

Magnetic Stirrer with Speed Advisor and Timer Based on Microcontroller

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Abstract—Magnetic stirrer is a laboratory tool used to stir or mix a solution with other solutions so that the solution is homogeneous. The existing magnetic stirrers are only equipped with a mixer speed regulator using an analog control knob. Technology and science have now progressed, so in this study a microcontroller based magnetic stirrer was designed. This tool is designed with digital speed and time settings, so that it is expected that errors from reading the speed and time of mixing the samples can be expected. The results of the homogeneity of the solution were carried out with 11 types of solutions from low to high viscosity levels. Testing the solution with a low viscosity level using 100ml water with 40ml syrup. For solutions 2 and 3, namely Water 100 ml with 20 ml and 40 ml special grade syrup. For a solution of 4,5,6 and 7, namely 100 ml air with 2.5 gr, 3.5 gr, 6.5 gr, and 10 gr salt. For solutions 8, 9, 10 and 11, namely water 100 ml with sugar 2.5 gr, 3.5 gr, 6.5 gr, and 10 gr. Based on the results of the analysis that has been carried out on a solution with low viscosity, it takes 1 minute of mixing at low, medium and high speeds. For a solution with a higher viscosity it takes 5 minutes at medium and high speeds. Mixing air with salt and air with sugar takes 10 minutes at high speed.

Keywords—Laboratory Equipment, Magnetic Stirrer, Microcontroller

I. INTRODUCTION

The laboratory is a place for conducting experiments and research. The laboratory is also a place to train students and for students in practical skills, demonstrations, experiments, research, and scientific development. Laboratory referred to her does not only mean a room or a building used for scientific experiments, for example in the fields of science, biology, chemistry, physics, engineering, and so on. Where the laboratory is also a place for scientific activities in the form of experiments, research, observation, demonstrations related to teaching and learning activities [1][2][3][4][5][6].

A solution is a homogeneous mixture of two or more substances that dissolve each other and the respective constituent substances cannot be distinguished physically. The solution consists of a solute and a solvent. Based on the electrical conductivity (ionization power), there are two kinds of solutions, such as electrolyte solutions and non-electrolyte solutions. Electrolyte solution is a solution that can conduct electric current. This solution is divided into strong electrolytes and weak electrolytes [7].

The analysis of a particular liquid sample requires additional substances or liquids or mixers that can help the analysis process. Liquid additives or mixers are often referred

to as reagents. Reagents are substances that are added in order to bring or induce a change reaction [8][9][10]. The mixture of the analytical samples must be perfect (homogeneous), so a mixer is needed to assist the mixing [11][12]. The tools used in the stirring or mixing process are expected to produce well mixed (homogeneous) samples. Manual mixing often results in poor samples because each sample has a different mixing time and speed.

Magnetic stirrer is a laboratory tool used to mix or mix a solution with another so that the solution is homogeneous [13][14][15]. The current magnetic stirrer is only equipped with a diverter speed controller using an analog control knob [16][17][18][19]. The laboratory assistant or user uses a stopwatch or time estimate to determine the stirring time of a sample. The weakness of this technology is inaccurate precision and accuracy.

The research that has been done, entitled Design of a Magnetic Stirrer with Setting the Speed of the Stirrer and the Setting of the Stirring Time. The design of a magnetic stirrer with a stirring speed and time setting that has been made can work stirring the sample at a speed of up to 3000 Rpm with a stirring time from 1 minute to 60 minutes. In the experiment, using a sample of a mixture of water with a syrup solution, a mixture of water with a solution of food coloring, and a mixture of soapy water and cooking oil. The three samples can be mixed as expected. Similar research is about the study of a magnetic based stirrer system and fluid heating using a microcontroller. In the stirrer test, it is carried out by rotating the fluid solution with different viscosities and obtaining the fluid rotation velocity value, while in the heating test, it is carried out by heating the fluid solution with different viscosities and monitoring changes in fluid temperature. Based on the calculation of the results of the stirring test data after entering the formula, the error varies greatly, so that the fluid rotation method with a stirrer cannot measure the viscosity of a solution.

