Study of Crepe Rubber Manufacturing Process, Economical State and Waste Management in Sri Lanka

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Abstract— At present, Sri Lankan natural rubber industry is a significant economic sector that significantly benefits from producing several products and raw rubbers using latex. Research paper unfolds about the crepe rubbers, which is considered as the purest form among the raw rubbers produced in Sri Lanka. The objective of this article is to study the crepe rubber production process, the economic status of the crepe rubber industry, waste management, and identifies the current state of the natural rubber industry, including crepe rubber industry. According to the study, the rubber industry seems to be confronted with critical challenges from the energy and the laborer scarcity, process irregularity and government inobservance, low productivity due to the old technique. These problems always indirectly affect the waste generation in the crepe rubber industry. Therefore, as a solution for waste management, the research paper indicates some proposals, improvements, and effluent quality parameters. The suggested details in this article support the reinstatement of the Sri Lankan natural rubber industry's economic losses and make a better image of the global market.

Index Terms—crepe rubber, economical state, manufacturing process, Sri Lankan rubber industry.

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1 INTRODUCTION

Sri Lanka has a proud natural rubber product manufacturing industry that plays a significant role in the economy, providing a considerable identification to Sri Lanka. The history of the rubber industry dates back to 1876. The first rubber tree was planted at Henarathgoda botanical garden in Gampaha by Sir Henry Wickham [1]. After 1876, within several decades, the evolution of the rubber industry in Sri Lanka took placed and became a prime source of the gross national product. Same as the tea industry, the rubber industry is an imperishable colonial inheritance that provides benefits and sustainable economic growth to the country. Tea, rubber, coconut are the major agricultural crops in Sri Lanka, and rubber is one of them that acquired the position as a world-class raw material supplier for the global requirement. The country produces globally demanded and acclaimed types of natural rubber, including Ribbed smoked sheet (RSS), all grades of Crepe Rubber, all grades of Technically Specified Rubber (TSR), and Latex Concentrate [2]. Crepe rubber holds an outstanding position among these types of natural rubbers as it is used to manufacture surgical and pharmaceutical items due to its highest purity and hygienic properties [3].

After tapping, preserved-field-rubber-latex is used to manufacture crepe rubber, which appears in the wrinkled surface, and there are different grades with different properties available in the market. Sri Lanka is a high demanded producer of crepe rubber when comparing with other producers in the global market because they cannot outmaneuver the quality of Sri Lankan crepe rubbers. According to the central bank report of Economic and Social Statistics -2019, 82.6Mn.kgs of rubber was produced in 2018, from that amount 14Mn.kgs of rubber was exported as the annual supply for the global market. It contributed LKR million 5,088 to Sri Lanka's Foreign Exchange Revenue [4]. Moreover, the Sri Lanka rubber sector has provided directly or indirectly over 300,000 employments to society that represents one side of economic benefit [1].

From annual rubber production 2018, crepe rubber production to the market was about 14.5Mn.kgs as the form of sole crepe, scrap crepe, and latex crepe, which is around 12% of the overall rubber production in the country [4]. Considering the central bank records, the crepe rubber manufacturing industry in Sri Lanka seems to be facing some challenges for the last four years. Accordingly, the production of crepe rubber decreased

gradually because of low production due to the old technique, the rising cost of production, environmental issues, energy and laborer scarcity, process irregularities and government inobservance [3],[5]. Therefore, the objective of this report focused on discussing the sustainable manufacturing of crepe rubber to reinstate the crepe rubber industry in Sri Lanka, as a result of that to increase the economic benefits of the society. Apart from that, this research aimed to discuss the waste management and environmental sustainability of the crepe rubber sector through the reduction of the cost of production that directly affects the economy of Sri Lanka. Otherwise, large quantities of water and chemicals and other utility waste can be released into the environment, which can increase the cost of production.

