Comparative Study of Low and High-Grade Crumb Rubber Processing Energy

T.P. Utomo, U. Hasanudin, and E. Suroso

***Abstract*—Rubber as one of the leading agro-industrial commodities that contributed significantly to Indonesia income needs to improve it competitiveness by using energy as efficiently as possible. The purpose of this study was to compare the energy required per unit of low-grade crumb rubber of SIR 20 and high-grade of SIR 3. The study was conducted using survey method of collecting primary and secondary data. Energy processes measured at the crumb rubber production process were man-power electrical energy, and fuel energy. Process energy data obtained would be theoretically calculated and presented in tabular forms and or diagrams. Descriptive analysis was performed to improve the efficiency of energy use in crumb rubber processing. The results showed that the energy process of low-grade of SIR 20 was 3.06722 MJ/kg of dry rubber which in form of 60.62 percent of electrical energy, 38.86 percent of fuel energy, and 0.52 percent of man-power. Energy process of high-grade of SIR 3 was 2.62615 MJ/kg of dry rubber which in form of 22.72 percent of electrical energy 76.89 percent of fuel energy and 0.39 percent of man-power. The results of cost analysis showed that the energy cost of low grade of SIR 20 was 0.0861 US$/kg of crumb rubber, while for high grade of SIR 3.**

***Index Terms*—crumb rubber, process e**

I. Introduction

Indonesia is well-known as one of the biggest natural rubber producers in the world. Based on this condition, Indonesia Government has categorized it as one of the ten strategic agro-industrial commodities [1]. Comparison of natural rubber production among main producer countries is represented in Table 1.

Table 1. Production of Natural Rubber Main Producer Countries (x 1,000 tons) [2]

Year	Thailand	Indonesia	Malaysia	India	China	Others
2002	2,615	1,630	805	641	468	1,181
2003	2,876	1,792	909	707	480	1,189
2004	2,984	2,066	1,098	743	486	1,224
2005	2,900	2,270	1,132	772	575	1,164
2006	3,130	2,415	1,280	853	600	1,242
2007	2,970	2,550	1,210	807	663	1,265

Manuscript received March 15, 2010

T.P. Utomo is with the Agro-industrial Technology Department, the University of Lampung – REPUBLIC OF INDONESIA (corresponding author: phone 62 – 813 – 86834307; fax 62 – 721 – 700682; e-mail: tantoutomo@unila.ac.id, tputomo@yahoo.com

U. Hasanudin, and E. Suroso are with the the Agro-industrial Technology Department, the University of Lampung – REPUBLIC OF INDONESIA

International Rubber Study Group (IRSG) predicted that Indonesia's natural rubber production in 2015 will equal the Thai natural rubber production, could be even higher. If the prediction is right, then Indonesia in 2015 will be the biggest natural rubber producer in the world [2].

Energy audit activities include initial energy analysis and detailed energy analysis [3]. Energy audit will help the company to find out the details of machineries energy efficiency at each stage of production. Audit results can also be used to perform analysis of energy savings opportunities that can be done and as a basis for planning the development of production systems by the company.

The purpose of this study was to compare the energy required per unit of product in crumb rubber production process between low grade of Standard Indonesia Rubber (SIR) 20 and high grade of SIR 3

II. Crumb Rubber Processing in Indonesia

Natural rubber industry in Indonesia can be divided into two different type based on owner namely state owned industry and private owned industry. All state owned industry have their own rubber tree fields for latex supply, but private owned industry usually process raw material in form of solid rubber, which is processed by rubber farmer. Based on current existing data, almost 85 percent of total rubber tree field in Indonesia are belong to rubber farmer [1], [4] Hence, rubber industry in Indonesia is dominated by rubber industry which there is a mutual symbiosis between processing unit (rubber factory) and raw material supplier (farmer).

Manufacture of crumb rubber with this pattern use of water resources and electrical energy in large quantities, among others caused by solid coagulated rubber latex (*bokar*) as raw material in dirty conditions and poor quality that does not meet the SNI 06-2047-2002. Dirt and poor quality *bokar* generates several types of waste including solid waste in the form of shavings and sand that affect the occurrence of waste handling costs, and mal-odor due to decomposition of organic materials in serum that shipped in *bokar* by microorganisms. This condition became problem for crumb rubber industry which is generally located in urban areas and near settlements. This is an obstacle for crumb rubber industry in Indonesia who had to produce as efficiently as possible in order to remain competitive with natural rubber produced by other countries.

