THE EFFECT OF USING AN EXTRA FAN ON CHANGES IN TEMPERATURE, VOLTAGE AND ELECTROLYTE SPECIFIC GRAVITY OF LEAD ACID BATTERIES IN ELECTRIC PALLET MOVERS

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Abstract-- Batteries are one of the vital components that are the main source of energy in electric forklifts which of course must be considered, especially their performance in issuing voltage and density of electrolyte which can be influenced by other factors such as temperature. The design of the battery itself tends to be closed so that it has very minimal air circulation which makes the hot temperature trapped and affects the performance of the battery itself. For these problems, an analysis of the addition of an extra fan on the battery cover was carried out to determine the extent of the extra fan's influence on battery performance (temperature, voltage, and electrolyte density) with a lead acid on the electric pallet mover. SPSS (Statistical Package for the Social Science) is used as a research method which is expected to produce data that shows how much influence the addition of an extra fan has on the battery performance of the electric pallet mover. The results of this study show that the addition of an extra fan to the pallet mover battery cover provides a significant change in the temperature, voltage, and density of the battery electrolyte. When the level of the extra fan is in the off state (none) compared to the level of the extra fan in the high speed state (6500 RPM) in the temperature test, the results show that the average change is 10.93oC. Then when the level of the extra fan is in the off state (none) compared to the level of the extra fan in the high speed state (6500 RPM) in the Voltage test, the results show that the average change is 0.6 volts. Meanwhile, when the extra fan level is in the off state (none) compared to the extra fan level in the high speed state (6500 RPM) in the Density test, the results show that the average change is 0.22.

Keywords: Hot Temperature, Specific Gravity, Temperature, Electrolyte, Lead acid Battery.

1. INTRODUCTION

Recent years have seen a growth in the ownership of electric vehicles (EVs), and the application of electric vehicles has diversified [1].Currently, electric vehicles are increasingly being developed and are one of the solutions in anticipating the impact of the energy crisis [2] In addition to passenger vehicles, many countries have also promoted the use of electric vehicles in the commercial field (e.g. urban logistics, public transportation, and inter-city freight transportation). [3].

CV Nusa Teknik Abadi is a maintenance, rental and sales service company for heavy equipment, especially diesel and electric forklifts. With the increasing interest in electric forklift rentals, conditions like this have been explained that it is important to implement a good maintenance system in each part. This is expected to get the ideal unit performance when rented to customers [4].

Forklifts are transportation of practical work aids for loading and unloading various goods [5]. Part of the electric forklift that is often problematic is the battery. this is because the battery is the main energy in electric forklifts. In addition, the battery is placed in a less air circulation space so that it can increase the heat temperature in the battery and affect the performance or performance of the battery. The battery is the main component that must be maintained in issuing voltage and current from the influence of temperature, considering that this component is expensive and easily damaged [6].

Therefore, the influence of battery temperature and forklift battery performance needs to be raised into a study. Researchers analyzed the addition of an extra fan on the battery cover to find out how the extra fan affects battery performance (temperature, voltage and electrolyte specific gravity) with lead acid on the electric pallet mover.

2. METHOD

This research was conducted by analyzing the addition of an extra fan on the battery cover to determine the extent of the effect of the extra fan on battery performance (temperature, voltage, and electrolyte specific gravity) with lead acid on the electric pallet mover using SPSS (Statistical Package for the Social Science). SPSS (Statistical Product and Service Solution) is a popular program for describing and analyzing statistical data. The drop-down menus in SPSS make it easy for users to perform all statistical procedures [7]. SPSS is used as a research Addition of extra fan to battery performance in electric pallet mover.