Technology and science have now progressed, so in this study a microcontroller based magnetic stirrer was designed. This tool is designed with digital speed and time settings. With digital technology, it is expected that errors from reading the speed and time of mixing samples can be minimized, efficient in terms of time, relatively easier to use and produce a homogeneous solution.



II. METHODS

This research is a research development or Research and Development (R&D). This research is developing and is one type of research that can be a link or break the gap between basic research and applied research. The definition of Research and Development (R&D) is often defined as a process or steps to develop a new product or improve an existing product.

In the purpose of this development research contains two information. First is to solved the problem and secondly is for learning specifications, model, problem, or device that will be produced to solve the problem. It can be argued that the aim of development research is to inform the decision making process as long as the development of a product develops and the developer's ability to create things of this type in future situations. Its purpose is to enhance the instructional design, development, and evaluation process that is based on other specific problem solving situations or generalized examination procedures.

The object of this research is a magnetic stirrer device. The way of observation is by direct measurement of the tool by observing using the observation guide. In this case, the time set on the analog magnetic stirrer will be compared with the time set on the microcontroller based magnetic stirrer. In addition, tests will also be carried out in the laboratory of the results of the mixing of the samples used.

In this research, using several tools, such as a multimeter, solder, pliers, cutter and screwdriver. Multimeters are used to measure currents and voltages when making tools [20][21]. Solder is used to solder electronic components in making tools. Pliers, cutters and screwdrivers are used as tools in making tools [22].

Several materials were used for the manufacture of tools, such as Arduino, infrared sensors, DC motors, LEDs, bussers, LCDs and other electronic components. Adunino is a microcontroller component used in making tools [23][24][25][26][27][28]. Infrared sensor is used to read motor speed (rpm). The DC motor is the driving force of this tool to stir the sample. LEDs are used as an indicator of an ongoing process. Bussser is an alarm that will sound as a sign that mixing or stirring has jam. LCDs and other electronic components as additional materials used in making tools [26][27][29][30][31].

Microcontroller based magnetic stirrer tool works with DC power supply at a voltage of 12 V. The power supply supplies the entire circuit to the DC motor. This circuit works from providing speed options via a push button to the Arduino displayed on the LCD. The Arduino microcontroller gets a choice of speed. It will immediately provide PWM input to the motor driver to drive the motor according to the speed choice. The motor driver that has been inputted will not be able to rotate because it is disconnected by the timer circuit. The timer circuit is given a time setting input so that the tool works. After that the start button is pressed to trigger the timer circuit and activate the relay so that the timer circuit starts counting down, which indicates that the tool starts working. The magnet above the DC motor will rotate with the stir bar on the test glass. This happens because of the mutual

attraction of the magnet with the stir bar. The timer information is displayed through the seven segment. Fig. 1 is a block diagram of a Microcontroller Based Magnetic Stirrer.

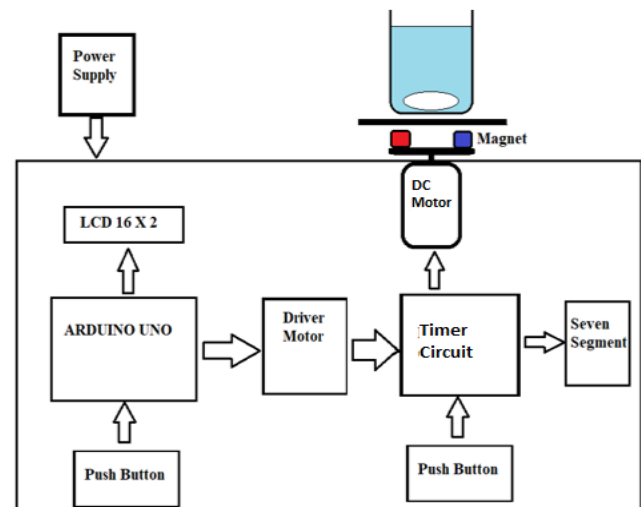


Fig. 1. Microcontroller Based Magnetic Stirrer Block Diagram

III. RESULT AND DISCUSSION

The manufacture of this tool uses a microcontroller to adjust the timer that works on the tool and the speed (rpm) of the tool when it is working. The timer set on this tool is set in seconds. This tool can run a maximum time of 999 seconds. This tool can also adjust the speed with three speed options, namely low (178.20 rpm), medium (233.00 rpm) and high (266.60 rpm). Fig. 2 is a microcontroller based magnetic stirrer that has been made.