Crumb rubber is dry rubber production process of the cleaning stage and size reduction, milling, shredding, drying, and compression to produce a dry rubber lumps. Dry rubber wrapped neatly in subsequent polyethylene plastic. Crumb rubber raw material can be either fresh rubber latex field that

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

further processed into high quality crumb rubber that is SIR 3, while raw materials in form of *bokar*, such as slab, lump, and *ojol*, was processed into low grade crumb rubber of SIR 20 [6]. In general, the stage of crumb rubber processing using *bokar* which was produced by farmers is presented in Figure 1

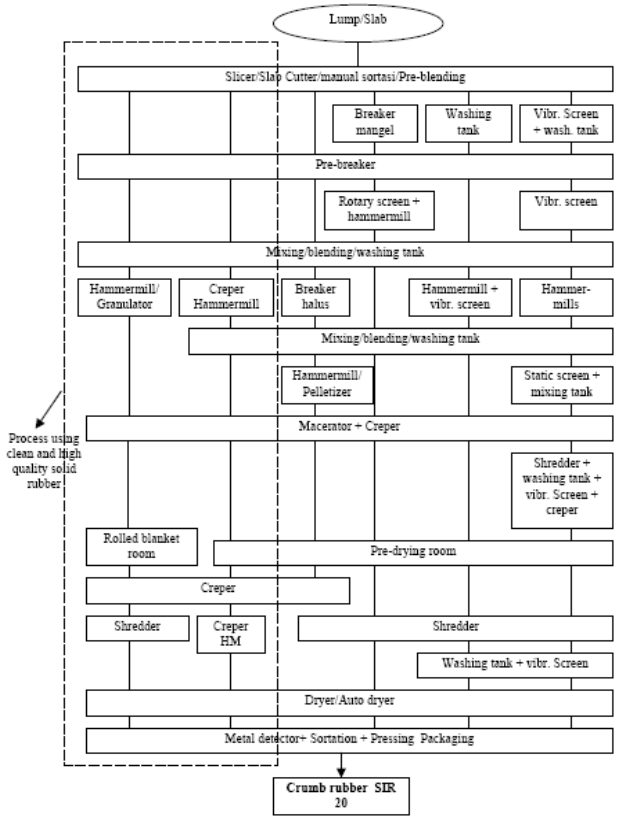


Figure 1. The stage of crumb rubber processing using *bokar*

III. Method

Research conducted at Crumbs Rubber Factories which produced high grade crumb rubber of SIR 3 and low grade of SIR 20. Research conducted by survey methods of two types data that were:

(1) primary data which were derived from observation, recording, and direct measurements in the field. Primary data includes a process flow diagram, the amount of manpower, the amount of fuel, equipment hours and hours of human labor at each stage of the process; and
(2) secondary data which were obtained from factories records included the number of latex filed andf *bokar* used, specification of equipments, working hours of machines, the capacity of the production machines and the amount of crumb rubber products were produced.

In this study the audit system following the crumb rubber processing procedures performed in crumb rubber factories. The audit process in processing low-grade rubber crumb of SIR 20 were arranged from *bokar* into packaging, meanwhile the crumb rubber processing high grade of SIR 3 were arranged from latex field reception. The audit process is also performed on crumb rubber manufacturing process that includes screening, grinding, shredding, drying, pressing, and packaging. Input energy audit included the manpower, electrical energy and fuel energy.

Energy for rubber processing, as measured in this study were:

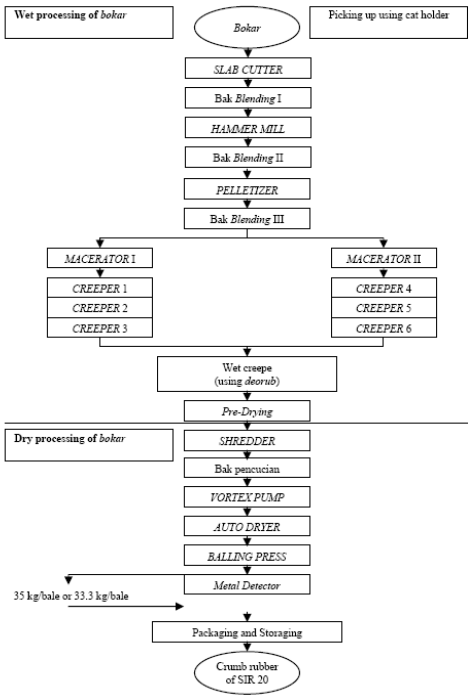
(1) man-power included the amount of labor each stage of production, working hours, amount of crumb rubber production and calorific value of human biological;
(2) electrical energy include types of devices, while the use of tools, electric power factor, equipment and production capacity of crumb rubber production, and
(3) fuel energy consumption including solar, solar heating value and the amount of crumb rubber production.

