

Thin Rubber Sheet Drying Curve Characteristics of Fresh Natural Rubber Latex

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Abstract

In general, the drying process of the rubber sheet is performed after the squeezing the hardened rubber to form the rubber sheet and basking the rubber sheet into the surrounding processes. In the present study, the drying process of fresh rubber latex is done without the hardened rubber to form the rubber sheet process. However, to obtain the rubber sheet quality equivalent with the rubber sheet obtained from the commercial rubber sheet process, the thin rubber sheet drying curve characteristics of fresh natural rubber latex is determined. It can be seen that the optimized quality thin rubber sheet depends on the rubber latex thickness, drying time and drying temperature. The obtained results of this study are expected to lead to guidelines that will allow the designing and developing the continuously drying thin rubber sheet processing which increasing quality/quantity of the rubber sheet and minimize degradation and destruction of the materials especially longer storage period. In addition, the reducing production time of the rubber sheet also decreases.

Keywords: Natural rubber; drying curve; rubber sheet

INTRODUCTION

To prevent the post-harvest degradation of various agricultural products, drying process is commonly employed in the various production processes. As materials are kept longer storage period, the degradation and destruction of the materials can be occurred. Therefore, the moisture content is eliminated from the materials. Natural rubber is an important plant that yields a product used extensively in various industry; automotive tires, medical equipment, glove manufacturing, and et al. For the downstream industries, the natural rubber was produced in the form of ribbed smoked sheets before being used in various industries. Generally, the works reported on the ribbed smoked rubber sheets by the rubber smoking process with direct heat from wood combustion (Tekasakul et al., [1,4]). During this process, fresh rubber sheets were produced from squeezing coagulated rubber slabs and dried in rubber sheet smoke rooms in a smokehouse using old rubber wood or firewood as a source of heat and smoke. Some study reviewed the technical crumb rubber drying process (Tham et al., [2]), however, there was paper reported the rubber sheet drying using solar energy as the heat source instead of traditional smoke house (Tanwanichkul

et al., [3]) and enhancement of the eco-efficiency through life cycle assessment in crumb rubber processing was also presented (Maulina et al., [5]). The moisture of the cup lump natural rubber can be determined by using infrared spectroscopy (Suchat et al., [6]). Most of the previous studies on this area had been carried with numerical analysis on the performance of mixed mode dryer and indirect solar dryers for natural rubber sheet drying (Dejchanchaiwong et al., [7,10,13]). In addition, techno-economic assessment of forced-convection rubber smoking room for rubber cooperatives had been considered and designed with a parabolic cover and enhanced panel (Jitjack et al., [8]). There were some paper presented on the application of CFD method to analyze the and design the innovative solar-biomass hybrid drier (Sonthikum et al., [9]). The assessment of sensible heat storage and fuel utilization efficiency enhancement in rubber sheet drying and determination of the contamination in fresh natural rubber latex using microwave reflectometer had been studied by Tekasakul et al., [11]; Somwong et al., [12]. Some of study reporting the role of mesostructure characterization on the asymmetrical flow fraction of natural rubber from different *Hevea brasiliensis* genotypes (Liengprayoon et al., [14]). Recently, the phenotypic variations, heritability and correlations in dry biomass, rubber and resin production among guayule improved germplasm lines had been studied (Abdel-Haleem et al., [15]).

According to the authors' knowledge, the papers have been continuously presented experimental studies on the moisture removal from the rubber sheet by drying with smoking rubber process which the fresh rubber sheets are obtained from squeezing coagulated rubber slabs and dried in rubber sheet smoke rooms in various smokehouse configurations. In order to decrease rubber sheet production time, the focus of this study is to present the directly drying fresh rubber latex into thin rubber sheet without from squeezing coagulated rubber sheets. In addition, the drying curve characteristics of the thin rubber sheet is determined.

EXPERIMENTAL APPARATUS AND METHOD

Materials

Natural rubber latex is purchased from several suppliers and used as received. Formic acid is purchased from Merck which are added to the rubber latex formulation of commercial grade.

