Inference Analysis of Dry Rubber Content Capacitance Properties in Discriminating Type of Rubber Clones

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ABSTRACT

This project describes the development of a capacitive sensor for measuring capacitance of the Dry Rubber Content (DRC) by using parallel plate for classification of rubber clones. Five dry rubber contents from different clones were identified: RRIM2002, RRIM2007, RRIM2008, RRIM2014 and RRIM3001. An aluminium tape had been used as a parallel plate sensor and paired with Arduino microcontroller for the output extraction. The device measures the output in capacitance value from the capacitance sensor based on the dry rubber content samples placed in between the two plates. Statistical analysis using the SPSS software is used to analyse data for each rubber clone; in which for discrimination of data, the normality distribution was tested. The analysis of normality revealed that the data is not normally distributed. Thus, non-parametric test Kruskal-Wallis test is used. Result shows that there is a statistical significance difference of the capacitance value among the five different rubber clone groups. This is proven by significant level of Kruskal-Wallis test of less than 0.05. RRIM2002 has the highest mean rank of capacitance value followed by RRIM2008, RRIM2014, RRIM3001 and the lowest is RRIM2007.

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Introduction

The rubber tree Hevea brasiliensis is well known for its latex production. It originated from Brazil and has been widely planted in South East Asia. Nowadays, the usage of rubber has increased in the production industry. Malaysia produces many products based on rubber such as gloves, rubber threads, hoses, engine mountings, dock fender and seismic bearings. The most rubber product that Malaysia exported is disposable gloves which supplied 60% of the world consumption based on 2010 data [1]. Thus, rubber industry is one of the main contributors for Malaysia's economy development [2].

Many studies have been done in order to improve the quality of natural rubber latex and to determine the differences among rubber tree clones. There are more than 30 types of rubber tree clones in Malaysia and each latex clones has differences in terms of dry rubber content (DRC) and viscosity [3]. Rubber Organized on rubber breeding was initiated by Rubber Research Institute of Malaya in 1928. Up until now, six series of clones have successfully been developed [4]. The series were RRIM500, RRIM600, RRIM800, RRIM900, and RRIM2000 and only several of these clones were recommended to be planted without any restriction. Each of these clones were developed to improve yielding, wood volumes, better growth vigour, better bark thickness, resistant to wind damage, resistant to rubber disease, response to chemical stimulation and also tolerant to dry trees [4]. Each clone differs in terms of dry rubber content.

Dry Rubber Content is a term related to natural rubber latex where it specified the rubber presented in rubber latex. Natural rubber latex is being weighed before dried in the oven. After the drying process, the dried sheet will be weighed back to calculate the DRC percentage.

In agriculture, capacitive sensing device is not something unfamiliar to apply in an experimental work. For example, the work of Javad Taghinezad on the prediction of water content in sugarcanes stalks [5]. The experiment was done to find a relationship between sugarcane stalks voltages (mV) and moisture content (M.C) of samples. In this experiment, it was found that the correlation dielectric constant and moisture content for the sample besides the quadratic trend line was fitted to data. In addition, M. Soltani investigated the dielectric of the banana properties for its quality [6]. In this work, the dielectric constant was able to assess changes in the quality parameters of banana fruits during ripening period. But, further researches still need to be conducted using this method at higher frequencies to develop a more reliable prediction of banana quality during ripening treatment.

Rubber clones are usually identified based on its morphological variation characteristics. Each clone has different characteristics than others. During immature branched stage, identification is done by leaf, shape of the leaf-storey and stem. As for during matured stage, main features that have been identified are the crown shape and intensity, branching habit, trunk, colour of latex, shape and colour of seed coat [7]. This method requires expertise involvement and cannot be quantified. Alternative method is needed to overcome this problem. In this work, alternative way to tackle this problem is by the development of a capacitive sensing device for clone's identification using the dry rubber content (DRC).