The calculation of energy input in this study using the analysis of production processes covered the energy needs with product and process specific. The calculation of input energy used, performed at each stage of production, where each of the input energy used at each stage in the process of crumb rubber production was converted into the same units of Mega Joule (MJ) [8].

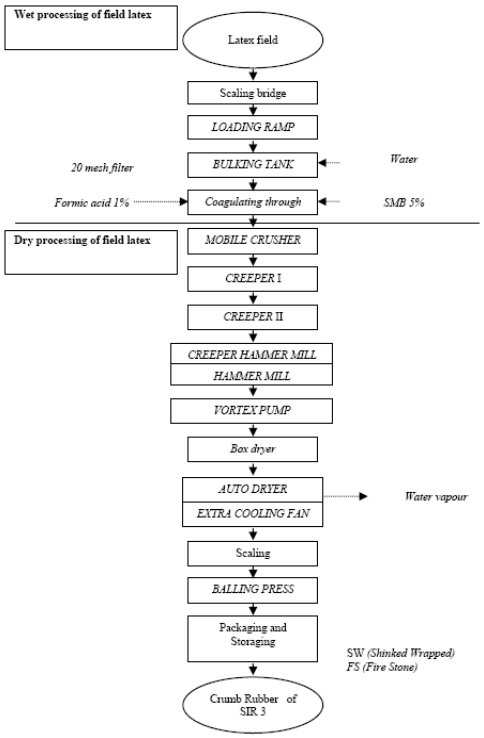
IV. Results and Discussion

4.1 Comparison of SIR 20 and SIR 3 Crumb Rubber Processing

Low grade crumb rubber processing of SIR 20 and high grade of SIR 3were divided into two main stages of wet and dry processes (Figure 2).



(a)



(b)

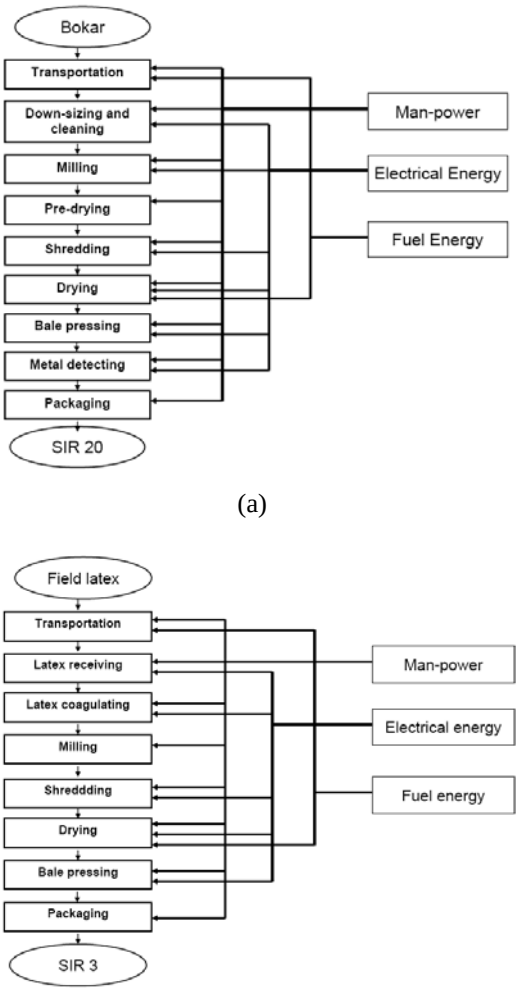
Figure 2. Crumb rubber processing of SIR 20 (a) and SIR 3 (b)

Crumb rubber processing quality of SIR 20 required size reduction, cleaning, and pre- drying process of about 12 days, otherwise the SIR 3 using a shorter time and processed within 1 day. Based on this condition, crumb rubber processing of SIR 20 should be done efficiently to reduce the required energy loss due to the size reduction and cleaning process of *bokar* and also waiting times during 12 days that led more working capital.

4.2 Comparison of High Grade and Low Grade Crumb Rubber Processing Energy

Crumb rubber processing of low-grade of SIR 20 and high grade of SIR 3 showed that both use electrical energy, diesel fuel, and man-power. In detail, the sources of energy and its used in the crumb rubber processing of SIR 20 and SIR 3 are presented in Figure 3.