Methods

Commercial rubber sheet drying method

The commercial rubber sheet manufacturing process was consisted of various steps as shown in Fig. 1(a) which started from the collecting of the rubber latex from the suppliers. Secondly, the rubber latex was diluted with water and 2%wt./vol. of formic acid was added to coagulate in the coagulation tank and then mixing with stirrer to mix well. All bubbles and various contaminants in the rubber latex were removed by surface wiping which these bubbles may cause quality degradation of the rubber sheets and after that the rubber latex mixture is poured into the aluminum tray with the

width*length*depth of 250*250*10 mm. Next, 60% moisture content of the hardened rubber slabs are squeezed to form thin rubber sheets with the thickness of 3–4 mm which controlled by the constant spacing of milling and then basking them into the surrounding. Next, the obtained rubber sheets are dried by the rubber smoking process with direct heat from wood combustion and then basking into the surrounding. Finally, the scaled and extracted dry rubber sheets are packed into the bales and bags.

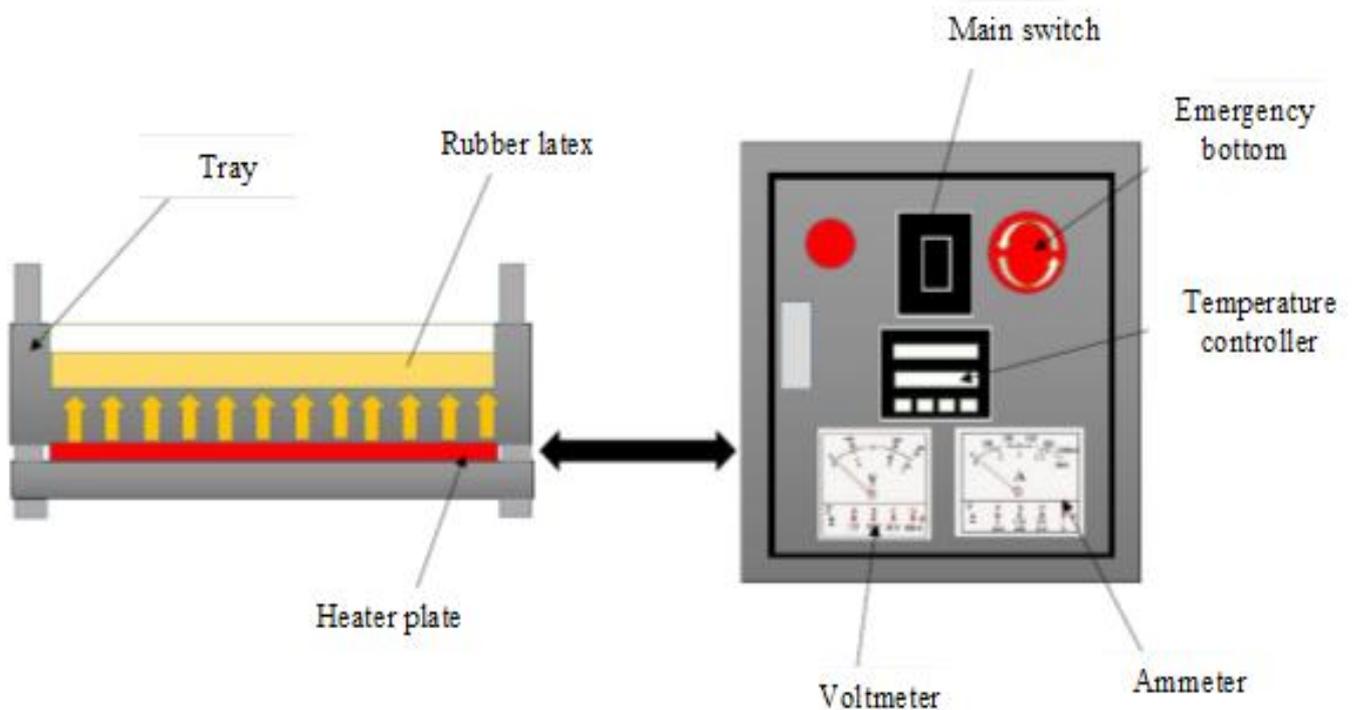


Figure 1. Schematic diagram of the rubber sheet tray with control system

Thin rubber sheet drying method

The thin rubber sheet drying process for this study is shown in Fig.1(b). As mentioned above, it can be seen that all most steps of this method are similarly to the commercial rubber sheet drying method as mentioned above except the squeezing the hardened of the rubber to form a sheet and drying processes. For this method, the diluted fresh rubber latex with water and formic acid is directly dried with heater tray with the

length*width*depth of 250*250*10 mm. The thin rubber sheet drying system is shown in Fig. 1 which consists of electric heater tray and control system. Experiments are performed with various drying temperatures, rubber latex thickness and drying time to obtain the optimized rubber sheet quality. The final rubber sheet colour and %moisture content obtained from the commercial rubber sheet drying method has been used to verify the final colour and %moisture content of rubber sheet obtained from the thin rubber sheet drying method.