2.1 Research Flowchart

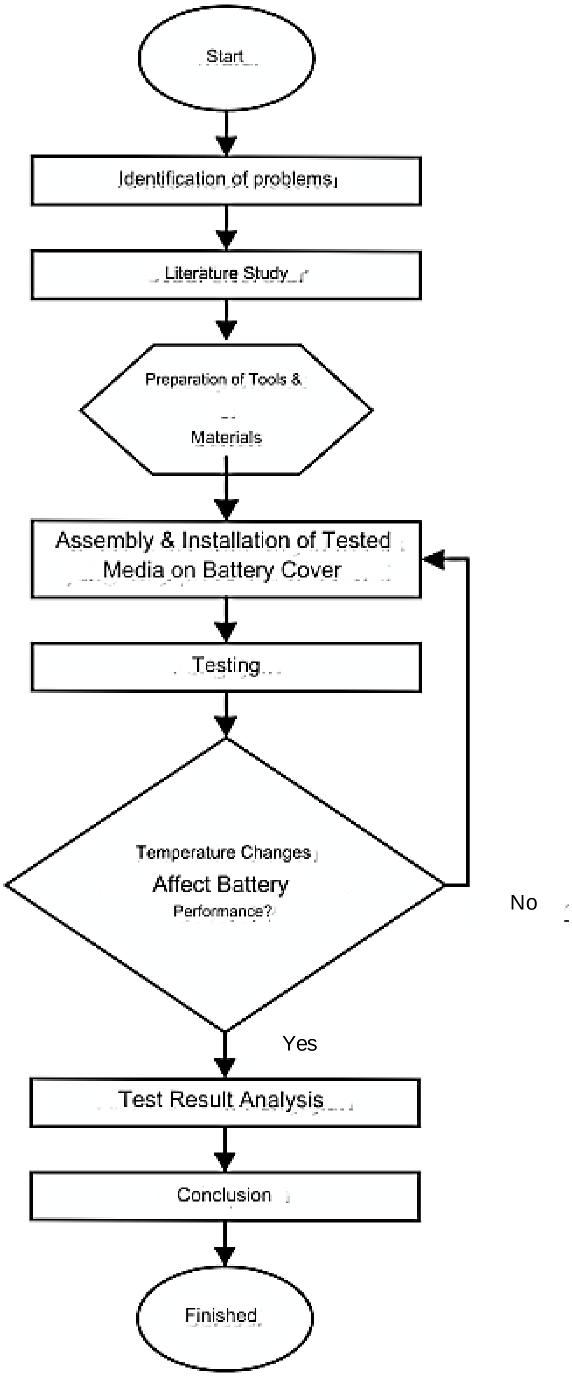


Figure 1. Flow Chart

The topic selection in this problem is the frequent occurrence of customer complaints related to forklift batteries experiencing an increase in temperature and decreased battery performance.

The data collected are primary and secondary data. Primary data is observation data that is carried out directly in the field through measurements or asking information from mechanics. Secondary data is in the form of documentation, historical data, manual books and specification data. Calculation and analysis of data from field studies and literature were carried out with SPSS (Statistical Product and Service Solution). After obtaining the results of the analysis carried out, conclusions are obtained from this research and provide suggestions to the company regarding the results of the research.

Translated with DeepL.com (free version)lapangan melalui pengukuran maupun meminta keterangan dari mekanik. Data sekunder berupa documentation, historical data, manual books and specification data. Calculation and analysis of data from field studies and literature were carried out with SPSS (Statistical Product and Service Solution). After obtaining the results of the analysis carried out, conclusions are obtained from this research and provide suggestions to the company regarding the results of the research.

2.2 Tools and Materials

The following are the tools and materials used in the research:

Table 1. Research Tools

No.	Tool Name
1.	Laptop (Core i5-8265 U / RAM 8 GB / 64 – Bit)
2.	Solid Work 2020
3.	SPSS v25
4.	Thermal Gun Benetech GM320
5.	Volt Meter
6.	Hydro Meter
7.	Tachometer
8.	Stopwatch
9.	Cutter
10.	Lem Akrilik
11.	Converter Step Down 24 VDC to 12 VDC
12.	Wire
13.	Electrical tape
14.	Observation sheet

Table 2. Research Materials

No.	Material Name
1.	Acrylic 3 mm with size :
•	80cm x 4cm
•	80cm x 15.5cm
•	80cm x 19cm
•	80cm x 10cm
•	32.5cm x 4cm x 15.5cm x 19cm x 10cm

2.	Extra fan Antminer 12V 5A 6500 RPM (3PCS)
3.	Baterai 24 V (12 cell)
4.	Wire
5.	Heat Sink

2.3 ASSEMBLY AND INSTALLATION OF RESEARCH OBJECTS

This stage is the process of assembling and installing the battery cover using 3 mm acrylic, extra fan 5 A, volt meter, speed controller and 24V to 12V converter. For the prototype fan cover can be seen in Figure 2.

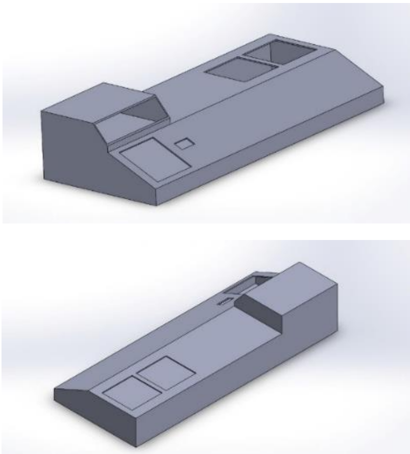


Figure 2. Prototype Cover Extra fan

The following is an overview of the electrical wiring of the battery cover assembly using 3 mm acrylic, 5 A extra fan, voltmeter, speed controller and 24V to 12V converter in Figures 3 and 4.