Fig. 2. Microcontroller Based Magnetic Stirrer

Magnetic stirrer was tested by mixing water with syrup, special grade syrup, salt and sugar. Stirring time is 1, 5, 10 and 15 minutes. The microcontroller based magnetic stirrer homogeneity test was compared with the results of the mixture using an analog manufactured magnetic stricter. The microcontroller based magnetic stirrer work test is presented in Table 1.

TABLE I. RESULT OF MICROCONTROLLER BASED MAGNETIC STIRRER WORK TESTING

No	Speed	Repeat	Not Burdened	100ml	150ml	200ml	250ml
1	Low	1	2390	178	115	111	106
		2	2390	179	115	111	106
		3	2391	178	115	112	106
		4	2390	178	116	111	106
		5	2391	178	115	111	106
2	Medium	1	2870	233	211	198	189
		2	2871	233	211	198	188
		3	2870	233	211	199	189
		4	2869	233	210	198	189
		5	2870	233	211	197	189
3	High	1	3310	267	245	230	216
		2	3310	266	244	230	215
		3	3311	266	245	230	216
		4	3310	267	245	231	216
		5	3310	267	244	230	216

This work test is carried out to determine the motor rotation in rpm at Low, Medium and High speed options. The results of testing the homogeneity of the solution using a microcontroller based magnetic stirrer and manufacturer's magnetic stirrer were obtained as shown in Table 2.

TABLE II. SOLUTION HOMOGENEITY TEST RESULTS

Speed	Time (Minutes)	Homogeneity of the Solution	
		Analog	Digital
Low	1	√	√
	5	√	√
	10	√	√
	15	√	√
Medium	1	√	√
	5	√	√
	10	√	√
	15	√	√
High	1	√	√
	5	√	√
	10	√	√
	15	√	√

The homogeneity test of the solution was carried out with 11 types of solutions from low viscosity to high viscosity levels. Testing the low viscosity level solution using 100 ml water with 40 ml syrup. Solutions 2 and 3 are 100ml water with 20ml and 40ml special grade syrup. For solutions 4, 5, 6 and 7, namely 100ml water with 2.5gr, 3.5gr, 6.5gr, and 10gr salt. For solutions 8, 9, 10 and 11, namely 100ml water with 2.5gr, 3.5gr, 6.5gr, and 10gr sugar.

In this study, a comparative statistical calculation was carried out by comparing the two dependent groups (paired test) to the results of the microcontroller based magnetic stirrer test using the factory based magnetic stirrer using the SPSS program. The results of the Between Subjects Factors test are shown in Table 3.

TABLE III. BETWEEN SUBJECT FACTORS RESULTS

Factor	Value Label	N	
Load	1.00	Not Burdened	15
	2.00	100 ml	15
	3.00	150 ml	15
	4.00	200 ml	15
	5.00	250 ml	15
Speed	1.00	Low	25
	2.00	Medium	25
	3.00	High	25

