International Journal of Applied Research and Sustainable Sciences (IJARSS)
Vol. 2 No. 1, 2024:11 – 18

Calculation of Impurity Levels in SIR 3CV Type Rubber and Mass Balance at the Drying Station in PT. XYZ North Sumatera

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A R T I C L E I N F O

Keywords: Impurity Level, Latex, Mass Balance, Drying Station

Received : 18 November
Revised : 18 December
Accepted: 19 January

A B S T R A C T

The quality of latex significantly affects the quality level of rubber produced, with one of its parameters being the impurity level, with a standard value of 0.03%. The impurity level strongly influences the rubber quality, where higher impurity levels correspond to lower rubber quality, and vice versa. The research method employed was experimental and calculation using mass balance. The calculated results indicated impurity levels in the rubber as follows: 0.0059%, 0.0069%, 0.0074%, 0.0419%, 0.0054%, 0.0429%, and 0.0444%. The average total impurity level was 0.0219%. However, some rubber samples did not meet quality standards due to contaminated tapping equipment, inadequate washing processes, and damaged filtration tools. In the mass balance at the drying station, the first input material was 125 kg/hour with a water component balance of 50%, HAS (Hevea Acidic Solution) 12%, SMBS (Sodium Metabisulfite) 8%, and latex 30%. The second input material is 18.75 kg/hour, consisting of 100% steam. The output material at the drying station is 143.75 kg/hour, with a water component balance of 43.47%, HAS 10.43%, SMBS 6.95%, latex 26.08%, and steam 13.07%.

DOI Prefix: https://doi.org/10.59890/ijarss.v2i1.1253
ISSN-E: **3026-0205**
https://journal.multitechpublisher.com/index.php/ijarss/inde

INTRODUCTION

PT. XYZ North Sumatra is a company engaged in rubber plantation and processing. The rubber plantation owned by PT. XYZ North Sumatra is one of the primary sources of raw materials for rubber processing compared to other raw material sources from external companies. The factory processes latex into rubber based on the Indonesian Rubber Standard (SIR). This necessitates the supervision of the quality of the raw materials used (PT. XYZ, 2020).

Standard Indonesian Rubber (SIR) is natural rubber obtained by processing latex from the Hevea Brasiliensis tree mechanically, with or without chemicals, and its quality is determined by technical specifications. The quality assessment is based on the analysis results of technical specification parameters set for SIR rubber, including analysis of impurity content, ash content, volatile matter content, initial plasticity analysis (Po), plasticity retention index analysis (PRI), nitrogen content analysis, and Mooney viscosity analysis (SNI 1903-2011) (Peramune & AFS, 2007).

PT. XYZ Sumatera Utara's factory is one of the rubber factories that processes latex from plantations into rubber, specifically SIR 3CV 60 and 3CV 50 types. The difference between SIR 3CV 60 and 50 lies in the Mooney viscosity value and the texture of the rubber, with a standard impurity content of 0.03%. The factory uses an additive, Hydroxylammonium Sulfate compound with a concentration of 10%, to stabilize the Mooney viscosity value of the produced latex, specifically the SIR 3CV (Constant Viscosity) type (Nurjannah et al., 2020).

The rubber plant plays a significant role in the Indonesian economy. Due to its many uses, this plant contributes to various aspects of life. For instance, it produces carbon dioxide, which helps reduce the effects of global warming. The wood from the rubber plant can be used as fuel, and its processed latex has numerous benefits in daily life. Many people rely on the latex-producing commodity for their livelihoods. Moreover, rubber cultivation is not limited to large state-owned plantations with hundreds of thousands of hectares; it is also undertaken by private enterprises and individuals ((Dewi et al., 2020; Novita et al., 2019).

The determination of impurity levels is based on the quantity of impurities collected on a 325-mesh sieve from a specific amount of rubber samples dissolved in mineral turpentine. Impurities in the rubber include sand, leaves, rubber stems, and also originate from machinery in the factory. To achieve good product quality, companies need to organize themselves effectively and consider factors that can affect the quality of the resulting goods. In addition to proper processing, the quality of the raw materials for the finished products must also be good.