Figure 3. Wiring Electrical Cover Extra fan

Figure 4. Assembly and Installation

2.4 Testing

This process is a test in how the extra fan works and conducts research whether it runs as desired by the author. After testing, the next step is to check the test results, if the results are not as expected, then return to the assembly and installation stages of the research object to be reviewed again. In testing there are research procedures, namely:

a). Perform battery electrolyte drain

In this study, the electrolyte liquid was drained and cleaned completely replaced by using zuur water, because it contains sulfuric acid. This draining process aims to make it easier when doing research. For more details, see Figure 5.

Figure 5 . Battery Electrolyte Drain

b). Manufacture of Speed Fan RPM Scale and Lead acid Scale

After draining the electrolyte liquid in the battery, the next step is to make an RPM speed extra fan scale to determine the speed variable during battery performance research using a tacho meter as shown in Figure 6.

Figure 6. Fan RPM Scale Making

Next is to make an observation table with load variables for lead acid, the lead acid scale used is 500 Kg, 1000 Kg, 1500 Kg and the extra fan speed scale is none speed, medium speed (4500 RPM) and high speed (6500 RPM). Here is an example of observation table 3.

Table 2.3 Research Observation Table

Fan speed	Load	Temperature	voltage	Specific gravity of electrolyte
None	500 KG			
	1000 KG			
	1500 KG			
Medium Speed (4500 RPM)	500 KG			
	1000 KG			
	1500 KG			
High Speed (6500 RPM)	500 KG			
	1000 KG			
	1500 KG			

c). Use of Measurement Tools

The measuring instruments used for this research are tacho meter, thermo gun, hydro meter and volt meter. Tacho meter serves to determine the variable RPM speed fan during testing. For testing tools in this study are in Figure 7.

Figure 7. Testing tools used

d). Data Retrieval

Data collection was carried out in 3 experiments, in 1 experiment there were 3 fan speed variables, namely none, medium speed (4500 RPM) and high speed (6500 RPM) and each speed fan there were lead acid load variables (500 KG, 1000 KG and 1500 KG). Recharging the battery is done at the time of each replacement of the speed fan, meaning that in this study there are a total of 9 times charging the battery in 3 experiments is expected to facilitate and obtain specific data in testing the performance of the battery. For temperature testing and specific gravity of the electrolyte are in Figures 8 and 9.

Figure 8. Battery Electrolyte Density Testing data collection

Figure 9. Retrieval of Battery Temperature Testing data

Then in taking data, the battery voltage measurement is carried out during the test with a digital volt meter so as to know the actual battery voltage when the lead acid takes place. The following is the position of the volt meter on the battery cover shown with a yellow circle in Figure 10.

Figure 10. Battery Voltage Testing data capture

3. RESULTS AND DISCUSSION

The data from this study were obtained from observations and measurements of temperature, voltage and specific gravity of electrolyte with various lead acid variables in 24 V lead acid batteries using extra fans with variable speeds, namely none, medium speed (4500 RPM) and high speed (6500 RPM).

a). Research Result Data

The following is the data from 3 research experiments on changes in temperature, voltage and battery electrolyte density against variable fan speed in tables 4, 5 and 6.

Table 4. Experiment 1 Result data

	Fan speed	Load	Temperature (C)	Voltage (V)	Density
Experiment 1	None	500 KG	39.6	24.23	1.2351
		1000 KG	42.7	23.82	1.2325
		1500 KG	48.2	23.41	1.2250
	Medium	500 KG	34.2	24.32	1.2475
		1000 KG	35.7	24.25	1.2400
		1500 KG	37.5	24.18	1.2375
	High	500 KG	32.8	24.35	1.2525
		1000 KG	33.5	24.32	1.2475
		1500 KG	34.1	24.29	12450

Table 5. Experiment 2 Result data

	Fan speed	Load	Temperature (C)	Voltage (V)	Density
Experiment 2	None	500 KG	40.0	24.21	1.2325
		1000 KG	43.2	23.62	1.2261
		1500 KG	49.5	23.28	1.2220
	Medium	500 KG	35.5	24.30	1.2453
		1000 KG	35.9	24.23	1.2394
		1500 KG	38.8	24.13	1.2368
	High	500 KG	33.8	24.33	1.2503
		1000 KG	33.8	24.31	1.2469
		1500 KG	34.3	24.29	12425

