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Hot Air Silkscreen Printing Dryer

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Abstract*:* The most efficient way to dry paint is by using hot air, which applies to any printing process, including silkscreen printing. This study used the developmental method of research. A researcher-made evaluation sheet adopted from the study of Ledesma (2020) [1] was used. However, some items were modified to answer some of the parameters included in this study. The main objective of the study was to fabricate a hot air silkscreen printing dryer. It effectively dried 10 pcs A4 size prints, 20 pcs 3"x 9" size prints, and 60 pcs 2.75" logo size prints per loading in varying times. The shortest drying time for A4 size prints was 3 minutes, and for 3"x 9" and 2.75" sizes was one minute. The device consumes 0.0833 KwHr with a computed cost of ₱1.0629 per minute of operation. Results also showed that the composition, fabrication, features, operating performance, and safety of the device were "Very Acceptable".

Keywords: hot air, drying device, silkscreen printing, operating performance

I. INTRODUCTION

Background of the Study

One of the first and yet the most popular methods of printing is silk screen printing. Until now, it has been widely practiced in small and big printing operations. Even in the presence of modern technology and new methods of printing, it is still the choice of t-shirt printer because of its low operation cost. In silkscreen printing operation, in particular, it is necessary to dry paints to finish the work or to proceed with another printing. There are several methods for drying paints in silkscreen printing, first and the most conventional way is by air drying. The silkscreen practitioner hung the printed garments/textiles for several hours allowing air to dry prints. Another method is by drying under the heat of the sun. This method is done only in daylight and in good weather conditions. Modern paint-drying techniques typically involve the use of commercially available devices that operate on electricity and require manual operation. These systems rely on the chemical properties of the ink and substrate used in printing (Saad et al., 2021) [2].

However, silkscreen printing requires a large space for drying printed materials. Even though it is considered low cost, it still consumes a large amount of electricity to speed up the drying process. It also requires a lot of human intervention in the manipulation of this device. Although silkscreen printing is a popular technique, it has various drawbacks including slow production and low-quality output (Jahangir, 2018) [3]. Electricity today is vital and widely used to make production easier to accomplish, but often it comes with a cost. In the t-shirt printing business, small and large-scale productions are always confronted with high electricity bills. The researcher, as a practitioner, experiences the said factors that lessen the productivity of the silkscreen printing business. This is the very reason why the researcher fabricated a device for an efficient and convenient drying mechanism that can reduce power consumption and increase printing production. The device is an alternative method of drying that uses ordinary blow dryers that produce hot air inside the compartment to dry the printed textiles. The device can load with a maximum capacity of printed t-shirts and dry in a short period. This can be operated in a limited space and with mobility during printing and drying.

Significance of the Study

The study would inspire t-shirt printing practitioners, t-shirt printing business owners, Drafting and Graphic Arts teachers and students to use the hot air silkscreen printing dryer

Scope and Limitation of the Study

The study was limited only to the fabrication and acceptability of hot air silkscreen printing dryer. It was conducted by the researcher with the aim to innovate a device that could increase the number of prints being dried, make the drying time of prints faster, and minimize power consumption with less energy cost. Also, it aimed to give opportunity to small-scale printers to engage in large-scale production. The instrument used to gather data was a questionnaire adopted from the study of Ledesma (2020).

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II. METHODOLOGY

This study used the developmental method of research. The designing and evaluation type of study was adopted and used in this study. The researcher designed and developed a hot air silkscreen printing dryer intended to lessen the drying time of prints on the t-shirt, increase the number of printed textiles being dried and lower energy costs.

III. RESULTS AND DISCUSSION

Technical Features and Functions of Hot Air Silkscreen Printing Dryer

The following were the technical features and functions of the HASPD:

Pull and push drawer drying compartment- made of 3/4" thick x 29 ½" in width x 22 ½" in height x 38" in length marine plywood installed with cabinet slider, insulation aluminum foam to isolate and allow hot air circulate inside. A removable tray is provided in which the printed textile is laid off, for loading and unloading of printed textiles to be dried.