2 MANUFACTURING PROCESS OF CREPE RUBBER

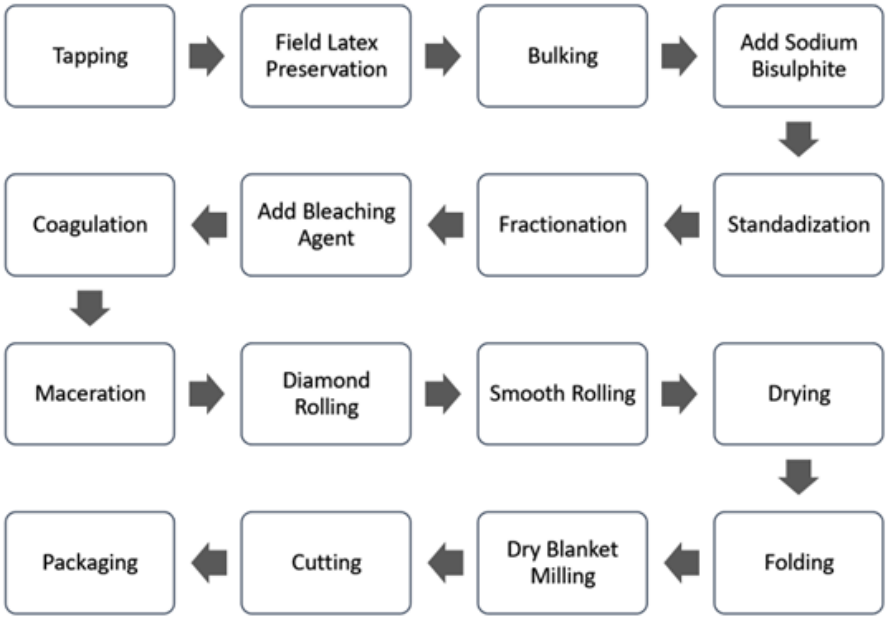

Fig. 1. Crepe rubber manufacturing process flow chart [3],[6]

Fig. 1. illustrates the main processing steps of crepe rubber manufacturing. At the beginning of this process, field latex, which is extracted from the rubber tree (Hevea brasiliensis) is well preserved with Sodium sulfite to prevent the latex pre-coagulation [2]. Pre-coagulation means non-rubbers in the latex decomposed due to the acidic nature formed by the bacteria [6]. Rather than using Ammonia, which causes the discoloration, 3.3% Sodium sulfite solution used as the anticoagulant for crepe rubber. Then the preserved field latex is transported to the factory and collected into bulk tanks. Mostly, these bulking tanks are rectangular in shape, depth is almost around 1.2m, and tank width is around 1.8m. To depth acquires time to settle the sediments in the latex, and too wide tanks do not acquire efficient homogenization of latex during the bulking stage. The capacity of the tanks is decided according to the total volume of the highest daily crop and the volume of the water amount going to be added in the standardization process [3].

Sodium Metabisulphite or Sodium Bisulfite is mixed with bulked latex in the bulking tanks to prevent the enzymatic discoloration. These preservatives added as soon as possible after freshly prepared. Enzymatic discoloration means different colors appeared in the coagulum, and it is due to the conversion of polyphenols into colored quinones and melanin by enzymatic oxidation. It is sufficient to add 500g of sodium metabisulphite for 100kg of dry rubber [6]. In the standardization stage, the calculated volume of water is added to dilute the latex, that necessary to continue the quality, consistency, and uniformity of the prepared crepe rubber. Moreover, the viscosity of the latex decrease by standardization, due to that, it will become easy to mix chemical into the latex. There are two recommended dilutions depend on either following fractionation or not. If the fraction is taken place, latex diluted into 15% dry rubber content, and if the fraction is not taken place, latex is diluted into

10% dry rubber content. After standardization, 10% diluted latex is subjected to fractionation, which partially coagulates the standardize latex. In fractionation, the latex coagulates in two stages; a first yellow fraction, then white fraction. Type of the clone, amount of anticoagulant used, nature, and the weather are the factors that affect the percentage of the yellow fraction—basically, two methods employed for fractionation [6].

1. Manual method using paddle

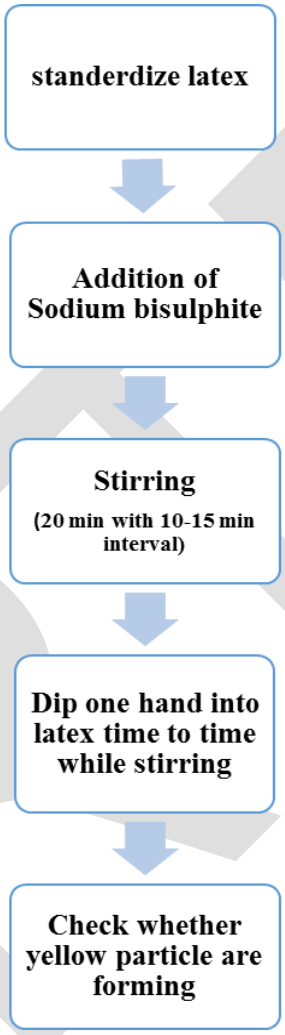

Fig. 2. Manual method process flow chart

If the yellow particles are visible, allow latex to become stable for about 10 minutes. Eventually, stir latex gently until yellow particles fixed into clots unless continuing the stirring till the yellow clots appear.