Methodology

Hardware design

A capacitance sensor development is the main part for this project. Getting the output from the sensing devices is most important in order to continue to the later stage of the experiments. Figure 1 shows a block diagram of measurement setup for this experiment. The parallel plates are a sensing element and ArduinoUno is used as a signal conditioning that its function is to read the capacitance value of the DRC clones.

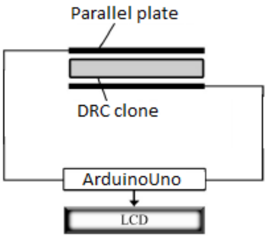

Figure 1: Block diagram of instrument for the measurement of the DRC capacitance value.

The sensing element is developed by using the aluminium plates. It consists of two conducting plates as shown in Figure 2. The value of capacitance is proportional to the cross-sectional area, A of the plates, while the permittivity (dielectric constant) is the insulating medium and distance between two plates, d. The value can be calculated by Equation (1) below:

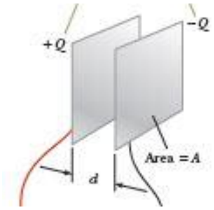

Figure 2: Basic construction of capacitance [9]

$$C = \varepsilon_r \varepsilon_o \frac{A}{d} \tag{1}$$

Where;

C = capacitance;

$\varepsilon_r \varepsilon_o$ = permititivity of electric;

A = Area of plate;

d = Distance betwen plate;

The measuring sensing element is built using the aluminium tapes with a 2 cm length and 2 cm width attached to the rectangular acrylic plastic as in Figure 3.

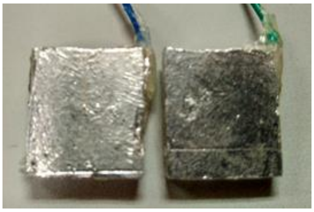

Figure 3: Aluminium plates

The arduino microcontroller (ArduinoUno) is used as a platform for the ease of creating a program in which an output is to read a voltage threshold (ADC value) from the capacitive sensor. In order to perform the programming of the Arduino microcontroller, a software called Arduino Language software is used. This software acts as a platform for the Arduino microcontroller towards capacitive sensor. The capacitance value is read from the analog input of the ArduinoUno which then executes the programming language written on it. The Arduino board has some stray capacitance of around 30 pF on the board and the micro-controller, so we need to calibrate the amount that the stray capacitance is allowed in the circuit. The circuit in Figure 4 shows the specified C1.

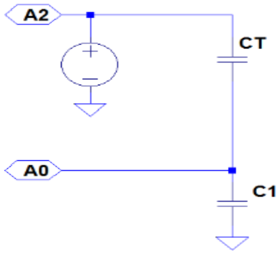

Figure 4: Circuit for capacitance measurement [9].

The analog to digital converter (ADC) value is to measure the voltage at VA0. While VA2 is set to 5 volts, the VA0 varies from 0 to 5 volts. For easier calculation, the ADC value does not need to convert into the voltage value. Then, the programming code can be written and the circuit can be simplified because the C1 can be replaced by the stray capacitance in variations below 30pF. The clones sample is sandwiched between the capacitive sensor plates that will undergo uniform deformation from both the top and bottom plates. The capacitance value measurements for each clone were then taken and recorded.

Data collection

DRC clones sample was taken from the Rubber Research Institute Malaysia (RRIM), Permatang Division, Kota Tinggi, Johor. The clones samples are from the 2002, 2007, 2008, 2014 and 3001 type. The DRCs were stored at the room temperature in airtight bags. To perform the data collection, five selected clones were measured by using the capacitive sensors with variations of thickness. Each of the selected clones has five samples, and each sample to be measured will then be divided into six parts. Reading of the measured samples was taken forty times where the total capacitance value reading collected is 1200 reading samples.