Table 6. Experiment 3 Result data

	Fan Speed	Load	Temp (C)	Voltage (V)	Density
Experiment 3	None	500KG	43.2	24.11	1.2265
		1000KG	44.6	23.42	1.2201
		1500KG	50.8	23.17	1.2005
	Medium	500KG	34.8	24.26	1.2427
		1000KG	36.2	24.20	1.2390
		1500KG	39.4	24.07	1.2362
	High	500KG	33.3	24.32	1.2487
		1000KG	34.0	24.29	1.2434
		1500KG	34.5	24.27	1.2421

From the graph above, it can be seen that the addition of extra fans with variable speed on lead acid affects the difference from changes in temperature, voltage and electrolyte density at each fan speed variable.

a). Variabel Speed Fan pada Lead acid Terhadap Suhu Baterai Lead Acid 24 Volt

The following data are the results of three research experiments of variable speed fan on lead acid against 24 volt lead acid battery temperature. For more detailed data shown in the table figure 3.1, figure 3.2 and figure 3.3.

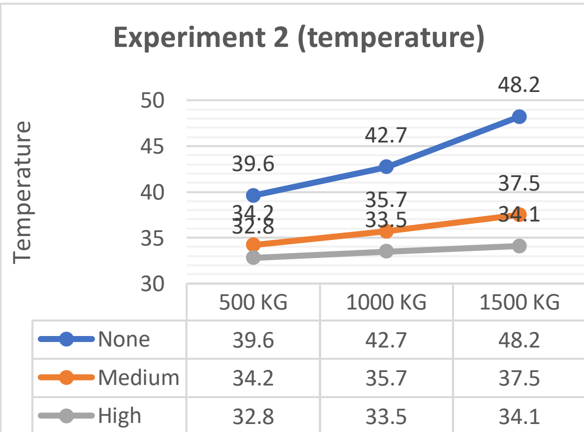


Figure 11. Research experiment 1 against temperature change

From the data in Figure 11, if seen in the 1st experiment graph data above, the battery temperature without using an extra fan will rise significantly and the highest temperature is when the lead acid is 1500 kg, which has a temperature of 48.2°C. While in the experiment of adding an extra fan with high speed speed, a stable temperature drop is obtained, which can be seen in the graph data above with lead acid loads starting from 500 kg getting a temperature of 32.8°C, 1000 kg lead acid load getting a temperature of 33.5°C and 1500 kg lead acid load getting a temperature of 34.1°C.

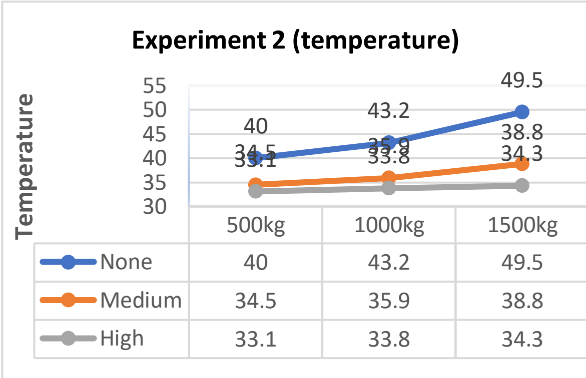


Figure 12. Research experiment 2 against temperature change

From the data in Figure 12, if seen in the graph data of the 2nd experiment above, the battery temperature without using an extra fan will rise significantly and the highest temperature is when the lead acid is 1500 kg, which has a temperature of 49.5°C. While in the experiment of adding an extra fan with high speed speed, a stable temperature drop is obtained, which can be seen in the graph data above with lead acid loads starting from 500 kg getting a temperature of 33.1°C, 1000 kg lead acid load gets a temperature of 33.8°C and 1500 kg lead acid load gets a temperature of 34.3°C.

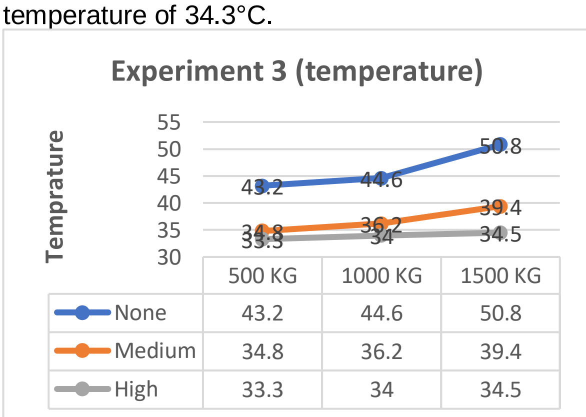
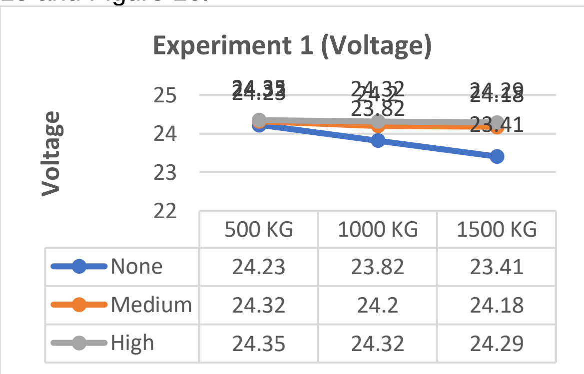