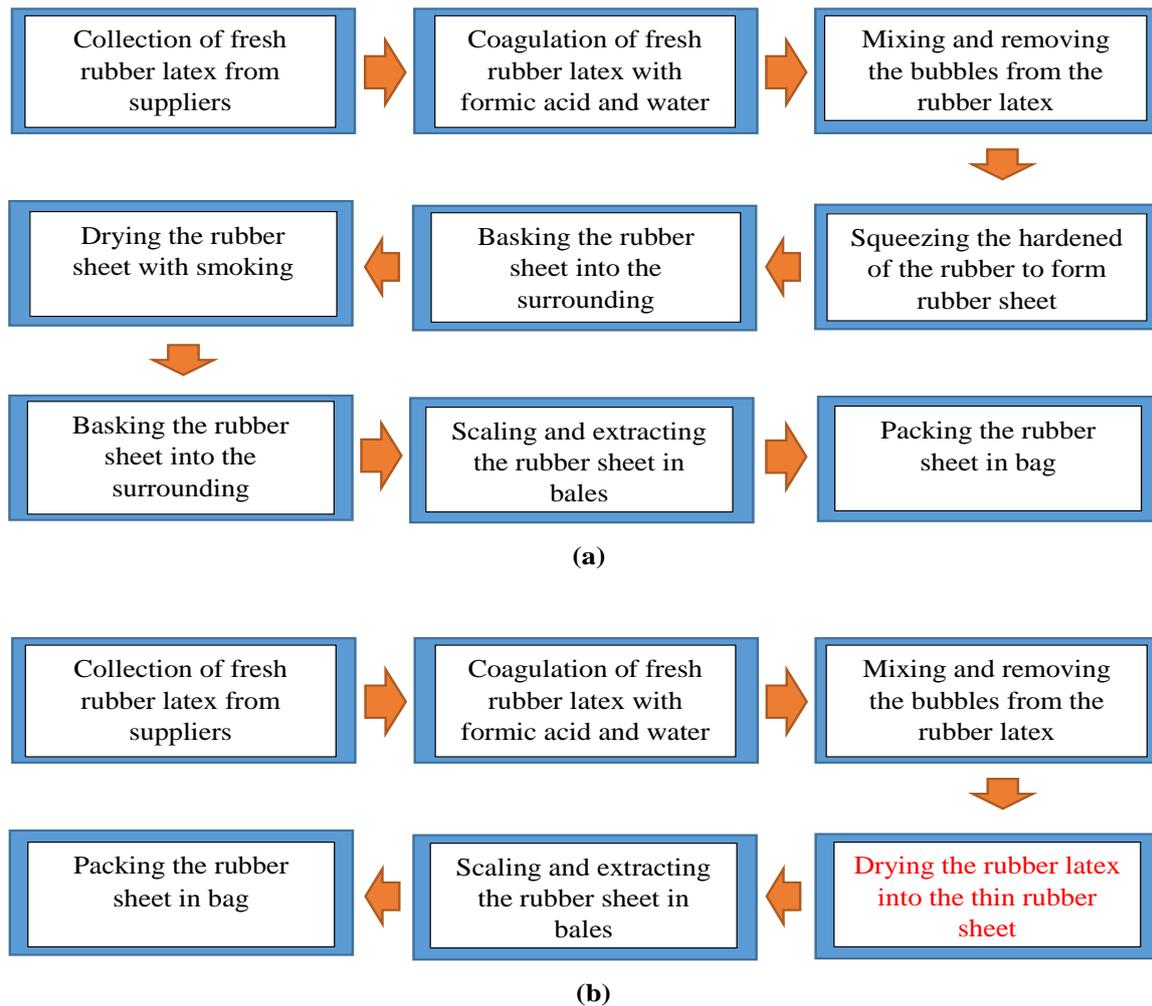


Figure 2 Manufacturing process of (a) the commercial natural rubber sheet method, (b) thin rubber sheet method

RESULTS AND DISCUSSION

In the commercial rubber drying sheet method, it can be done by squeezing the hardened rubber slabs to form rubber sheets and then dried by smoking process with direct heat wood combustion and basking into the surrounding. While the present study, the fresh rubber latex is directly dried to form thin rubber sheet. It can be seen that the commercial rubber sheet method has a long time period production. Therefore, the direct drying process is applied to approve the rubber sheet

process. Figure 3 shows the final rubber sheet colours obtained from the commercial process and from the present study (direct drying). The final colour and %moisture content obtained from the commercial method are used to verify the thin rubber sheet quality obtained from the present study. It can be seen that the final colour obtained from both methods are similarly and %moisture content is about 20-25%.