Observation of electrical energy consumption in the process of crumb rubber of SIR 20 showed that the energy used by electric motors and drive equipment such as slab processing machine cutter, hammer mill, pelletizer, macerator, creeper, shredder, vortex pump, auto dryer, balling press and bale cutter. Meanwhile the production process of SIR 3 electrical energy used by motor-motor processing equipment and machinery including a monster mill, bulking stirrer of tanks, mobile crusher, creeper, hammer mill, vortex pump, auto dryer and balling press. Comparative observations about the electrical energy consumption for the processing of crumb rubber of SIR 20 and SIR 3 are presented in Figure 4.



(a)

(b)

Figure 3. Sources of SIR 20 (a) and SIR 3 (b) processing energy

Stages	Energy (MJ/Kg)	Percentage (%)
Down-sizing and cleaning	0.66073	35.59
Milling	0.54762	29.49
Pre-drying	0.03204	1.73
Shredding	0.16155	8.70
Drying	0.25085	13.51
Bale pressing	0.18288	9.85
Metal detecting	0.02103	1.13
Total	**1.85670**	**100.00**

(a)

Stages	Energy (MJ/Kg)	Percentage (%)
Field latex receiving	0.00290	0.49
Latex Field coagulating	0.01449	2.43
Milling	0.14439	24.20
Shredding	0.17801	29.83
Drying	0.20851	34.95
Bale pressing	0.04836	8.11
Total	**0.59666**	**100.00**

(b)

Figure 4. Electrical energy consumption of SIR 20 (a) and SIR 3 (b)

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

Figure 4 showed that the electric energy crumb rubber processing low grade of SIR 20, which was 1.8567 MJ / kg of dry rubber, electrical energy needed is greater than SIR 3, namely 0.5967 MJ/kg of dry rubber. Electrical energy for crumb rubber processing low-grade of SIR 20 most widely used for the process of *bokar* downsizing and cleaning mill into wet crepe. Observation was consistent with [6] and [7] that the SIR 3 required less energy in form of electrical energy.

Observation of the diesel fuel energy used in crumb rubber production process low grade of SIR 20 showed that the diesel fuel energy used in *bokar* transportation activities from the raw materials to processing plants use a cat holder and drying process on the drier, meanwhile the diesel fuel energy to crumb rubber production process of SIR 3 for latex field transportation activity and drying process (Figure 5).

Stages	Energy (MJ/Kg)	Percentage (%)
Bokar transportation	0.02305	1.94
Drying	1.16707	98.06
Total	**1.19012**	**100.00**

(a)

Stages	Energy (MJ/Kg)	Percentage (%)
Latex Field Transportation	0.04232	2.10
Drying	1.97693	97.90
Total	**2.01925**	**100.00**

(b)

Figure 5. Fuel energy consumption of SIR 20 (a) and SIR 3 (b)

Figure 5 showed that the process of high grade crumb rubber of SIR 3 needed more diesel fuel energy than the production process of SIR 20. This was caused SIR 3 that used fresh latex field contains more water than SIR 20 because of some water contained in the *bokar* had lost in the pre-drying process. Also the energy used for processing raw rubber latex crumbs made from the garden with a new drying technology requires less energy [7].

Observation of man-power used in the production process SIR 3 and SIR 20 shows that man-power was used in all stages is presented in Figure 6.

Staged	Energy (MJ/Kg)	Percentage (%)
Bokar transportation	0.00122	7.67
Down-sizing and cleaning	0.00257	16.16
Milling	0.00294	18.49
Pre-drying	0.00257	16.16
Shredding	0.00245	15.41
Drying	0.00122	7.67
Bale pressing	0.00171	10.75
Metal detecting	0.00073	4.59
Packaging and Storaging	0.00049	3.08
Total	**0.01590**	**100.00**

(a)

Stages	Energy (MJ/Kg)	Percentage (%)
Latex field transportation	0.00068	6.64
Machines cleaning	0.00184	17.97
Latex field receiving	0.00134	13.09
Latex coagulating	0.00101	9.86
Milling	0.00134	13.09
Shredding	0.00134	13.09
Drying	0.00101	9.86
Bale pressing	0.00101	9.86
Packaging and Storaging	0.00067	6.54
Total	**0.01024**	**100.00**

(b)

Figure 6. Man-power consumption of SIR 20 (a) and SIR 3 (b)

Figure 6 showed that the man-power for crumb rubber processing of SIR 20 more than 50 percent was used in wet processing process that aimed to cleanse and shrink the size of *bokar*. This could be an opportunity for efficiency of energy by producing *bokar* clean and sized according to SNI therefore wet process did not required size reduction and cleaning.