Figure 13. Research experiment 3 against temperature change

From the data in Figure 13, if seen in the 3rd experiment graph data above, the battery temperature without using an extra fan will rise significantly and the highest temperature is when the lead acid is 1500 kg, which has a temperature of 50.8°C. While in the experiment of adding an extra fan with high speed speed, a stable temperature drop is obtained, which can be seen in the graph data above with lead acid loads starting from 500 kg getting a temperature of 33.3°C, 1000 kg lead acid load getting a temperature of 34.0°C and 1500 kg lead acid load getting a temperature of 34.5°C.

b). Variable Speed Fan on Lead acid against 24 Volt Lead Acid Battery Voltage

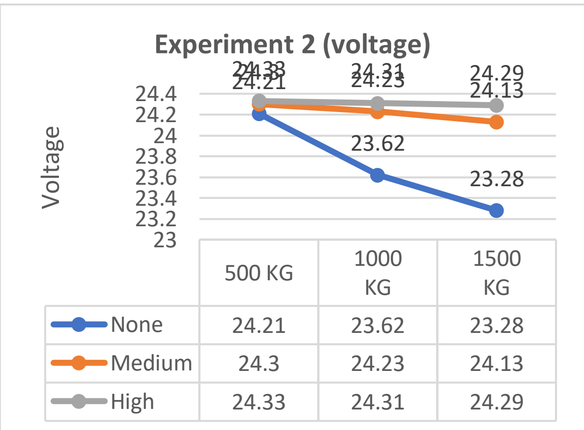
The following data are the results of three research experiments of variable speed fan on lead acid against 24 volt lead acid battery voltage. For more detailed data shown in Figure 14, Figure 15 and Figure 16.



	500 KG	1000 KG	1500 KG
None	24.23	23.82	23.41
Medium	24.32	24.2	24.18
High	24.35	24.32	24.29

Figure 14. Research experiment 1 on voltage changes

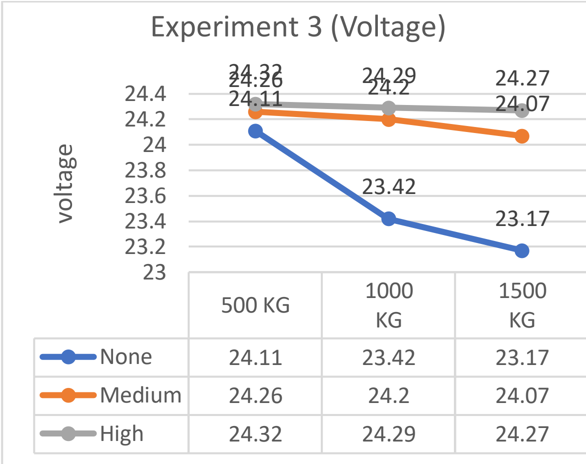
From the data in Figure 14, if seen in the graphical data of the 1st experiment above, the battery voltage without using an extra fan will drop significantly and the lowest battery voltage is when the lead acid is 1500 kg, which has a voltage of 23.41 volts. While in the experiment of adding an extra fan with a high speed speed, a stable voltage increase is obtained, which can be seen in the graph data above with a lead acid load starting from 500 kg getting a temperature of 24.35 volts, a lead acid load of 1000 kg getting a voltage of 24.32 volts and a lead acid load of 1500 kg getting a voltage of 24.29 volts.



	500 KG	1000 KG	1500 KG
None	24.21	23.62	23.28
Medium	24.3	24.23	24.13
High	24.33	24.31	24.29

Figure 15. Experiment 2 on voltage changes

From the data in Figure 15, if seen in the graphical data of the 2nd experiment above, the battery voltage without using an extra fan will drop significantly and the lowest battery voltage is when the lead acid is 1500 kg, which has a voltage of 23.28 volts. While in the experiment of adding an extra fan with a high speed speed, a stable voltage increase is obtained, which can be seen in the graph data above with a lead acid load starting from 500 kg getting a temperature of 24.33 volts, a lead acid load of 1000 kg getting a voltage of 24.31 volts and a lead acid load of 1500 kg getting a voltage of 24.29 volts.