Pull and push type storage drawer. This part of the device serves as a storage for the materials and tools for printing such as textile paints, squeegee, and silk screens. It is located below the drying compartment.

Power breaker. It serves as a terminal switch. Its purpose is to turn on and off the electrical source and prevent power overloading.

Digital timer with automatic shutdown and alarm. It is made of electronic components installed for setting time while drying. Its function is to let the operator manipulate the digital timer with an alarm and automatically shut off the device allowing the drying process done properly and successfully.

Blow drier. It is composed of 1000 watts drier installed on top of the box. Its function is to supply hot air to dry prints on textiles.

Top air inlet cover. It is placed on top of the device, that serves as cover to secure the blow driers and electrical wiring from outside elements that may damage the device and the safety of the operator. It is a box made of ½" plywood provided with holes on top and sides. These holes are covered with screen mist that prevents unwanted materials from entering the air inlet of the blowers. The top portion is designed for convenient opening during the maintenance period and for electrical maintenance.

Digital temperature control. It is an electronic device with a capacity of 15 amperes and 220V power voltage. It is used as a temperature reader and temperature control that may shut down if it reaches the maximum temperature being set by the operator.

Caster Wheels. It is attached at the base of the device. Its function is to move the device for ease of mobility wherever the operator decides to place it.

Considering the technical features of the HASPD, it conforms to the invention of Li (2021) [4] of a drying device for silkscreen printing, which has a drying box body with conveying openings on both sides, air heater, air distribution plate with multiple vent holes, and circulating fan. The device greatly improves drying efficiency while preventing damage to the conveyor belt and printed materials due to high temperatures during direct heating. It also includes a pressing device to protect the printed materials. The device has different parts that has its individual functions. This greatly contributes to the effectiveness of the device on drying printed materials which is its main function

Operating Performance of Hot Air Silkscreen Dryer in terms of Number of Printed Textiles Dried

Table I shows the performance of the hot air silkscreen printing dryer in terms of number of prints dried. The result in trial one (1) shows that it can dry 10 pieces of A4 size prints of both classic and rubberized textile paints on both cotton and athletic textiles per loading. For trial two (2), result shows that it can dry 20 pieces of 3"x 9" size prints of classic and rubberized paints on both cotton and athletic textiles per loading. Finally, for trial three (3), it can dry 60 pieces of 2.75" x 2.75" logo size prints of classic and rubberized textile paints on both cotton and athletic textile per loading.

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This result was based on actual observations of evaluators present while the evaluation was conducted. This implies that the hot air silkscreen printing dryer can dry a volume of printed textiles of classic and rubberized textile paints on both cotton and athletic textiles per loading. It can dry 10 pieces of A4 size prints, 20 pieces of 3"x 9" size prints and 60 pieces of 2.75" x 2.75" logo size prints per loading.

Results conformed to the study of Abuan et al. (2022) [5] on the performance of textile paint dryers on the number of prints dried by the device. The result of this study showed that the textile paint dryer effectively dried 30 to 50 pcs of printed fabrics within 15 minutes and could be used in mass-printing production. In comparison with the result of the performance of the hot air silkscreen printing dryer in terms of the number of printed garments/textiles dried, the HASPD performed better by having more outputs. The device dries print in increasing number and in less period of time making the device effective and more convenient in drying prints in silkscreen printing t-shirt production.