Figure 3 Photograph of the rubber colour (a) smoking rubber (b) thin rubber sheet drying



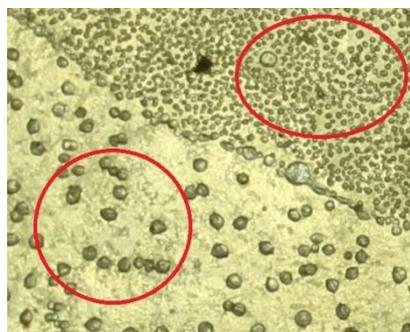
(d) Drying temperature at 50°C, 100 minutes



(c) Drying temperature at 60°C, 60 minutes



(e) Drying temperature at 70°C, 40 minutes

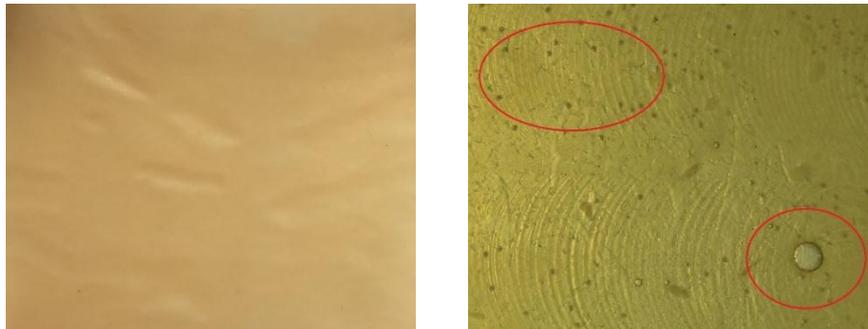


(b) Drying temperature at 80°C, 25 minutes

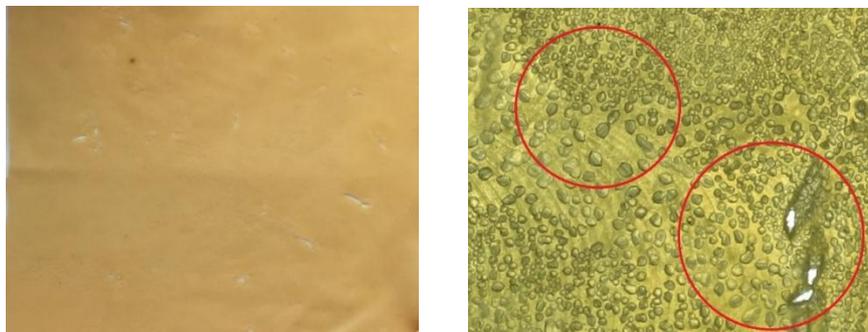
Figure 4. Effect of drying temperature on the physical properties for rubber latex thickness of 3 mm



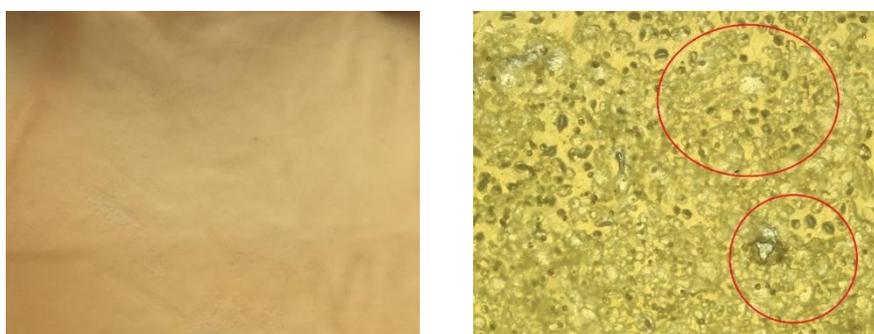
(a) Drying temperature at 50°C, 220 minutes