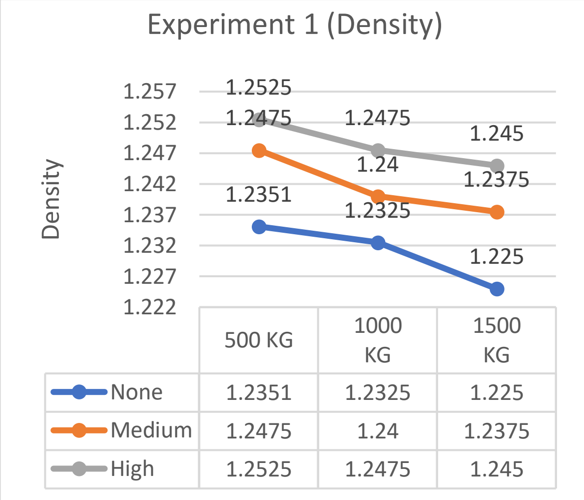
	500 KG	1000 KG	1500 KG
None	24.11	23.42	23.17
Medium	24.26	24.2	24.07
High	24.32	24.29	24.27

Figure 16. Research experiment 3 against voltage changes

From the data in Figure 16, if seen in the graphical data of the 3rd experiment above, the battery voltage without using an extra fan will drop significantly and the lowest battery voltage is when the lead acid is 1500 kg, which has a voltage of 23.17 volts. While in the experiment of adding an extra fan with a high speed speed, a stable voltage increase is obtained, which can be seen in the graph data above with a lead acid load starting from 500 kg getting a temperature of 24.32 volts, a lead acid load of 1000 kg getting a voltage of 24.29 volts and a lead acid load of 1500 kg getting a voltage of 24.27 volts.

c). Variable Fan Speed on Lead acid against Electrolyte Density of 24 Volt Lead Acid Battery

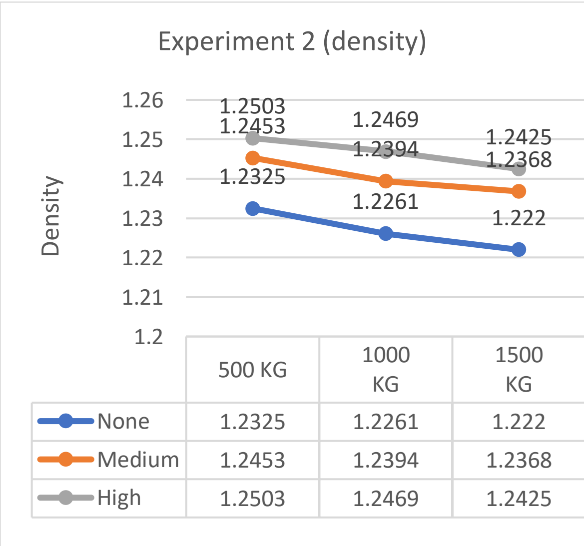
The following data are the results of three research experiments of variable speed fan on lead acid against the electrolyte density of 24-volt lead acid batteries. For more detailed data shown in Figure 17, Figure 18 and Figure 19.



	500 KG	1000 KG	1500 KG
None	1.2351	1.2325	1.225
Medium	1.2475	1.24	1.2375
High	1.2525	1.2475	1.245

Figure 17. Experiment 1 on changes in electrolyte density

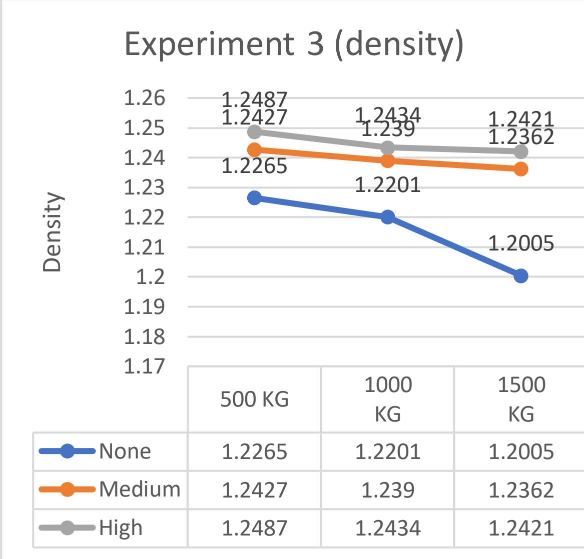
From the data in Figure 17, if seen in the graph data of the 1st experiment above, the density of the battery electrolyte without using an extra fan will drop significantly and the density of the electrolyte



	500 KG	1000 KG	1500 KG
None	1.2325	1.2261	1.222
Medium	1.2453	1.2394	1.2368
High	1.2503	1.2469	1.2425

Figure 18. Experiment 2 on changing electrolyte density

From the data in Figure 18, if seen in the graph data of the 2nd experiment above, the density of the battery electrolyte without using an extra fan will drop significantly and the lowest battery electrolyte density is when the lead acid is 1500 kg, which has an electrolyte density of 1.2220 While in the experiment of adding an extra fan with high speed speed, a stable increase in electrolyte density is obtained, which can be seen in the graph data above with a lead acid load starting from 500 kg getting a temperature of .2503, a lead acid load of 1000 kg getting an electrolyte density of 1.2469 and a lead acid load of 1500 kg getting 1.2425.