Table I. Operating performance of hot air silkscreen printing dryer in terms of number of printed textiles dried

No. of Trial	Size of Print	Type of Textile	Textile Paint	Number of Prints Per Loading (pcs.)
1	A4	Cotton and Athletic	Classic and Rubberized	10
2	3"X 9"	Cotton and Athletic	Classic and Rubberized	20
3	2.75" X 2.75" Logo	Cotton and Athletic	Classic and Rubberized	60

Operating Performance of Hot Air Silkscreen Printing Dryer in terms of Drying Time in Drying A4 Size Prints

Table II shows the result of the performance of hot air silkscreen printing dryer in drying A4 size prints. In drying A4 size prints, data are recorded in three (3) allotted periods of drying. First allotted period is one (1) minute, second period is with three (3) minutes and third period is with five (5) minutes of drying time. Based on the results, first allotted period of one (1) minute has a result of "Not Dry" for drying classic and rubberized textile paints for both cotton and athletic textiles. For the second period, the result is "Dry" in drying classic and rubberized textile paints on both cotton and athletic textiles in three (3) minutes of drying. Finally, for third period the result is "Dry" in drying classic and rubberized textile paint on both cotton and athletic textiles in five (5) minutes of drying.

Results imply that the hot air silkscreen printing dryer is not effective in drying A4 size prints within one (1) minute, but it can effectively dry prints within three (3) minutes to five (5) minutes of drying prints with classic and rubberized on both cotton and athletic textiles.

Table II. Operating performance of hot air silkscreen printing dryer in terms of drying time in drying A4 size prints

Textile	Textile Paint	Time	Results
Cotton	Classic	1 Minute	Not Dry
		3 Minutes	Dry
		5 Minutes	Dry
	Rubberized	1 Minute	Not Dry
		3 Minutes	Dry
		5 Minutes	Dry

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Athletic	Classic	1 Minute	Not Dry
		3 Minutes	Dry
		5 Minutes	Dry
	Rubberized	1 Minute	Not Dry
		3 Minutes	Dry
		5 Minutes	Dry

Operating Performance of Hot Air Silkscreen Printing Dryer in terms of Drying Time in Drying 3"x 9" Size Prints

In drying 3" x 9" size prints, data were recorded in three (3) allotted periods of drying as shown in Table 6. First allotted period is with one (1) minute, second period with three (3) minutes and third period with five (5) minutes of drying time. Based on the results, the one-minute period of drying has a result of "Dry" for drying classic and rubberized textile paints for both cotton and athletic textiles. For three (3) minutes of drying, the result is "Dry" in drying classic and rubberized textile paints on both cotton and athletic textiles. Finally, for the third period the result is "Dry" in drying classic and rubberized textile paint on both cotton and athletic textiles in five (5) minutes of drying. Results imply that the hot air silkscreen printing dryer is effective in drying 3"x 9" size prints in all allotted periods. Thus, the shortest drying time for 3"x 9" size prints both for classic and rubberized textile paints on both cotton and athletic textiles is 1 minute.

Table III. Operating performance of hot air silkscreen printing dryer in terms of drying time in drying 3"x 9" size Prints

Textile	Textile Paint	Time	Results
Cotton	Classic	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry
	Rubberized	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry
Athletic	Classic	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry
	Rubberized	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry

Operating Performance of Hot Air Silkscreen Printing Dryer in terms of Drying Time in Drying 2.75"x 2.75" Logo Size Prints

Table IV shows the result of the performance of hot air silkscreen printing dryer in drying 2.75"X 2.75" logo size prints. Data for drying time are recorded in three (3) allotted periods. First allotted period is with one (1) minute, second period is with three (3) minutes, and third period with five (5) minutes of drying time. Based on the results, the first allotted period has a result of "Dry" for drying classic and rubberized textile paints for both cotton and athletic textiles in one (1) minute of drying.

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For the second period, it has a result of "Dry" in drying classic and rubberized textile paints for both cotton and athletic textiles in three (3) minutes of drying. Finally, for the third period the result, it has a result of "Dry" in drying classic and rubberized textile paint on both cotton and athletic textiles in five (5) minutes of drying. Result implies that the shortest drying time for 2.75" logo size prints was one (1) minute.