LITERATURE REVIEW

Natural rubber and latex

Rubber, known in Latin as Hevea Brasiliensis, is a primary plant used as the main source of natural rubber worldwide. The rubber plant is a type of tree that can grow tall and has a very large trunk. The height of this plant typically reaches 15-25 meters. The trunk of the rubber plant usually grows straight and has high branching. It is from the trunk of the rubber plant that latex is produced and is often referred to as latex. The latex is then collected and processed into rubber. Natural rubber is a hydrocarbon compound that is a natural polymer resulting from the coagulation of natural latex and is a macromolecule of polyisoprene $(C_5H_8)_n$ that bonds head to tail. The constituent material of natural rubber is isoprene (C_5H_8), which binds head to tail in a 1,4 arrangement, forming polyisoprene $(C_5H_8)_n$, where n represents the degree of polymerization, indicating the number of monomers polymerized to form the polymer (Forrest, 2018; Qotimah, 2021).

Latex is a milky white fluid/solution obtained by tapping the rubber tree's trunk. This latex is naturally produced within the rubber plant's cells. Latex is obtained from the Hevea brasiliensis plant, processed, and traded as an industrial material in the form of rubber sheets, crepe, concentrated latex, and crumb rubber. Latex is a colloidal solution with rubber particles and is not suspended rubber in a medium that contains various substances. The components contained in latex are not completely soluble but are evenly dispersed in water. These colloidal particles are so small and fine that they can penetrate a filter (Chandra et al., 2020).

Impurity level

The impurity level consists of substances that are insoluble in latex, tested for their impurity level in the laboratory. Impurities are foreign objects that are insoluble and cannot pass through a 325-mesh sieve. The presence of relatively high impurities in rubber can reduce its superior dynamic properties in natural rubber vulcanization, such as heat generation and crack resistance. These impurities also interfere with the production of thin vulcanization. Estate latex is latex obtained from the process of tapping rubber trees. The criteria for good estate latex are as follows: Free from impurities or other objects, such as wood chips or leaves. Not mixed with latex slurry, water, or latex serum. It has a white color and the characteristic fresh rubber smell. The Dry Rubber Content for grade 1 is around 28%, and grade 2 is around 20% (Verheye, 2010).

Drying Station

The drying process at the PT. XYZ North Sumatra plant employs an automatic method using a single dryer apparatus. The shredded rubber, processed in the extruder, is then conveyed with a jetting transfer pump to the box dryer through pipes. The shredded rubber, along with water, flows from the extruder and is arranged in boxes made of stainless steel that are perforated to allow water to be filtered, leaving the rubber. Each box is divided into 4 sections and filled fully but not compacted to ensure even drying of the produced crumb rubber. Once filled, the boxes are then placed into the single dryer. In the single dryer, the rubber is heated to a temperature of 121–141°C for 13 minutes and subsequently cooled using a cooling fan installed in the dryer. The single dryer at the PT. XYZ North Sumatra plant consists of several components that operate automatically and are controlled by the operator through a control panel. These components include the Main Fan, Burner, Exhaust Fan, and Cooling Fan (PT. XYZ, 2020).

METHODOLOGY

Research tools and materials

Several tools used in this research include a grinding machine, analytical balance, scissors, sieve, 500 mL Erlenmeyer flask, 500 mL spray bottle, hot plate, filter clamp, Erlenmeyer flask clamp, desiccator, 50 mL burette, 10 mL pipette, oven, and thermometer. Some of the materials used include latex samples, turpentine, silica gel, and distilled water.