	500 KG	1000 KG	1500 KG
None	1.2265	1.2201	1.2005
Medium	1.2427	1.239	1.2362
High	1.2487	1.2434	1.2421

Figure 19. Experiment 3 on changing electrolyte density

From the data in Figure 19, it can be seen that the density of battery electrolyte affects the addition of extra fans with variable fan speed when lead acid. If seen in the graphical data of the 3rd experiment above, the density of battery electrolyte without using extra fans will drop significantly and the lowest battery electrolyte density is when lead acid 1500 kg, which has an electrolyte density of 1. 2005 While in the experiment of adding an extra fan with highspeed speed, the increase in electrolyte density is stable, which can be seen in the graph data above with a lead acid load starting from 500 kg getting a temperature of 1.2487, a lead acid load of 1000 kg getting an electrolyte density of 1.2434 and a lead acid load of 1500 kg getting 1.2421.

d). Data Analysis Process

Data analysis in this study is with the help of SPSS (Statistical Package for the Social Science) using the one way anova method. The purpose of using the analysis with the one way anova method is to find a statistical settlement comparison regarding the effect of using an extra fan on the battery cover.

In the one way anova method there are several types of tests carried out, which include normality test, homogeneity test and hypothesis testing. In addition, the normality test and homogeneity test are prerequisite tests to proceed to the anova test. so that hypothesis testing can be carried out.

a). Normality Test

In research, if the sample is taken from a population that is assumed to be normally distributed, then before data processing it is necessary to test the normality of the distribution of data obtained from the sample. [8]. The normality test aims to see whether or not the distribution of participant data on a research variable is normal.

The basis for decision making in the normality test is, if the significant value is greater than 0.05 then the data is normally distributed. Conversely, if the significant value is smaller than 0.05 then the data is not normally distributed.

The following are the results of the normality test of the Aospan score distribution in each speed fan group on each variable using SPSS software, in table 7.

Table 7. Normality Test

	Speed fan	Kolmogrov-Sminov[a]			Shapiro-Wilk		
		Static	df	Sig.	Static	df	Sig.
Temprature	None	.196	9	.200*	.920	9	.391
	Medium	.195	9	.200*	.916	9	.358
	High	.137	9	.200*	.969	9	.885
Voltage	None	.194	9	.200*	.900	9	.254
	Medium	.127	9	.200*	.966	9	.861
	High	.207	9	.200*	.957	9	.766
Density	None	.204	9	.200*	.834	9	.050
	Medium	.207	9	.200*	.911	9	.325
	High	.142	9	.200*	.953	9	.725

Based on table 7, it can be seen that the results of normality testing with the Kolmogorov-Smirnov test and Shapiro-Wilk test show that the three variables, all speed fan groups have a significant value (p-value) of more than 0.05, which means that the data in the group follows a normal distribution. Thus, it can be continued for the anova test so that hypothesis testing can be carried out.

b). Homogeneity Test

The homogeneity test aims to determine the level of equality of variance values in each group in one variable. The homogeneity test in this study uses the Levene test which tests the null hypothesis (H0) where the variances in different groups are the same (the difference between variances is zero). If the Levene test result is significant at $p \leq 0.05$, it can be concluded that the variances are significantly different. Therefore, the assumption of homogeneity has been violated. However, if Levene's test is not significant ($p > 0.05$) then the variance values are equal [9].

The following is a table of the results of the homogeneity test of the distribution of temperature, voltage, and density data with the levene test using SPSS software on Table 8.

Table 8. Homogeneity Test

	Levene static	df1	df2	Sig.
Temprature	9.767	2	24	.001
Voltage	27.833	2	24	.00
Density	2.171	2	24	.136

Based on the results Table 8 the homogeneity test above, it can be seen that temperature and voltage have a significance value of $p < 0.05$ which means that the data is not homogeneous. While the density data has a significance of $p> 0.05$ which means that the data is homogeneous or the data comes from a population that has the same variance.

c). Hypothesis Test

The hypothesis test used in this study is to use the analysis of variance or anova method. Anova uses two sub-analyses, namely within- subjects test, testing score differences within one group (pretest and posttest), and between- subjects test, testing score differences between groups (control and experimental). The rule used is significant at $p \leq 0.05$. The following are the results of the anova analysis test in Table 9.