2. Aeration technique

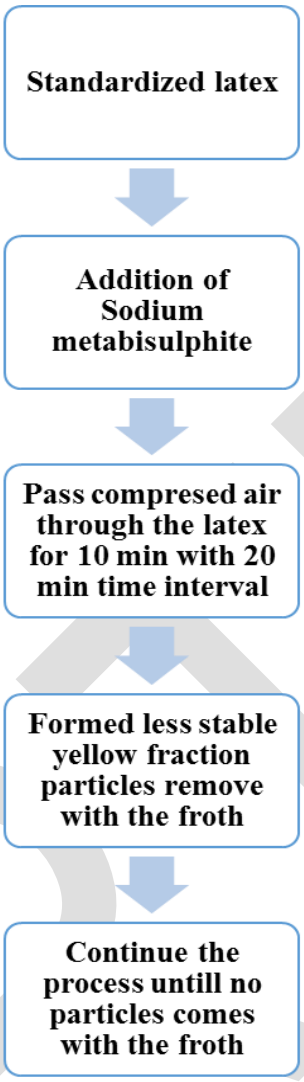

Fig. 3. Aeration technique process flow chart

The resultant fractionated latex having superior quality with the right color, less liable to mould growth and discoloration during storage. After extracting yellow portion, the latex should be straining through a 60 mesh sieve to produce pure white crepe, and Toluene mercaptan added as a bleaching agent to bleach the remaining carotenoid pigments in the latex. After that, the latex introduced to the coagulation tank and 85% formic acid added to coagulate the latex into crepe rubber. Water is added to dilute the chemical to get homogenize dispersion. Instead of the formic acid oxalic acid can be used when the water is heavily contaminated in some seasons. Then the coagulum removed from the tank as cubical pieces and sent through a series of mills to remove water, to get thin lases and drying rubber efficiently. In the beginning, sliced coagulum pass through the macerator under water spray to acquire the required thickness to pass through the smooth roller. The macerated coagulum is passed through the mill while removing remaining non-rubber which resulting in the coloration, underwater spray. Then the laces are wound on the drum to remove the moisture and dry fast. Then laces are transferred to the drying tower to obtain the drying for 3 to 4 days. The laces are hanged inside the drying tower with the help of reapers, in the meantime temperature should be maintained around 34°C with the support of

boiler radiation system and natural ventilation.
Then inspection of the laces should be done and introduced into the blanketing section. Here the dry laces further inspected, and dirt should be removed. After that, crepe laces stacked on one another to make 25kg bulk, and folded mats are passed through the blanketing mill. Blanket sheets then cut into required sizes and packed using low-density polyethylene.

There are two type of crepes are available based on the bleaching step [6].

1. Bleaching without fractional coagulation (un-fraction bleached crepes)
2. Fractionation and then bleaching (fraction bleached crepes)

Also, after taking the coagulum from the tank coagulum, it was processed into different grades of rubber depending on the customer requirement and machine availability.

1. Blanket crepe rubber
2. Thin lace rubber
3. Sole crepe rubber

3 ECONOMICAL STATE OF RUBBER INDUSTRY

Table 1 illustrates the Economic data of the rubber industry in Sri Lanka from 2009 to 2018, shows total production with local usage and export data of rubber as smoked sheets, sole crepe, scrap crepe, latex crepe, latex, and TSR.

Table 1. Important information about Sri Lankan rubber industry, 2009-2018 [4]

Item	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total production (Mn.kgs)	136.9	152.9	158.9	152.0	130.4	98.6	88.6	79.1	83.1	82.6
Smoked sheets	54.6	59.3	60.7	59.2	62.8	48.5	44.4	39.8	41.5	41.3
Sole crepe	5.4	6.7	3.4	1.9	2.4	2.4	1.9	1.6	1.5	1.4
Scrap crepe	3.5	1.8	1.3	1.3	2.4	1.0	0.9	0.8	0.8	2.6
Latex crepe	31.7	52.5	59.9	36.5	15.4	11.8	8.3	12.6	9.2	10.5
Latex	29.9	24.3	24.9	44.4	37.9	27.2	25.5	20.5	28.9	26.0
T.S.R	11.8	8.3	8.0	8.7	9.6	7.6	7.6	3.8	1.2	0.8
Local usage (Mn.kgs)	84.9	107.2	111.7	110.0	107.3	85.6	73.2	51.0	54.8	58.6
Exports (volume,Mn.kgs)	56.0	51.9	42.6	37.4	23.6	16.3	10.4	16.2	17.2	14.0
F.O.B. Price (Rs/kg)	202.3	377.54	535.4	420.74	389.81	362.83	342.03	294.33	343.56	363.93
Cost of production (Rs/kg))	115.5	119.83	129.56	136.0	150.0	160.0	170.0	180.0	195.0	205.0

