ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 12(2), DOI: 10.17485/ijst/2019/v12i2/138532, January 2019*

Development and Innovation of a Crayon Recycling Device

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Abstract

Objectives: To develop and test a crayon recycling device in terms of power consumption and quality of the product in terms of vibrancy of the color, coloring ability and strength and cost of production. **Methods and Analysis:** The researchers tested the quality of the product in terms of vibrancy of the color and coloring ability with a remark perceived by the raters that there is no significant difference among treatment 2 and 3. In treatment 1, the bigger broken crayons took a longer time to melt and leave hollow space in the core part. In treatment 3, the smaller chopped crayons at .25-inch length has the shortest time to melt and is evenly solid at the core part. The researchers used manually fabricated melt pan situated above the heating element. It was observed that using the melt pan in the melting process is very useful because it took a short time to liquefy the crayons. In the quality of the crayon, comparing the other three treatments with treatment 1, a highly significant difference exists due to the composition of the crayon as well as the strength of the product with a remark that treatment 1 and treatment 2 shows that it can carry a total load of 19.614 N before the product breaks. **Findings:** From the discussion and analysis of the gathered data and findings, the crayon recycling device is efficient and can be used by the stakeholders in creating visual arts and can compete with the commercialized crayon recycling device. Based on the results and discussions, the following conclusions were drawn from the study. The crayon recycling device is efficient in producing quality recycled crayons which are comparable to newly produced crayons. **Applications:** The crayon recycling device is very efficient in terms of its power consumption. It is also economically viable in recycling small pieces of crayons.

Keywords: Crayons, Development, Fabrication, Innovation, Recycling

1. Introduction

Crayons are usually used mainly by children for writing drawing, coloring, and the like. Crayons have long been used as a children's playtime staple. Crayons are a powerful tool of expression to support learning, development, creativity, and imagination in the hands of young minds[1]. Crayons are considered to be the favorite of preschoolers because of the size and usability. Simple motor skills control like a soft glide is needed to use it. Due to their nature, however, crayons wear down to small pieces with constant use. Crayons get broken easily and undergo premature breakage. Premature breakage refers to the common problems of crayons during usage. Typically, children who are beginners use an extraordinarily high amount of pressure in applying the writing instrument to the study which causes the crayon to break prematurely[2].

Unfortunately, the smaller pieces become difficult to use. As a result, they lose some of their play value and tend to cause clutter. This results in waste because crayons are typically sold per box, not per piece, thus requiring the purchase of an entire collection to replace worn individual colors[3]. Paraffin crayons can take up years to naturally biodegrade into the ecosystems and only in the right conditions and environment. Decomposing back into the ecosystem can be a prolonged process. Sometimes crayons mix with by-products can cause low-carbon pollution and create landfill pollution because crayons are made from renewable resources[4]. Many crayons are not being

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recycled. When crayons are broken, its usability diminishes, and the youngsters who are the frequent users hesitate to use it anymore. These broken crayons usually end up in landfills which are harmful to the environment. With such environmental reason and also some economic reasons as well, the researchers came up with an idea to design, fabricate and test a device that can reduce, reuse, and recycle (3Rs). Recycling old crayons is a great alternative to throwing them away. It could be a great help to the environment. The device recycles broken crayons and other materials by melting and molding[5].

2. Materials and Methods

It presents the data gathering procedures; the flowchart is shown in Figure 1, materials needed, review of existing designs, preparation, general procedure, assembly and fabrication of the device, and data gathering procedure.

2.1 Review of Existing Design

Before making the design, the researchers considered the existing models of Electric crayon making or recycling devices that served as the basis in creating their design.

2.2 Making the Design

The design was inspired and conceptualized from the principle of innovated crayon device is shown Figure 2.

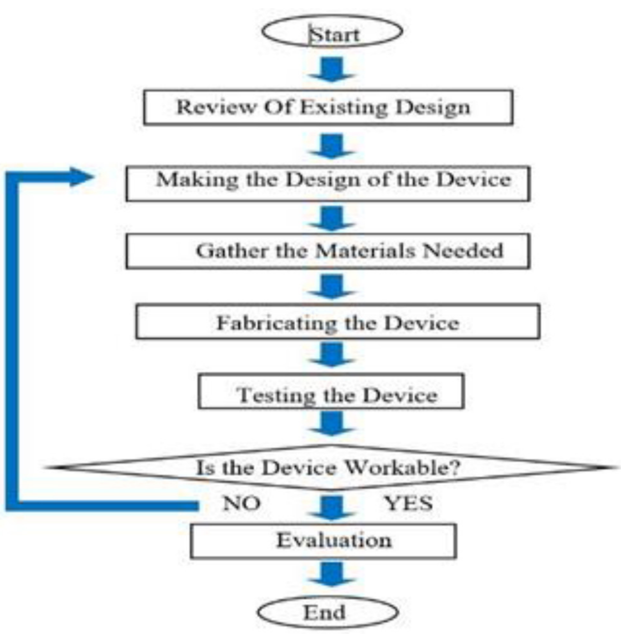

Figure 1. Flowchart.