Table 9. Uji Anova

		Sum of squares	df	Mean Square	F	
Temprature	Between groups	586.465	2	293.233	44.142	.000
	Within Groups	159.431	24	6.643		
	Total	745.896	26			
Voltage	Between groups	1.954	2	.977	16.674	.000
	Within Groups	1.406	24	.059		
	Total	3.360	26			
Density	Between groups	.002	2	.001	26.139	.000
	Within Groups	.001	24	.000		
	Total	.003	26			

From the data analysis of Table 9, it can be said that H0 is rejected because $p < 0.05$, which means that there is a difference in the average of each variable (temperature, voltage, and density) in the speed fan group. Therefore, the next test must be carried out, namely the post hoc test.

Table 10. Post Hoc Test

Depent variable		(I) Speedfan	(J) Speedfan	Mean Diference (I-J)	Std.Error	Sig
Temperature	Games-Howell	None	Medium	8.31111*	1.47574	.000
			High	10.93333*	1.35252	.000
		Medium	None	-8.31111*	1.47574	.000
			High	2.62222*	.64924	.007
		High	None	-10.93333*	1.35252	.000
			Medium	-2.62222”	.64924	.007

Voltage	Games-Howell	None	Medium	-.51889*	.13949	.013
			High	-.61111*	.13716	.005
		Medium	None	.51889*	.13949	.013
			High	-.09222*	.02798	.021
		High	None	.61111*	.13716	.005
			Medium	.09222"	.02798	.013
Density	Bonferroni	None	Medium	-.01601*	.00315	.000
			High	-.02207*	.00315	.000
		Medium	None	.01601	.00315	.000
			High	-.00606	.00315	.200
		High	None	.02207	.00315	.000
			Medium	.00606	.00315	.200

The Post Hoc Test results in Table 10 are divided into two, some using Bonferroni and some using Games-Howell, this is because the temperature and voltage variables do not meet the assumption of homogeneity. The table above shows that the none speed fan group on the temperature variable has an average difference with the medium speed fan of 8.31°C with a significance of 0.000 ($p < 0.05$). This value shows that the temperature has decreased significantly. And when the speed fan (none) is compared with the speed fan (high speed), the average difference is 10.93°C. This means that the battery temperature is 10.93°C hotter when the speed fan (none).

Each group in the temperature variable has an average difference, which means that the fan speed greatly affects the battery temperature. The interpretation of the post hoc test results of the voltage variable is the same as the temperature variable, namely the average difference in voltage occurs in each speed fan group. The largest average difference occurs when comparing the voltage when the fan speed (none) with the voltage when the fan speed is high, where the difference is up to 0.6 volts with a significant value (p-value) of 0.005. As for the density variable, there was an average change of 0.016 at medium fan speed and 0.22 at high fan speed. The decrease in the density of the electrolyte from the battery shows that the higher the intensity of the speed fan, the greater the change in density when compared to speedfan none. While the speed fan medium and speed fan high, only have a very small average difference with a significant value (p-value) of 0.200 which means that the average difference detected in the anova results is due to the speed fan none group compared to other speed fan groups.

4. CONCLUSIONS AND SUGGESTIONS

4.1Conclusion

Based on the results of the analysis carried out on testing the effect of adding extra fans on changes in temperature, voltage and density of battery electrolyte, the authors draw the following conclusions:

1. The design of this simple battery cooling system uses a simple framework made of acrylic with a 5 A fan motor because it has excellent rotation and power as a battery pendigin, so that air circulation in the battery is normal and can maintain battery performance.
2. Based on the research data, the authors draw the conclusion that changes in temperature when without using an extra fan (none) compared to using an extra fan (high speed 6500 RPM) have an average change of 10.93°C. Then for changes in battery voltage, when without using an extra fan (none) compared to using an extra fan (high speed 6500 RPM)) has an average of 0.6 volts. While the change in battery electrolyte density when without using an extra fan (none) with using an extra fan (high speed 6500 RPM) is 0.22.

   Changes in temperature, voltage and electrolyte density of the battery show that the higher the intensity of the fan speed, the greater the change in temperature, voltage and electrolyte density when compared to without using an extra fan (none). So it can be said that the addition of extra fans with variable fan speed affects the performance of a battery [10].

4.2 Suggestions

The following are some suggestions that can be used as a reference for further research.

1. For future research, testing can be carried out with other parameters such as current / ampere and time measurements.
2. For similar research, we recommend using other types of batteries, which can use lithium batteries because of the rapid development of batteries.
3. For further research, it can examine the design of the battery cover using the addition of an extra fan so that the battery cover design and extra fan airflow can be specifically known.

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