These results contrast to the study conducted by Shen (2022) [7], the drying time is longer and the structure of the drying device is more complex due to the numerous components required for careful drying to achieve quality standard prints. As for the results of the performance of HASPD in drying prints in classic and rubberized textile paints on both cotton and athletic textiles, the device is effective. Drying time varies on the size of the prints being dried.

The larger the size of prints being dried by the device, the longer period of drying it will take. The smaller the size of prints the shorter time it will take to dry.

Table IV. Operating performance of hot air silkscreen printing dryer in terms of drying time in drying 2.75" x 2.75" logo size prints

Textile	Textile Paint	Time	Results
Cotton	Classic	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry
	Rubberized	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry
Athletic	Classic	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry
	Rubberized	1 Minute	Dry
		3 Minutes	Dry
		5 Minutes	Dry

Operating Performance of Hot Air Silkscreen Printing Dryer in terms of Power Consumption

Table V shows the performance and power consumption of hot air silkscreen printing dryer in drying classic and rubberized textile paint printed on athletic textiles. Data were recorded in three (3) allotted periods. For the allotted one (1) minute drying, it had a power consumption of 0.0833; for the allotted three (3) minutes drying had a power consumption of 0.2499; and for the five (5) minutes drying, it had a power consumption of 0.4165. It has a constant voltage of 215 volts and 23.25 ampere in all allotted periods done.

This implies that the longer the time of drying the higher power consumption will be. The shorter the time of drying the lower the power consumption is consumed. The results conformed to the study of Ledesma (2020) [1] on the performance and power consumption of the device in adhering transfer paper to garments and textiles. The power consumption might vary depending on the allotted time element.

However, it still consumed minimal power and was eco-friendly. The device also showed similar results when it comes to the sublimation of transfer paper to mugs and the adhesion of transfer paper to logos, which is enough to provide profit to the producer or entrepreneur using the product. As for the result of the performance of HASPD in terms of power consumption, the power consumption of the device varies on the allotted time of drying.

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Table V. Operating performance of hot air silkscreen printing dryer in terms of power consumption

Power Consumption					
Period of Drying	**Voltage in Volts**	**Current in Ampere**	**Power (Watts)**	**Time in Hour**	**Energy Consumption KwHr.**
1 minute	215	23.25	5,000	0.0166	0.0833
3 minutes	215	23.25	5,000	0.0500	0.2499
5 minutes	215	23.25	5,000	0.0833	0.4165
Mean	215	23.25	5,000	0.0499	0.2499

Legend; Power = Voltage x Current/1000 Energy consumption = kw x time in hour

Operating Performance of Hot Air Silkscreen Printing Dryer in terms of Energy Cost

Table VI shows the operating performance of the hot air silkscreen printing dryer in terms of energy cost in drying prints of classic and rubberized textile paints for both cotton and athletic textiles. Data were based on three (3) allotted periods. The first was with one (1) minute of drying, second with three (3) minutes of drying, and third with five (5) minutes of drying. For the one (1) minute drying, it had a kilowatt hour of 0.0833 multiplied by the energy rate of ₱12. 7610 got a billing rate of ₱1.0629 per one (1) minute of drying. It was followed by the second period with a kilowatt hour of 0.2499 multiplied by the energy rate of ₱12. 7610 got a billing of 3.1889 per three (3) minutes of drying. Third, had a kilowatt hour of 0.4165 multiplied by the energy rate of ₱12. 7610 got a billing of ₱5.3149 per five (5) minutes of drying.

The result is related to the study of Ledesma (2020) [1] on the performance of the device in pressing logo size dark transfer paper. Based on the result, observation 1 had a kilowatt hour of 0.00074 and a billing rate of ₱0.00882 per piece. Observation 2 with kilowatt hour of 0.00132 with a billing rate of ₱0.01466, and for observation 3 had a kilowatt hour of 0.00206 with a billing rate of ₱0.02288 per piece. This result further supports the result of HASPD in term of energy cost showing that the higher the power consumption the higher the billing cost, and the lower the power consumed the lesser the energy cost.