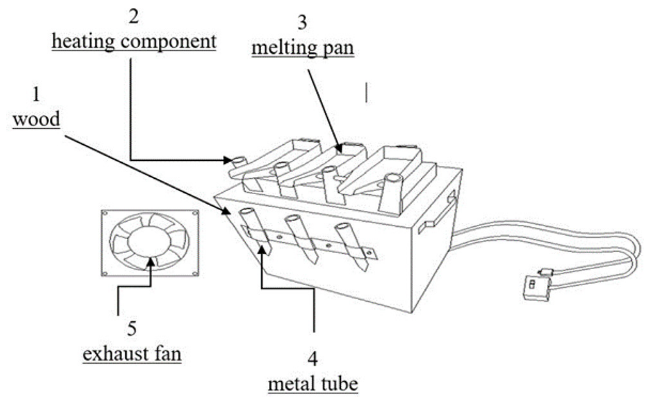

Figure 2. Pictorial diagram of the innovated crayon recycling device.

2.3 Materials of the Study

The materials used in the study were the heating filament of an old flat iron, switch, led, wire (3m), AC Cord, AC DC adaptor, male plug, wood, molders and melt pans.

2.4 Assembly Procedure

The materials needed are prepared for the fabrication of the device based on the design. Some are recycled, others are fabricated and bought.

2.5 Fabricating the Device

The wood (1) served as the cover would hold the heating component (2) together with the melt pan (3). This component would connect to the heating component to absorb the heat. Melting pans contain the heating component that increases temperature causing the crayon to liquefy. The metal tube (4) serves as the cast or mold for the liquefied crayon. The exhaust fan (5) would lessen the heat from the device. The switch would control the exhaust fan during the particular operating conditions.

2.6 Treatments of the Study

T1 - crayons chopped at one fourth inch length
T2 - crayons chopped at half inch length
T3 - crayons chopped at 1-inch length
T4 - control

2.7 Data Gathering Procedure

The researchers gathered data through testing the device regarding the device output capacity, the power output, the quality of the recycled crayon, and the cost of production.

Regarding the quality of the recycled crayons, the researchers gathered data by comparing the four samples labeled as T1, T2, T3, and T4. Testing the strength in Newton (N) was done by multiplying gravity with the weight (load) at the breaking point of the crayons. The vibrancy and coloring ability of the four treatments were tested by ten raters (drafting students, graduates, and instructors who are experts in using coloring materials like crayons) by using the following 5 points Likert Scale:

5- Very vibrant /Very easy to apply
4- Vibrant/Easy to apply
3-Slightly vibrant/Slightly easy to apply
2-Less vibrant/Less easy to apply
1-Not vibrant/Hard to apply

3. Discussion of Results

It presents the analysis and interpretation of data concerning the study.

3.1 General Observation

The following observations were recorded during the conduct of the study.

The process of recycling crayon requires a lot of considerations if it is to be introduced to consumers especially children. The opinion of the parents, guardian, or teachers on the device and the process must be considered and deliberated. It has been observed that crayons can seriously hurt when melted and liquefied. Extra care should be applied when doing any crayon recycling process. In treatment 1, the bigger broken crayons took a longer time to melt and leave hollow space in the core part. In treatment 3, the smaller chopped crayons at .25 inch length has the shortest time to melt and is evenly solid at the core part. The researchers used manually fabricated melt pan situated above the heating element. It was observed that using the melt pan process is effective because it took a short time to liquefy the crayons.

3.2 Power Consumption of the Device

Power consumption of the blower

$$\mathbf{P = 12 \times 0.24}$$

$$2.88\text{W} \times \frac{1\text{h}}{100} = 0.00288\ (9.47) = 0.02727\ \text{V per hour}$$

The power consumption of the heating element

$$\mathbf{W \times \frac{1h}{1000}(kWh)}$$

$$670\ \text{W} \times \frac{1\text{h}}{1000}(9.47) = 6.3449\ \text{V per hour}$$

3.3 Quality of the Product

Table 1 shows the vibrancy of the color of the four samples. The table reveals that Treatment 1 is superior in its vibrancy with a mean of 4.9, Treatment 2 and Treatment 3 tied at 4.7 mean. Treatment 4 got a rated mean of 3.0.

Analysis of Variance shown in Table 2. Remarks that there is no significant difference between Treatment 2 and 3. However, comparing the other three treatments with treatment 1, a highly significant difference exists due to the composition of the crayon. Crayon is hydrocarbon like oil. So it is carbon and hydrogen. When it melts or burns, the carbon is released, and the hydrogen is combined with the air's oxygen to create evaporated water thus leaving more concentrated colorant or pigment on the re-hardened crayon.