Work procedure

The sample is ground approximately 30 g with a roller gap of 0.33 mm ± 0.05 mm twice, then placed in a plastic bag. The sample is weighed as 20 g, and the rubber is cut into 10–12 pieces. Turpentine is filled with 230 mL into a 500 mL Erlenmeyer flask. 10 g of rubber pieces are added to the Erlenmeyer flask containing turpentine. The Erlenmeyer flask and its contents are heated in an infrared heater at a temperature of 125 °C. The Erlenmeyer flask is stirred gradually until the solution dissolves completely. The turpentine solution is poured through a 325 mesh sieve to filter impurities in the sample. The impurities are allowed to settle at the bottom of the Erlenmeyer flask for further rinsing. The remaining impurities in the Erlenmeyer flask are rinsed with 30–50 mL of hot turpentine twice. The rinsing is poured into the sieve, and then cold turpentine is sprayed into it. Hot turpentine is sprayed around the walls of the Erlenmeyer flask to end the rinsing. The sieve containing impurities is dried in an oven at a temperature of 100 °C for 1 hour. The sieve is cooled for ±30 minutes in a desiccator, then weighed (Forrest, 2018).

Calculation of impurity content and mass balance

To ascertain the impurity content, the following formula is employed:

$$\text{Impurity level (\%)} = \frac{A-B}{C} \times 100\% \text{ ....(1)}$$

Here, A represents the weight of the sieve containing impurities (g), B signifies the weight of the empty sieve (g), and C denotes the weight of the sample (g) (Tarigan & Simatupang, 2019).

The material balance (mass balance) can be formulated in a conservative system, as illustrated in Figure 1, where F^1 represents the rubber clump output from the extruder, F^2 denotes steam, and F^3 represents the rubber clump that has been dried and exited the dryer.

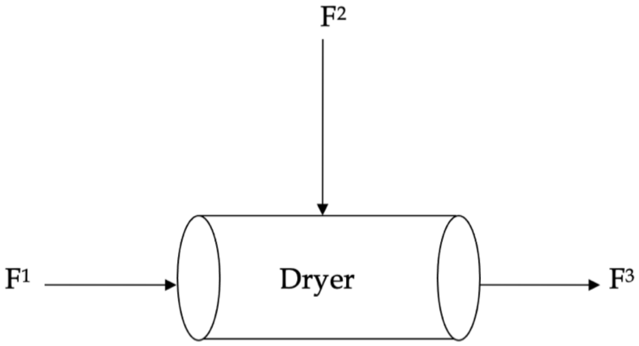

Figure 1. Illustration for Mass Balance in Drying Station (Simatupang, Saragih, et al., 2021; Simatupang, Yunianto, et al., 2021)

RESEARCH RESULT

Table 1. Data Tabulation for Impurity Content Calculation

Sample	Sieve Weight (g)	Sample Weight (g)	Impurity + Sieve Weight (g)	Impurity Content (%)
1	18.9382	20.0010	18.9394	0.0059
2	23.5851	20.0011	23.5865	0.0069
3	17.8900	20.0015	17.8915	0.0074
4	24.0420	20.0003	24.0504	0.0419
5	18.2618	20.0015	18.2629	0.0054
6	38.6837	20.0042	38.6923	0.0429
7	39.0118	20.0010	39.0207	0.0444

Table 2. Mass Balance at Drying Station

Component	In (kg/hour)				Out (kg/hour)	
	Percentage (%)	Mass Flow Rate of Rubber Clumps Exiting the Extruder	Mass Flow Rate of Steam	Percentage (%)	Mass Flow Rate of Dried Rubber Clumps	Percentage (%)
Water	50	62.5	-	-	62.488125	43.47
HAS	12	15	-	-	14.993125	10.43
SMBS	8	10	-	-	9.990625	6.95
Latex	30	37.5	-	-	37.49	26.08
Steam	-	-	18.75	100	18.788125	13.07
Amount	125		18.75		143.75	
Total	143.75				143.75	