Table VI. Operating performance of hot air silkscreen printing dryer in terms of energy cost in drying 2.75”x 2.75” logo size prints

Textile	**Textile Paint**	**Time**	**Power Consumption KwHr**	**Energy cost**
Cotton	Classic	1 Minute	0.0833	₱1.0629
		3 Minutes	0.2499	₱3.1889
		5 Minutes	0.4165	₱5.3149
	Rubberized	1 Minute	0.0833	₱1.0629
		3 Minutes	0.2499	₱3.1889
		5 Minutes	0.4165	₱5.3149
Athletic	Classic	1 Minute	0.0833	₱1.0629
		3 Minutes	0.2499	₱3.1889
		5 Minutes	0.4165	₱5.3149
	Rubberized	1 Minute	0.0833	₱1.0629
		3 Minutes	0.2499	₱3.1889
		5 Minutes	0.4165	₱5.3149

Legend: Energy cost = KwHr x energy rate Energy rate (CAPELCO) = ₱12.7610/KwHr

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General Acceptability of Hot Air Silkscreen Printing Dryer in Terms of Composition, Fabrication, Features, Operating Performance and Safety

Shown in Table VII is the overall result of the hot air silkscreen printing dryer in terms of composition, fabrication, features, and safety. The table revealed that the device was "Very Acceptable" in all of its factors and parameters such as composition, fabrication, features, and safety having a total mean of 4.78.

It further revealed that the overall mean of composition was 4.81 interpreted as "Very Acceptable". Likewise, its fabrication has an overall mean of 4.84, its features have mean of 4.80, followed by the operating performance having an overall mean of 4.79, and for safety, with mean of 4.68. All of which were interpreted as "Very Acceptable".

Table VII. General acceptability of the hot air silkscreen printing dryer in terms of composition, fabrication, features, operational performance and safety

Factors and Parameters	Mean	Verbal Interpretation
Composition	4.81	Very Acceptable
Fabrication	4.84	Very Acceptable
Features	4.80	Very Acceptable
Operating Performance	4.79	Very Acceptable
Safety	4.68	Very Acceptable
Total	4.78	Very Acceptable

Legend:

Scale of Means	Verbal Interpretation
4.21-5.00	Very Acceptable
3.41-4.20	Acceptable
2.61-3.40	Moderately Acceptable
1.81-2.60	Less Acceptable
1.0-1.80	Least Acceptable

IV. CONCLUSION

The hot air silkscreen printing dryer (HASPD) has different technical features with specific functions that can contributes to the efficiency of the device in drying textile paints in silkscreen printing. The device is made of quality materials capable of enduring an operation of mass production of printed textiles by silkscreen printing.

The number of printed textiles being dried is dependent on the size of prints being loaded. The larger the print the lesser the number of printed textiles being dried per loading. The smaller the size of prints the more printed textiles being dried per loading.

The device can effectively dry classic and rubberized printed textile paints on both cotton and athletic textiles. The drying time is dependent on the size of the prints being dried. The larger the size of the print the longer its drying time, while the smaller the size of the print the shorter its drying time.
The power consumption of the device is dependent on the allotted period for drying time. The longer the device is in drying operation, the higher the power consumption it will have. The shorter the time the device is in drying operation the lower the power consumption is consumed. The drying time is also very minimal due to the device's fast drying performance.

The device is very convenient to use in a silkscreen printing drying operation. It has less energy consumption which results in a low energy bill as computed based on power consumption multiplied by energy rate.

The device was fabricated with quality materials that can withstand continuous drying operation and ensure the safety of the user. It distributes hot air evenly and dries prints equally on any surface of the dying compartment. It can also effectively dry prints in numerous pieces in one set of drying, cutting the drying time into minimal and increasing the number of prints on textiles being dried.

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