Treatments carrying the same letter do not significantly vary.

Table 3 shows the coloring ability of the crayons. The table reveals that the treatment 1 and treatment 2 attained the highest mean of 5.0 followed by treatment 3 with 4.5 mean. Treatment 4 though has the lowest mean of 4.1

Table 1. Vibrancy of the Color as perceived by the raters

Treatments	Respondents									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	4	5	5	5	5	5	5	5	5	5
2	5	5	5	5	5	5	5	3	4	5
3	4	5	5	5	5	5	5	4	4	5
4	5	3	4	4	3	2	2	2	2	3

Summary

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	10	49	4.9	0.1
Row 2	10	47	4.7	0.4555556
Row 3	10	47	4.7	0.2333333
Row 4	10	30	3.0	1.1111111

Table 2. ANOVA of table 1.0

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	23.675	3	7.8916667	16.614035**	6.107 E-07	2.8662656
Within Groups	17.1	36	0.475			
Total	40.775	39				

**** Highly significant LSD = 0.261525**

Treatments	
T1	**a**
T2	**b**
T3	**b**
T4	**c**

***Treatments carrying the same letter do not significantly vary**

implying that it has the least coloring ability among the treatments.

Analysis of Variance shown in Table 4. Remarks that there is no significant difference between the Treatment 1 and Treatment 2. However comparing the Treatment 3 and Treatment 4 to both the Treatment 1 and 2, a highly significant difference exists due to the actual colorant of the crayon. According to the colors used in crayons are achieved with the useof pigments, and pigments, unfortunately, are not soluble. What this means is that when a crayon is melted, the color of the crayon breaks down into small pigment particles that exist in a dispersed manner among the melted wax. These pigments appear to change the color of the wax[6,7].

LSD = 0.146965

Treatments carrying the same letter do not significantly vary.

Table 3. Coloring ability as perceived by the raters

Treatments	**Respondents**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	5	5	5	5	5	5	5	5	5	5
2	5	5	5	5	5	5	5	5	5	5
3	5	5	4	5	4	5	5	4	4	4
4	5	5	4	4	4	4	4	4	4	3

Summary

Groups	*Count*	*Sum*	*Average*	*Variance*
Row 1	10	50	5.0	0
Row 2	10	50	5.0	0
Row 3	10	45	4.5	0.277778
Row 4	10	41	4.1	0.322222

Table 5 shows the strength of the four samples. The treatment 1 and treatment 2 shows that it can carry a total load of 19.614 N before the product breaks while the treatment three can carry a load of 20.5947 N and shows that it has the heaviest load applied. The treatment 4 has the lightest load applied that has 6.8649 N. The first 3 Treatment do not significantly differ with each other, however, treatment four which is the control. This is due to the physical composition of crayons. Crayons are made up of softer ingredients; they are a compound that includes pigments and oils. This is why it feels different to write with them, and when a strong force is applied to a new crayon, it easily breaks. The recycled crayons are stronger or harder to break because of there-hardening process. Table 6 shows the actual market costs of parts and materials excluding the fabrication labor and transportation cost.

4. Conclusions and Recommendations

4.1 Conclusions

Based on the discussion and analysis of the gathered data and findings, the crayon recycling device is efficient and can be used by the stakeholders in creating visual arts and can compete with the commercialized crayon recycling device.

Based on the results and discussions, the following conclusions were drawn from the study:

- The crayon recycling device is efficient in producing quality recycled crayons which are comparable to newly produced crayons.

Table 4. ANOVA of table 2.0

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.7	3	1.9	12.66667**	8.36 E-06	2.866266
Within Groups	5.4	36	0.15			
Total	11.1	39				

**** Highly significant LSD = 0.146965**

Treatments	
T1	a
T2	a
T3	b
T4	c

***Treatments carrying the same letter do not significantly vary**

- The crayon recycling device is very efficient regarding its power consumption.
- The crayon recycling device is economically viable.

4.2 Recommendations

Based on the findings and conclusions drawn from the study, the researchers highly recommend the following:

- A further study should be conducted to improve the design of the device.
- The use of flat based melt pan should be considered for better and more uniformed melting of the crayons.

Table 5. The table below shows the treatments on how much Newton (N) was put to the test the strength of the product before it breaks

Treatment 1	2 kg	19.614 N
Treatment 2	2 kg	19.614 N
Treatment 3	2.1 kg	20.5947 N
Treatment 4	0.7 kg	6.8649 N

Table 6. Cost of production

Quantity (pcs)	Description	Cost
1	Switch	25
1	LED	15
2	Wire (3m)	45
1	Male Plug	35
1	AC DC Adaptor	185
1	Exhaust Fan	150
3	Melt Pan	400
TOTAL		**Php 855**

- Usage of the device to recycle old broken crayons to help mitigate climate change.

The provisions of a safety cover to avoid accidental burning of users.

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