TABLE IV. DESCRIPTIVE STATISTICAL TEST RESULTS

Load	Speed	Mean	Std Deviation	N
Not Burdened	Low	2390,4	0,54772	5
	Medium	2870,0	0,70711	5
	High	3310,2	0,44721	5
	Total	2856,86	388,8056	15
100 ml	Low	178,2	0,44721	5
	Medium	233,0	0,0	5
	High	266,6	0,54772	5
	Total	225,933	37,71409	15
150 ml	Low	115,2	0,44721	5
	Medium	210,8	0,44721	5
	High	244,6	0,54772	5
	Total	190,2	56,72389	15
200 ml	Low	111,2	0,44721	5
	Medium	198,0	0,70711	5
	High	230,2	0,44721	5
	Total	179,8	52,02362	15
250 ml	Low	106,0	0,0	5
	Medium	188,8	0,44721	5
	High	215,8	0,44721	5
	Total	170,2	48,35612	15
Total	Low	580,2	924,1528	25
	Medium	740,12	1087,005	25
	High	853,48	1253,806	25
	Total	724,6	1087,562	75

In this test, five tests were carried out on the load, such as unencumbered, with a load of 100ml, 150ml, 200ml and 500ml. This tool is made using 3 speed options, namely low,

medium and high. Descriptive test results are obtained as shown in Table 4.

In Table 4, it is found that when conditions are not burdened with a choice of low speed, the average motor rotation is 2390.40 rpm, with an average medium speed of 2870 rpm motor rotation and with high speed motor rotation an average of 3310.20 rpm. Likewise, with the loading of 100ml, 150ml, 200ml and 250ml.

Furthermore, the Tests of Between Subjects Effects test was performed. This test is carried out to get whether the data is normally distributed or not. The test results can be seen in Table 5. In this test, the results of the data are not normally distributed which is shown by the results of the load, speed, load and speed of less than 0.05.

Next, the Homogeneous Subsets test was carried out. This test is carried out to determine whether the statistical data is homogeneous or not. This testing is done on the load and speed data. The test results are shown in Table 6.

TABLE V. TEST OF BETWEEN SUBJECTS EFFECTS

Source	Type III Sum of Squares	DF	Mean Square	F	Signification
Corrected Model	87525672,0 ^a	11	7956879,273	510471,888	0,000
Intercept	50656474,286	1	50656474,286	3249855,275	0,000
Load	85273878,933	3	28424626,311	1823575,822	0,000
Speed	1109444,686	2	554722,343	35588,093	0,000
Load * Speed	1309235,947	6	218205,991	13998,959	0,000
Error	982,0	63	15,587		
Total	126905041,0	75			
Corrected Total	87526654,000	74			

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

TABLE VI. HOMOGENOUS LOAD SUBSETS

Load	N	Subset			
		1	2	3	4
200 ml	15	170.2			
150 ml	30		185.0		
100 ml	15			225.9	
Not Burdened	15				2856.8
Sig		1.000	1.000	1.000	1.000

At the load of homogenous subsets test results, the test values are in a different subset. At 200ml load, the value obtained is 170.2, located in subset 1, the 150ml load, the value obtained is 185.0, is in subset 2, the 100ml load, the value obtained is 225.9, is located in subset 3 and when it is not burdened the value obtained 2856.8 is located in subset 4. This shows that each load data is in a different subset and this means that the data is not homogeneous. The speed data test results are obtained as shown in Table 7.

TABLE VII. HOMOGENOUS SUBSETS THE SPEED

Speed	N	Subset		
		1	2	3
Low	25	580,2		
Medium	25		740,12	
High	25			853,48
Sig		1,000	1,000	1,000

At the load of homogenous subsets test results, the test values are in a different subset. At the low speed of 200 the value obtained 580.2 is located in subset 1, the medium velocity value obtained is 740.12 is in subset 2 and the high velocity value obtained is 853.48 located in subset 3. This shows in each speed data are in different subsets and this means the data is not homogeneous. In testing the tests of between subject's effects and homogeneous sub sets, the data results are not normally distributed and not homogeneous. For further testing, it was carried out using the Wilcoxon test.

In testing the homogeneity of the solution using a microcontroller based magnetic stirrer and the manufacturer's magnetic stirrer will compare the results of the resulting solution. In this test using the same mixing speed and the same stirring time. So the results obtained are homogeneous and not homogeneous, therefore for statistical testing used is the non-parametric Wilcoxon signed ranks test. Testing with solution 1, 100ml water with 40ml syrup, obtained statistical test results as shown in Table 8. In the homogeneous test for solution 1, the value of 1,000 is obtained where the value is greater than 0.05. This means that there is no difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a manufactured magnetic stirrer (analog).