Calibration

Calibration process is a necessary action for any develop equipment in order to define whether the acquitted results are reliable or not. The Arduino Uno has been programmed with various stray capacitance (C1) values from 20 pF, 22.78 pF, 24.98 pF and 30 pF which may vary to the smallest error percentage where it is proportional to the accuracy of the capacitive sensor. The execution of this arduino Uno program will have repetition check with four selected capacitor values (CT) which comprise of 0.05 nF, 47 nF, 100 nF and 2200 nF for determination of which capacitor may produce the least error percentage. Hence, the final output will give the best C1 value for further use in the circuit.

Statistical calculation

Data collected from measurement capacitance value of clones is being analysed using IBM SPSS software. It is to determine whether the capacitance value will be well-model with normal distribution or not. From the results of the normality test, it shows a significance level value of Kolmogorov-Smirnov (K-S) test whether the value of the significance p-value is greater than 0.05 or conversely.

Then, if data is normally distributed, parametric test is done. If not, non-parametric test will be used. The test is allowing the comparison of more than two groups of independent variable on continuous or ordinal dependent variable.

Result and Discussion

In Table 1, the result of calibration for different stray capacitance values was shown. By referring to this table, the highest average error is shown by 30pF (C1) with the average of 13.92, followed by 20.00pF (C1) with the average value of 9.32. The third highest value for average error is 8.99 which belongs to 24.98pF (C1). Thus, the least average error is for the 22.78pF (C1) at 5.40. From the average error percentages, the best stray capacitance value should be 22.78pF (C1). It is suitable to be used in this research work because the range of the DRC clones capacitance value is between 15pF to 100pF.

Table 1: Mean Absolute Error

Capacitor	**Stray Capacitor**			
	20.00	**22.78**	**24.98**	**30.00**
0.05nF	12.17	1.04	11.10	32.06
47nF	10.59	6.10	10.40	9.27
100nF	11.75	11.72	11.76	11.65
2200nF	2.77	2.73	2.72	2.68
Average	9.32	5.40	8.99	13.92
Min	2.77	1.04	2.72	2.68
Max	12.17	11.72	11.76	32.06

Later, we proceed with classification of the clones. All clones are measured by its capacitance sensor. The statistical calculation is performed to compute on how possible the distribution of data is. The data for the measurement of clones is recorded manually and being analysed using the SPSS software. The first test uses the normality tests for all data sets. This test then compares the ECDF (empirical cumulative distribution function) of the sample data with the distribution expected if the data is normal. If the difference is adequately large, the test will then reject the null hypothesis of the population normality. In the special case of testing for normality of the distribution, samples are uniform and will compare to the standard normal distribution. The measurement outcome for the Kolmogorov-Smirnov (K-S) test has produced significant level that is 0.00 for all data sets as shown in Table 2. We can conclude that our data is not normally distributed.

Table 2: Result of Normality Test

Clone	**Kolmogorov-Smirnov**		
	Statistic	**df**	**Sig.**
2002	0.083	1200	0.000
2007	0.870	1200	0.000
2008	0.248	1200	0.000
2014	0.249	1200	0.000
3001	0.850	1200	0.000

Since all data are not normal, then non-parametric test is conducted. Kruskal-Wallis (one-way ANOVA on ranks) test was chosen for the next step because the data are more than two groups of independent variable and continuous or ordinal of dependent variable.

Table 3 shows Kruskal-Wallis test for all data. This test is measured from all k samples into a single set of size N. These assembles are rank-ordered from the lowest to the highest, with tied ranks included are appropriate. Mean rank of each clone is determined by the sum of all data in each group of clone, and then divided with the number of sample size, N.

Table 3: Rank of Mean

Clone	**N**	**Mean Rank**
2002	1200	4088.05
2007	1200	2198.15
2008	1200	3590.36
2014	1200	2900.81
3001	1200	2225.14
Total	6000	

Data is distributed according to the chi-squared distribution. It is distributed in a positive skewed ranging between 0 and ∞. The number of sample is minus by one to get the df (degree of freedom).