(b) Drying temperature at 60°C, 120 minutes

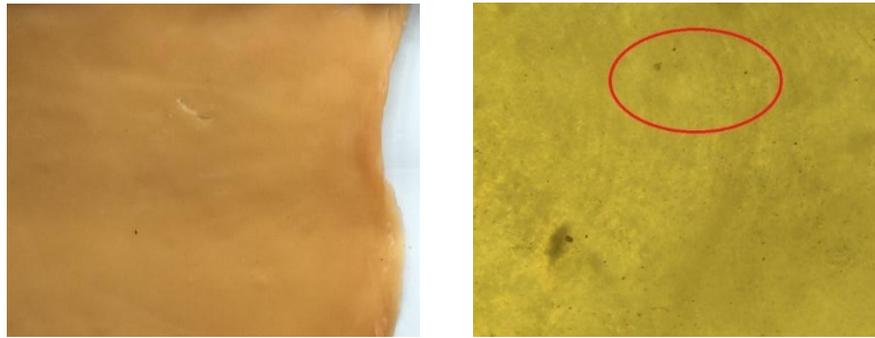


(c) Drying temperature at 70°C, 70 minutes

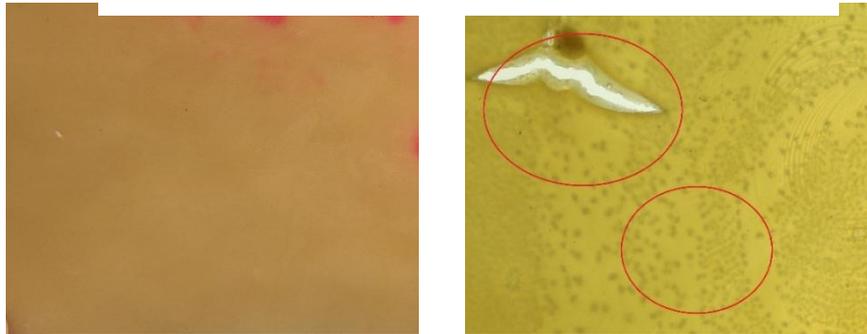


(a) Drying temperature at 80°C, 40 minutes

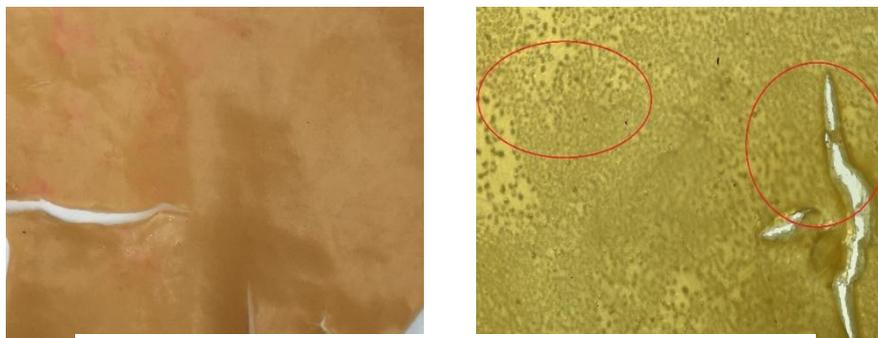
Figure 5. Effect of drying temperature on the physical properties for rubber latex thickness of 5 mm



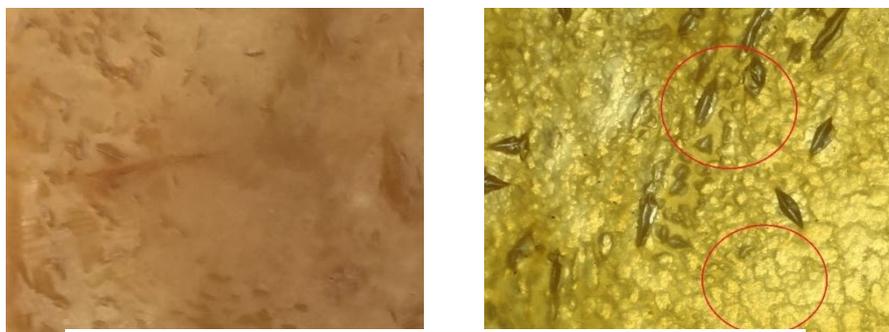
(a) Drying temperature at 50°C, 360 minutes



(b) Drying temperature at 60°C, 250 minutes



(c) Drying temperature at 70°C, 150 minutes



(d) Drying temperature at 80°C, 100 minutes

Figure 6. Effect of drying temperature on the physical properties for rubber latex thickness of 10 mm