Testing with solution 2, 100ml water with 20ml special grade syrup, obtained statistical test results as shown in Table 9. In the homogeneous test for solution 2, the value of 1,000 was obtained where the value is greater than 0.05. This means that there is no difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a magnetic stirrer manufacturer (analog).

Testing with solution 3, 100ml water with 40ml special grade syrup, obtained statistical test results as shown in Table 10. In the homogeneous test for solution 3, the value was 0.000, where the value was less than 0.05. This means that there is a difference in results between using a microcontroller based magnetic stirrer (digital) and a magnetic stirrer manufacturer (analog).

Testing with solution 4, 100ml water with 2.5gr salt, obtained the results of statistical tests as shown in Table 11. In the homogeneity test for solution 4, a value of 1,000 was obtained where the value was greater than 0.05. This means that there is no difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and the manufacturer's magnetic stirrer (analog).

TABLE VIII. TESTING WITH SOLUTION 1

	Digital - Analog
Z	0,000 ^b
Asymp. Sig. (2-tailed)	1,000
a. Wilcoxon Signed Ranks Test	
b. The sum of negative ranks equals the sum of positive ranks.	

TABLE IX. TESTING WITH SOLUTION 2

	Digital - Analog
Z	0,000 ^b
Asymp. Sig. (2-tailed)	1,000
a. Wilcoxon Signed Ranks Test	
b. The sum of negative ranks equals the sum of positive ranks.	

TABLE X. TESTING WITH SOLUTION 3

	Digital - Analog
Z	-5,000 ^b
Asymp. Sig. (2-tailed)	0,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

TABLE XI. TESTING WITH SOLUTION 4

	Digital - Analog
Z	0,000 ^b
Asymp. Sig. (2-tailed)	1,000
a. Wilcoxon Signed Ranks Test	
b. The sum of negative ranks equals the sum of positive ranks.	

TABLE XII. TESTING WITH SOLUTION 5

	Digital - Analog
Z	0,000 ^b
Asymp. Sig. (2-tailed)	1,000
a. Wilcoxon Signed Ranks Test	
b. The sum of negative ranks equals the sum of positive ranks.	

Testing with solution 5, 100ml water with 3.5gr salt, obtained the results of statistical tests as shown in Table 12. In the homogeneity test for solution 5, the value of 1,000 was obtained where the value was greater than 0.05. This means that there is no difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and the manufacturer's magnetic stirrer (analog).

Testing with solution 6, 100ml water with 6.5gr salt, obtained the results of statistical tests as shown in Table 13. In the homogeneity test for solution 6, a value of 1,000 was obtained where the value was greater than 0.05. This means that there is no difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and the manufacturer's magnetic stirrer (analog).

TABLE XIII. TESTING WITH SOLUTION 6

	Digital - Analog
Z	0,000 ^b
Asymp. Sig. (2-tailed)	1,000
a. Wilcoxon Signed Ranks Test	
b. The sum of negative ranks equals the sum of positive ranks.	

TABLE XIV. TESTING WITH SOLUTION 7

	Digital - Analog
Z	-6,708 ^b
Asymp. Sig. (2-tailed)	0,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

TABLE XV. TESTING WITH SOLUTION 8

	Digital - Analog
Z	-4,472 ^b
Asymp. Sig. (2-tailed)	0,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

TABLE XVI. TESTING WITH SOLUTION 9

	Digital - Analog
Z	-5,000 ^b
Asymp. Sig. (2-tailed)	0,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

Testing with solution 7, 100ml water with 10gr salt, obtained the results of statistical tests as shown in Table 14. In the homogeneity test for solution 7, the value was 0.000, which is less than 0.05. This means that there is a difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a manufactured magnetic stirrer (analog).

