	kg	0	
Net wool	kg	963,007	
Odd size waste	kg	0	
Odd size waste Recl.	kg	0	
Edge trim	kg	79,888	
Waste	kg	102,167	
Gross wool	kg	1,145,062	
Recycling	kg	153,907	
Norm wool	kg	978,934	
Line wool	kg	978,934	
Time available	hour	326.65	
Melting time	hour	322.95	
Effective time	hour	307.08	
Stand still	hour	388.92	
No. of stops		170	
No. of series		238	
			Budget
Charging rate	kg/hour	4,355	4,300
Coke	%	13.1	11.7
Secondary Combustion Materials	%	0.0	0.0
Spinning efficiency	%	74.1	74.0
Recycling	%	13.4	12.5
Gross wool 1	kg/hour	3,729	3,500
Other waste	%	8.9	4.5
Edge trim	%	7.0	4.5
Odd size waste	%	0.0	0.0
Volume efficiency	%	101.7	102.0
Time efficiency	%	94.0	96.0
Material efficiency	%	69.6	76.0
Line wool 2	kg/hour	2,997	3,300
Cupola efficiency	%	96.1	99.0
Cupola time efficiency	%	98.9	99.0
Melting time efficiency	%	95.1	97.0
Corrected charging rate	kg/hour	4,186	4,189
Corrected coke	%	13.6	11.8
Corrected spinner efficiency	%	77.1	87.0
Corrected material efficiency	%	72.4	-20.0

เอกสารนี้เป็นเอกสารที่สงวนไว้สำหรับการใช้งานเพื่อการศึกษาเท่านั้น ไม่อนุญาตให้นำไปใช้ประโยชน์ด้านการค้า
ไม่ว่ากรณีใดๆ ทั้งสิ้น อีกทั้งห้ามมิให้ดัดแปลงเนื้อหา และตั้ง 88 อ้างอิงถึงเจ้าของเอกสารทุกครั้งที่มีการนำไปใช้

AUTHOR BIOGRAPHY

Name: Nipon Sarachan

Date of Birth: 11 May 1984

Address: 775 Bangkhae-Nua, Bangkhae, Bangkok 10160

Education: Bachelor's Degree Major Information Technology for Business from Chulalongkorn University (2007)

Email: nipon.cu@gmail.com

Working Experience: Total Experience 7 years in International Company

- 4 years in Manufacturing and Supply Chain Management (2013-2017)
 - Position: Supply Chain Planner, Company: Thai Houghton, Chemical Industry
 - Position: Senior Materials Controller and Operations Management, Company: Rockwool (Thailand), Mineral Smelting Industry
 - Position: Production Planner, Company: Huntsman (Thailand), Chemical Industry
- 3 years in Logistics and Transportation Management (2010-2013)
 - Position: Customer Service, Company: Kuehne+Nagel (Thailand), Third Party Logistics Service Provider
 - Position: Logistics Analyst, Company: APL Liner (Thailand), International Transportation and Logistics Service Provider