By studying Table 1, it appears the fluctuation of total production and also within that period local consumption of rubber fluctuated. The highest use depicts in 2011 as 111.7 Mn.kgs reduced to 58.6 Mn.kgs in 2018. In the year 2011, the most top total production and export income among ten years' details, achieved exported revenue

was higher, and even a low volume of rubber was exported compared with the previous two years. The unit price of rubber was higher in 2011 than in the last two years. The exported size of 42.6 Mn.kgs in 2011 reduced to 14 Mn.kgs in 2018. Therefore, a considerable amount of reduction seems in exported income from 2011 (LKR million 22,811) to 2018 (LKR million 5,088). Further details clarified in bellow bar charts. Fig.4, Fig.5, and Fig.6 respectively represent the total rubber production, total crepe rubber production, and production of crepe rubber vs. other types from 2009 to 2018. Fig.4 indicates a decrement of total rubber production; meanwhile, Fig.5 shows a decrement of crepe rubber production the same as Fig.4. Fig.6 depicts the percentage of crepe rubber production from total rubber production in Sri Lanka. Fig.6 illustrates an overall decrement of crepe rubber production percentage from the total rubber production.

After evaluating the details of Fig.6, the year 2011, which earned the highest exporting income among the following ten years, from the total rubber production, 40% was crepe rubber. Still, when comparing with the recent year 2018, it was only 18% crepe rubber production. Furthermore, this gives a clue to the country that the crepe rubber sector faces some challenges; therefore, the rubber industry needs overall attention while the overriding focus on crepe rubber production. If the crepe rubber production upgrades to a better level than now, it will be benefitted to the economy of Sri Lanka by earning foreign exchange through exporting with a unique prize. Therefore, under these circumstances identifying the causes behind the decrement of crepe rubber manufacturing and defining ways to counteract are highlighted by this research.