Testing with solution 8, 100ml water with 2.5gr sugar, obtained the results of statistical testing as shown in Table 15. In the homogeneous test for solution 8, the value was 0.000, which is less than 0.05. This means that there is a difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a magnetic stirrer manufacturer (analog).

Testing with solution 9, 100ml water with 3.5gr sugar, obtained the results of statistical tests as shown in Table 16. In the homogeneity test for solution 9, the value was 0.000, which is less than 0.05. This means that there is a difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a manufactured magnetic stirrer (analog).

Testing with solution 10, 100ml water with 6.5gr sugar, obtained the results of statistical tests as shown in Table 17. In the homogeneity test for solution 10, the value was 0.000 where the value was less than 0.05. This means that there is a difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a magnetic stirrer manufacturer (analog).

Testing with solution 11, 100ml water with 10 gr of sugar, obtained the results of statistical testing as shown in Table 18. In the homogeneous test for solution 11, the value was 0.000, where the value was less than 0.05. This means that there is a difference in the results of the solution between using a microcontroller based magnetic stirrer (digital) and a magnetic stirrer manufacturer (analog).

TABLE XVII. TESTING WITH SOLUTION 10

	Digital - Analog
Z	-3,873 ^b
Asymp. Sig. (2-tailed)	0,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

TABLE XVIII. TESTING WITH SOLUTION 11

	Digital - Analog
Z	-3,873 ^b
Asymp. Sig. (2-tailed)	0,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

TABLE XIX. RESULT OF STATISTICAL TESTING OF A MICROCONTROLLER BASED MAGNETIC STIRRER WITH A MANUFACTURER'S MAGNETIC STIRRER

No.	Solution	Value of Significance	Analog and Digital Comparison
1.	Solution 1	1,000	No
2.	Solution 2	1,000	No
3.	Solution 3	0,00	Yes
4.	Solution 4	1,000	No
5.	Solution 5	1,000	No
6.	Solution 6	1,000	No
7.	Solution 7	0,00	Yes
8.	Solution 8	0,00	Yes
9.	Solution 9	0,00	Yes
10.	Solution 10	0,00	Yes
11.	Solution 11	0,00	Yes

Based on the results of statistical tests using the non-parametric Wilcoxon signed ranks test, which was tested on 11 solutions, the significance value was obtained according to Table 19.

In solutions 1, 2, 4, 5 and 6 there is no difference in producing a homogeneous solution using a microcontroller

based magnetic stirrer compared to the manufacturer's magnetic stirrer. For solutions 1,2,4,5 and 6 with low, medium and high speeds within 1-15 minutes can produce a homogeneous solution. For the test results on all types of solutions using a microcontroller based magnetic stirrer in Figure 2. From 132 experiments with mixing times of 1, 5, 10, and 15 minutes, 75% of the solution can produce a homogeneous solution.

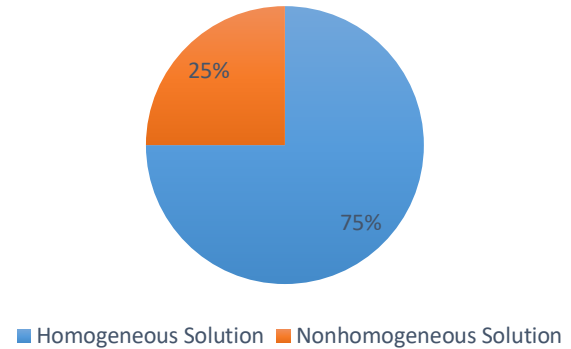


Fig. 2. Result of Testing the Solution Using a Microcontroller Based Magnetic Stirrer

Based on the results of statistical testing and solution testing using a microcontroller based magnetic stirrer in a solution with low viscosity with water mixing with syrup, it takes 1 minute to mix with low, medium and high speeds. For a water solution with special grade syrup for solutions with higher viscosity, it takes 5 minutes at medium and high speeds. To mix water with salt and water with sugar it takes 10 minutes at high speed.