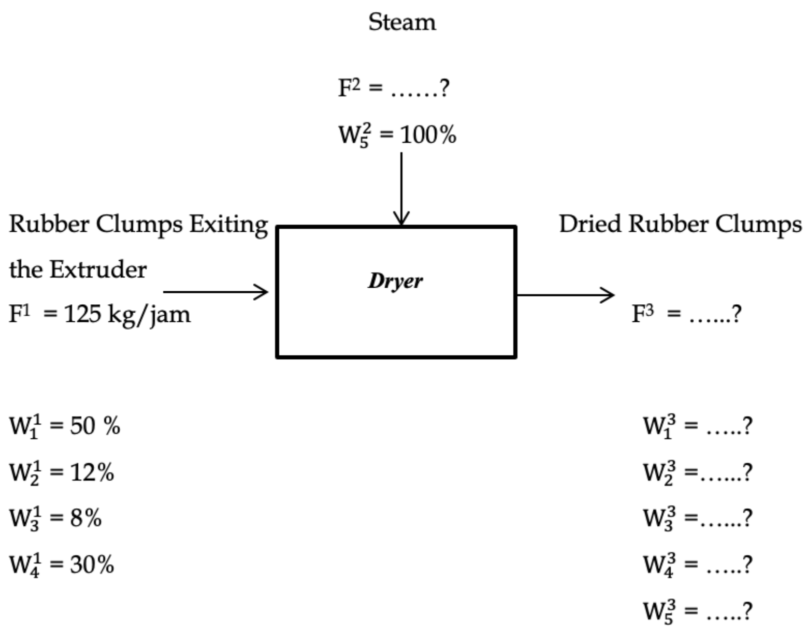

Figure 2. Mass Balance in Drying Station

In addition, W_1^1 = Water at first rate, W_2^1 = HAS at first rate, W_3^1 = SMBS at first rate, W_4^1 = Latex at first rate, W_5^2 = Steam at second rate, W_1^3 = Water at third rate, W_2^3 = HAS at third rate, W_3^3 = SMBS at third rate, W_4^3 = Latex at third rate and W_5^3 = Steam at third rate.

DISCUSSION

Impurity content is one of the parameters that must be met to improve the quality of rubber. Impurities present in rubber include sand, leaves, rubber stems, fragments of rubber bowls, and tree branches. To meet the standard impurity content parameter, these impurities in the rubber must be minimized. SIR 3CV has several aspects in determining its quality, and one of them is the impurity content.

Impurity testing has been conducted on SIR 3CV rubber at PT. XYZ in North Sumatra. This impurity testing is done by dissolving rubber samples in a turpentine solution. The turpentine solution serves to separate impurities from the rubber sample. The turpentine solution, which has dissolved with the rubber, is then filtered using a mesh sieve. The filtered impurities are then weighed and calculated as the impurity weight. To maintain the quality of the crumb rubber and ensure it meets the standard impurity parameter, the maximum impurity content set is 0.03%.

From the calculations, the results show impurity levels in rubber samples as 0.0059%, 0.0069%, 0.0074%, 0.0419%, 0.0054%, 0.0429%, and 0.0444% (Table 1). The total average impurity content is 0.0219% from the data. However, some rubber samples do not meet the quality standards, which usually occurs due to contaminated tapping equipment, insufficient cleaning processes, and damaged sieving equipment. Research on SIR 20 crumb rubber has been conducted for tire production with an impurity content reaching 0.16% (Aryanti et al., 2018).

In the mass balance at the drying station (Table 2 and Figure 2), the first inflow at the station is 125 kg/hour with a component balance of 50% water, 12% HAS, 8% SMBS, and 30% latex. Then, the second inflow at the station is 18.75 kg/hour with a component balance of 100% steam, while the outflow is 143.75 kg/hour with a component balance of 43.47% water, 10.43% HAS, 6.95% SMBS, 26.08% latex, and 13.07% steam. This indicates that the impurity content in the tested rubber still meets the SNI standard of 0.03%. If the impurity content exceeds the specified requirements, the quality of the rubber may not be good as it does not comply with the maximum impurity content criteria.

CONCLUSIONS AND RECOMMENDATIONS

From the impurity content testing results, it can be concluded that the average percentage of impurity content in SIR 3CV rubber is 0.0221%, which means that the impurity content obtained still meets the SNI standard set at a maximum of 0.03%. Furthermore, based on the mass balance calculations, the amount of incoming material is equal to the amount of outgoing material, which is 143.75 kg/hour.

ACKNOWLEDGMENT

The authors would like to express their gratitude to PT. XYZ Sumatera Utara for the cooperation in the form of fieldwork practice for Eri Budi Mulia (Alumni of PTKI Medan, Class of 2022).

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