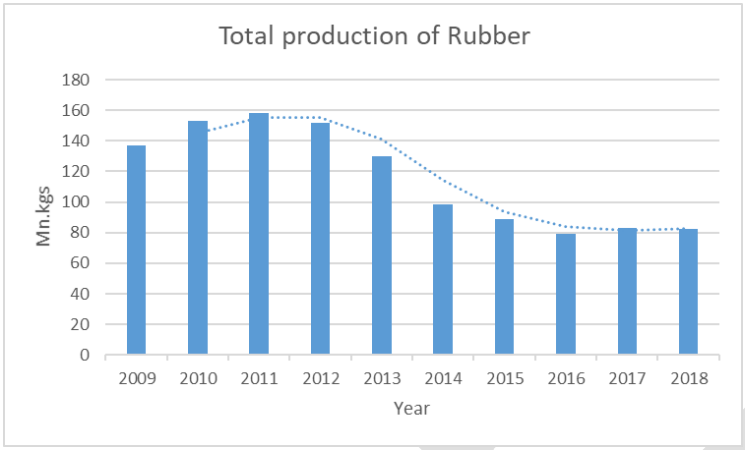

Fig. 4. Total production of rubber in Sri Lanka 2009-2018

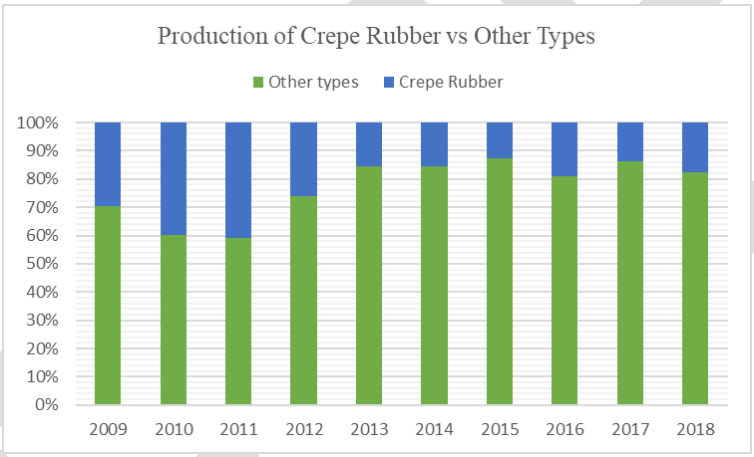

Fig. 5. Total production of crepe rubber in Sri Lanka 2009-2018

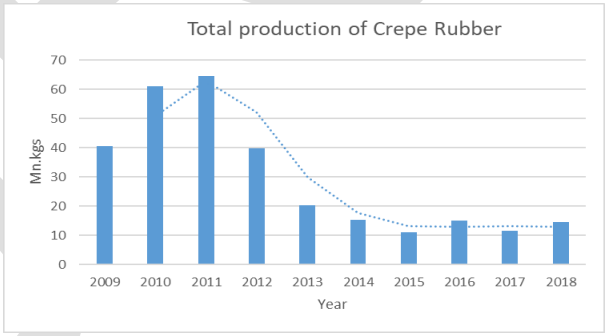

Fig.6. Production of crepe rubber vs other types in Sri Lanka 2009-2018

4 WASTE MANAGEMENT

Rubber industry requires a significant amount of energy, water, firewood, chemicals, machines, and the workforce due to its regular vast consumption. In Sri Lanka, over 160 [6] factories are located in rubber-growing areas around the wet zone, mostly raw rubbers. RSS holds the primus palace of the total production of rubber annually due to its vast distribution among small scale producers additional to the large scale producers. In present-day context crepe rubber industries at least not grown up to that level due to the highest purity of

crepe rubber challenging to achieve through small scale production without the relevant facilities, skilled laborers, and heavy-duty machines, that causes to limit the crepe rubber production into few factories throughout the country.

Crepe rubber industry requires a large amount of water to run the plant to follow the procedure as mentioned earlier. Approximately 40-50 liters of effluents per 1kg discharges from a crepe rubber manufacturing factory, which processes 1500-2500 kg of raw crepe per day [6]. That denotes a massive amount of effluent released to the environment annually. In crepe rubber manufacturing, water is essential for washing, factory cleaning, dilution of chemicals, standardization of latex, and cooling pieces of machinery. In almost all stages resulting water that contains harmful pollutants released into the environment as an effluent. Not only organic contaminants, but the effluent also contained numerous types of chemicals that are potentially toxic to humans and the environment [6]. While coagulating the latex into cubic pieces, the resulting serum composed of non-rubbers such as protein, sugar, organic acids, phosphorus, and nitrogen gives the fundamental composition to determine the average effluent quality parameters. According to the raw rubber type, the average effluent quality parameters including pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) varies as bellow in Table 2.

Table 2. Average effluent quality parameters of effluent generating from various types of raw rubber

Parameter	RSS	Crepe	TSR	Concentrate latex	Dipped products	Tolerance limits
pH	4.9	5.0	5.7	3.7	7.2	6.5-8.5
C.O.D	3300	3500	2740	6201	2011	400
B.O.D	2630	2500	1747	3192	1336	50/60
Settlable solids	50	45	155	100	200	
Suspended solids	140	130	237	190	241	100
Total solids	3745	3500	1915	7576	2457	1500/1000
Ammoniacal nitrogen	75	80	66	401	126	300/40
Total nitrogen	500	550	147	616	180	300/60
Sulphates		374		1610	72	1000
Sulphides		15				2
Sulphites		190				

According to the state of Sri Lanka, often, the effluent does not appropriately refine using proper drain system even if technology and knowledge exist. As usual practice in crepe rubber factories, generating wastewater allows combining with the surrounding areas probably to a river like sensitive ecosystems or to a paddy field [5]. Fortunately, attention toward this pollution is rising due to the recognition of government and non-government environmental authorities in Sri Lanka. Therefore, nowadays, pollution controlling methods and treatments are introduced and implemented in the country in an acceptable manner.

As a treatment, any existing biological treatment such as Oxidation ditch, RBC, and Activated sludge system can be implemented to refine the wastewater. Organic maters and other pollutants in the effluent are biodegradable. Sri Lankan Rubber Research Institute has been developed some cost-effective biological treatments to refine the effluent released by the rubber factories [6].

Generally, water is a limited resource; therefore, it is better to reduce the water consumption to manufacture crepe rubber and overall rubber production industry. Reuse of used water, use of water with substandard quality, restricted or no water used in mill cooling, and limited washing of laces and sheets are the

easily acquired steps that can be taken to reduce high water consumption through the process.

5 CONCLUSION

Eventually, the objectives of this paper were successfully fulfilled, and the study reveals the current economic state of the Sri Lankan rubber industry, including the crepe rubber industry. The total 82.6Mn.kgs of rubber was produced in 2018; from that amount, 14Mn.kgs of rubber was exported. From annual rubber production 2018, crepe rubber production to the market was about 14.5Mn.kgs as the form of sole crepe, scrap crepe, and latex c crepe, which is around 12% of the overall rubber production in the country.

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