The results of the non-parametric Wilcoxon signed ranks test which were tested on 11 solutions showed that in solutions 1, 2, 4, 5 and 6 there was no difference in producing a homogeneous solution using a microcontroller based magnetic stirrer compared to the manufacturer's magnetic stirrer. For solutions 1, 2, 4, 5 and 6 with low, medium and high velocities within 1 minute can produce a homogeneous yield. For homogeneity results in all types of solutions using a microcontroller based magnetic stirrer and a manufacturer's magnetic stirrer can be seen in Table 20.

There is a difference between digital and analog from Table 20. In solution 3, 100 ml water with 40 ml special grade syrup using a microcontroller based magnetic stirrer requires a minimum mixing time of 5 minutes at medium speed and 1 minute for high speed. Meanwhile, magnetic stirrers with analog speed settings require a minimum mixing time of 1 minute at low, medium and high speeds. This difference is caused by the manufacturer's magnetic stirrer with the analog speed setting at any speed in the initial 30 seconds the rotation speed is in high condition and after 30 seconds the speed is constant according to the set speed. For solutions 7, 8, 9, 10 and 11 the results are in accordance with Table 21. Testing with 11 solutions with different viscosity solutions using a microcontroller based magnetic stirrer and a magnetic stirrer manufacturer can produce a homogeneous solution.

TABLE XX. RESULT OF HOMOGENEITY TEST OF SOLUTION

No	Solution	Significant	Analog – Digital Comparison	Speed	Analog Time				Digital Time			
					1	5	10	15	1	5	10	15
1.	Solution 1	1,000	No	Low	√	√	√	√	√	√	√	√
				Medium	√	√	√	√	√	√	√	√
				High	√	√	√	√	√	√	√	√
2.	Solution 2	1,000	No	Low	√	√	√	√	√	√	√	√
				Medium	√	√	√	√	√	√	√	√
				High	√	√	√	√	√	√	√	√
3.	Solution 3	0,00	Yes	Low	√	√	√	√	X	X	X	X
				Medium	√	√	√	√	X	√	√	√
				High	√	√	√	√	√	√	√	√
4.	Solution 4	1,000	No	Low	√	√	√	√	√	√	√	√
				Medium	√	√	√	√	√	√	√	√
				High	√	√	√	√	√	√	√	√
5.	Solution 5	1,000	No	Low	√	√	√	√	√	√	√	√
				Medium	√	√	√	√	√	√	√	√
				High	√	√	√	√	√	√	√	√
6.	Solution 6	1,000	No	Low	√	√	√	√	√	√	√	√
				Medium	√	√	√	√	√	√	√	√
				High	√	√	√	√	√	√	√	√
7.	Solution 7	0,00	Yes	Low	√	√	√	√	X	X	X	X
				Medium	√	√	√	√	X	X	X	X
				High	√	√	√	√	X	√	√	√
8.	Solution 8	0,00	Yes	Low	X	√	√	√	X	X	X	X
				Medium	√	√	√	√	X	√	√	√
				High	√	√	√	√	√	√	√	√
9.	Solution 9	0,00	Yes	Low	X	√	√	√	X	X	X	X
				Medium	√	√	√	√	X	√	√	√
				High	√	√	√	√	X	√	√	√
10.	Solution 10	0,00	Yes	Low	X	√	√	√	X	X	X	X
				Medium	X	√	√	√	X	√	√	√
				High	X	√	√	√	X	√	√	√
11.	Solution 11	0,00	Yes	Low	X	X	√	√	X	X	X	X
				Medium	X	X	√	√	X	X	√	√
				High	X	√	√	√	X	√	√	√

IV. CONCLUSION

Microcontroller based magnetic stirrer in a solution with low viscosity by mixing water with syrup requires mixing for 1 minute at low, medium and high speeds. For a water solution with special grade syrup for solutions with higher viscosity, it takes 5 minutes at medium and high speeds. To mix water with salt and water with sugar, it takes 10 minutes at high speed. Microcontroller based magnetic stirrer and manufacturer's magnetic stirrer can produce a homogeneous solution.

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