Table 4: Kruskal-Wallis Test with Variable Grouping Clone

Variable	Caps_pF
Chi-Square	1114.072
df	4
Asymp. Sig (p-value)	.000

Since our significance level is less than the alpha which is 0.05, we can conclude that there are significance differences among the clones. A Kruskal-Wallis Test revealed a statistically significant difference in the capacitance value across five different clones groups (Gp1, n=1200: 2002 clone, Gp2, n=1200: 2007 clone, Gp3, n=1200: 2008 clone, Gp4, n=1200:2014 clone, Gp5, n=1200:3001 clone), $\chi 2$ (4, n=6000) = 1114.072, p = .000, with a mean rank clones score of 4088.05 for clone 2002, 3590.36 for clone 2008, 2900.81 for clone 2014, 2225.14 for clone 3001 and 2198.15 for clone 2007.

Conclusion

In this work, the sensing elements and Arduino Uno microcontroller used were reliable in the experimental set-up. Calibration of the devices is finalized by choosing the least mean absolute error percentage. Because of the range for DRC clones capacitance is in between 15pF to100pF, the best obtained value for the stray capacitance is 22.78pF. A total of 6000 capacitance measurement was collected from the identified five rubber clones. Each rubber clones has 1200 of readings sample with 240 each representing in one sample. Data is recorded and analyzed by using the statistical method of normality test. All samples analyzed indicate that it is not normally distributed; thus, non-parametric test Kruskal-Wallis test is used. The tests configured shown that there were statistical difference in capacitance value across five different clones groups. This work proved that classification of five different clones using the DRC can be based on its capacitance value. This can be shown on Kruskal-Wallis test. Among the five rubber clones, the highest capacitance properties is RRIM2002 clone with 4088.05 mean rank. It is then followed by the RRIM2008, RRIM2014, RRIM3001 and RRIM2007 with mean ranks of 3590.36, 2900.81, 2225.14 and 2198.15, respectively. Therefore, based on the Kruskal-Wallis test, there is a statistically significant difference among the five rubber clones because the significance level (presented as Asymp. Sig) is less than 0.05 with the value of 0.00.

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References

[1] N. I. Strategy, "Rubber Products Innovation", Malaysia, Agensi Inovasi,2011.[Online].Available:http://www.innovation.my/pdf/innovating_formulation_of_nis/Rubber Products Innovation.pdf

[2] Malaysia Rubber Board, "Official Portal", Malaysia Rubber Board (Lembaga Getah Malaysia), 2012.

[3] M. Z. A. Aziz, F. N. Osman and H. Hashim, "Automated Rubber Seed Clones Identification Using Reflectance Sensors and PIC", in proceedings of the 9th WSEAS international conference on circuits, systems, electronics, control & signal processing, 2010, pp.55-59.

[4] M. Benong, M. N. Mohd Aris, Z. Ab Ghani, and N. R. Abdul Hamid, "1Malaysia Clone", Sains dan Teknologi Lemb. Getah Malaysia, (2009), vol. 6, no. 2, p8-10

[5] Javad Taghinezhad, Reza Alimardi and Ali Jafari (2012), "Development of a Capacitive Sensing Device for Prediction of Water Content in Sugarcanes Stalks", International Journal of Advance Science and Technology, Vol.44, (2012), p61-p66.

[6] M. Soltani, R. Alimardani, M. Omid, "Prediction of banana quality during ripening stage using capacitance sensing system", Australian Journal of Crop Science

[7] M. Z. Abd. Aziz, R. Othman, M. Benong, and O. S. Huat, RRIM 200 SERIES CLONES. Rubber Research Institute of Malaysia, 1997.

[8] A. P. Malvino, David J. Bates (2007), "Electronic Principles", McGraw-Hill/Higher Education.

[9] Serway_Jewett, Physics for Scientists and Engineers with Modern Physics vol. 8th Edition.