Figures 4-6 show effect of drying temperature on the physical property of the thin rubber sheet for different rubber latex thickness of 3,5,10 mm, respectively. It can be clearly seen from three figures that the drying period time for the optimized

rubber sheet colour and %moisture content is tend to decrease with increasing drying temperature. For a giving rubber latex thickness, the bubbles content and size in the rubber sheet at high drying temperature is more than that at lower ones. The

bubbles content in the rubber sheet can be occurred in two steps of the rubber sheet process; coagulation if fresh rubber latex with formic acid, water and drying steps. The bubbles content in the rubber sheet is one of many criteria used to classify the rubber sheet grade and results in rubber sheet cost. For a giving drying temperature, the bubbles content in the rubber latex thickness of 10 mm is higher than those in the rubber latex thickness of 3, 5 mm. In addition, at high rubber latex thickness, there are some tears in the rubber sheet especially at high drying temperature.

Effects of relevant parameters on the optimized rubber sheet colour and %moisture content are plotted as in Fig. 7. It can be seen clearly seen from figure that the drying time rapidly decreases with increasing drying temperature. However, this effect tends to diminish as drying temperature increases > 70°C. From Fig. 7, however, to obtain the highest quality of thin rubber sheet, the relevant parameters should be kept at 55-65°C drying temperature, 5-7 mm rubber latex thickness and 100-200 minutes drying time.

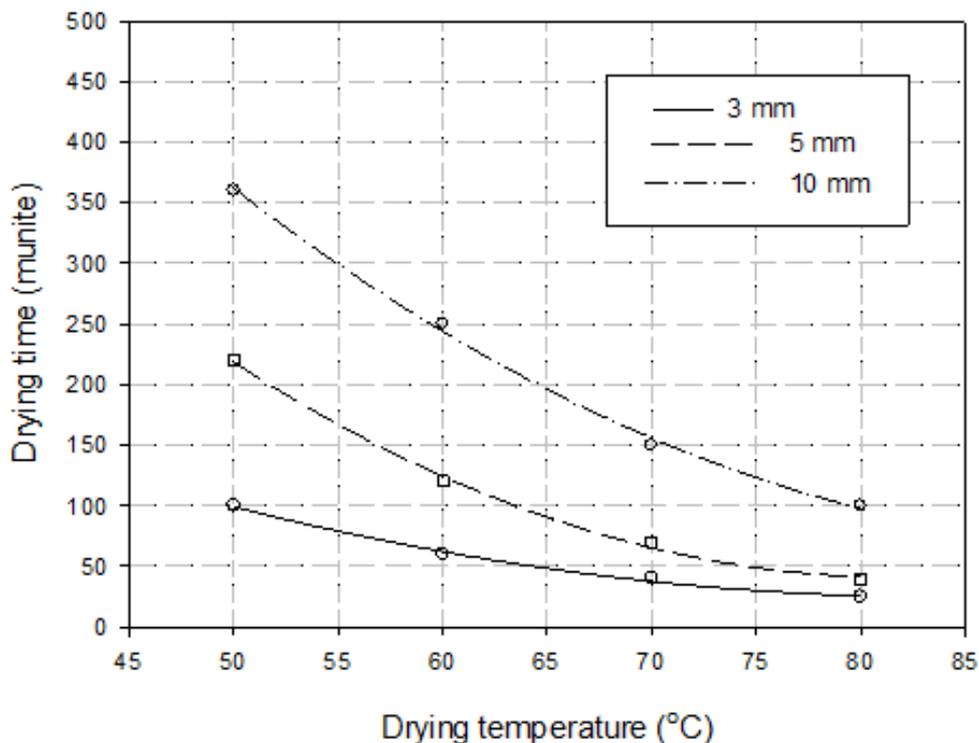


Figure 7 Drying curve characteristics of thin rubber sheet

CONCLUSIONS

The results of the moisture removal of fresh rubber latex by thin rubber sheet drying method are presented. Thin rubber sheet quality is verified with the rubber sheet obtained from the commercial rubber sheet method. It can be seen that the quality of thin rubber sheet depends on the drying temperature, rubber latex thickness and drying time. The obtained thin rubber drying thickness of the 3,5,10 mm rubber latex thickness are 0.25, 0.45, 0.76 mm, respectively. Based on the verified thin rubber sheet quality, the optimized parameters are plotted in the form of the thin rubber sheet drying curve characteristics. The drying curve characteristics are used to guidelines for designing the continuously drying thin rubber sheet machine which minimize degradation and destruction of the rubber latex especially longer storage period and results in reducing production time of the rubber sheet process.

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