Based on the comparison of crumb rubber processing, low grade of SIR 20 processing used more energy than of SIR 3. This is allegedly due to the raw materials used for the SIR 20 came from the inferior *bokar* compared to the raw materials used for the SIR 3, so that the raw materials in form of bokar needed size reduction process and the cleaning and drying (pre-drying). This resulted in processing raw rubber crumbs made from *bokar* have long stages ranging from transportation to packaging. In addition, machines used in crumb rubber processing of SIR 20 are more numerous. Machine that dominated the use of energy especially electrical energy at this plant was hammer mill (175 HP) with a capacity of 4000 kg / hour.

The results of cost analysis to determine the cost of crumb rubber per unit of product by converting the energy value (MJ) to a form of price (US$) show that the energy of crumb rubber processing low grade quality of SIR 20 equivalent to 0.0861 US$ per kg of dry rubber crumb rubber, while for high grade quality of SIR 3 equivalent to 0.0562 US$ per kg of dry rubber.

V. Conclusion

Energy production process low-grade rubber crumb quality of SIR 20 was 3.06272 MJ/kg of dry rubber which in form of 60.62 per cent of electrical energy, 38.86 percent of the energy in the form of diesel fuel, and 0.52 percent of man-power. Energy from the electrical energy used in most stages *bokar* cleaning and size reducing of 0.66073 MJ/kg of dry rubber (35.59 percent); energy from the diesel fuel mostly used in the drying stage use the dryer of 1.16707 MJ / kg of dry rubber (98.06 percent); and energy from the process of manpower most widely used in the milling stage at 0.00294 for creeper MJ / kg of dry rubber (18.49 percent).

Energy production process high-grade rubber crumb quality of SIR 3 was 2.62615 MJ/kg of dry rubber which in form of 22.72 percent of electrical energy, 76.89 percent of the diesel fuel, and 0.39 percent of manpower. Energy from

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

the electrical energy used in most stages of the drying of rubber crumbs 0.2085 MJ / kg of dry rubber (34.95 percent); energy from the diesel fuel mostly used in the drying stage of the rubber crumbs use tunnel dryer is 1.9769 MJ/kg of dry rubber (97.90 percent); and energy that comes from the process of manpower most widely used at this stage of washing/machines cleaning for 0.00184 MJ/kg of dry rubber (17.97 percent).

Energy crumb rubber processing low grade quality of SIR type 20 equivalent USD 0.0861, - per kg of dry rubber crumb rubber, while for high grade quality of SIR type 3 equivalent USD 0.0562, - per kg of dry rubber.

REFERENCES

[1] Estate Directorate General, Ministry of Agriculture, Republic of Indonesia. 2007. Trading Development Profile of Indonesia Rubber Comodity. www.agribisnis.deptan.go.id/Pustaka/Buletin% 20Agsts.doc. Accessed on April 2, 2009.

[2] H. Smit. 2007. Natural rubber: a global perspective an outloook for the future. Presented in *Asean Rubber Conference 2007:* Phnom Penh, June 14-16, 2007. Phnom Penh: Next View and Association for Rubber Development of Cambodia.

[3] Media Perkebunan. 2008. In the year of 2015 Indonesia would be the biggest Natural Rubber Producer in the World. Media Pekebunan 66th ed, September 22 – Oktober 21, 2008.

[4] A.F.S. Budiman. 2000. The Future of Natural Rubber Production and Quality in Indonesia.

[5] N. Setiawaty. 2002. Energy Audit on CPO (Crude Palm Oil) Processing in PT. Perkebunan Nusantara VII Unit Usaha Rejosari Lampung Selatan. Agriculture Faculty, the Univeristy of Lampung. Bandar Lampung, Indonesia.

[5] G. Sugiran. 2008. Energy Audit on Crumb Rubber Processing. Agriculture Faculty, the University of Lampung,. Bandar Lampung, Indonesia.

[6] D Maspanger and S. Honggokusumo. 2004. The Effect of Cleaner Production Application on crumb rubber processing to improve Global Market. Presented in *Seminar/Temu Usaha Sosialisasi Produksi Bersih Industri Crumb Rubber*. Pekanbaru, Oktober 6, 2004.

[7] T.P. Utomo. 2008. Cleaner Production-Based Design of Crumb Rubber Production Process. Dissertation. Post-Graduate School, Bogor Agricultural University. Bogor., Indonesia.

[8] R.R.H Saputra. 1997. Energy Audit on crumb rubber production at Bojongdatar Estate Pandeglang. Agricultural Technology Faculty, Bogor Agricultural University. Bogor, Indonesia.

ISBN: 978-988-18210-8-9
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)