Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7766396

ACCEPTABILITY TESTING AND DEVELOPMENT OF A MECHATRONICS BASED 2" CIRCULAR SOAP CUTTING AND STAMPING MACHINE

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Abstract - *The main thrust of the study was to developed a Mechatronics Based 2" Circular Soap Cutting and Stamping Machine that is capable of performing the basic automation process involving cutting, pushing, stamping, releasing and ejecting. Most of the machine are relatively expensive for small manufacturing companies especially when it involves the whole process. The researcher wanted to developed an alternative inexpensive cutting and stamping machine out of locally available parts. The developed Mechatronics Based 2" Circular Soap Cutting and Stamping Machine underwent various trials repeatedly using different laboratory techniques. It also utilized descriptive research method through survey questionnaire to measure the acceptability level and to gather more information that is substantial in the development of the machine. iv Trials has been made on the aspect of performance production rate, where the overall Z.LSL is greater than the critical value so the decision is to accept the lot. The chosen respondent also evaluated it where the overall mean of the survey result is equal 4.73 and appeared to be highly acceptable. It is recommended that the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine will be adopted and will be utilized in an automated production and as well as for instructional purposes for further observation and development of the machine.*

Keywords: *Circular Soap Cutting, Stamping Machin*

INTRODUCTION

Soap is undoubtedly the oldest product to be produced specifically as a surfactant (Willcox) and is manufactured in bars, granules, flakes and liquid and it was invented not only for the purpose of personal hygiene but also for other domestic purposes and is used as lubricants in industries (Warra, 2013). Soap has numerous applications in our daily life) and is of high priority provided man understands the necessity to continually keep its environment clean (Ogedengbe, 2019). Thus, the production of soap is one area in business that can be considered as profitable.

There are several techniques employed in making soap, most of which involve heat (Davidsohn, 2020). The final product is achieved through a series of steps with value addition at each step to fulfill and satisfy the expectations of the manufacturer and/or end users (Ogedengbe, 2019). The soap making process involves five major steps: saponification, soap

washing or glycerol extraction, fitting, molding, and drying (Warra, 2013). Almost all the high-class soaps used in the market pass through the milling process, which generally consists briefly of the given operations: drying of soap, mixing of perfume, milling, compressing, cutting, and stamping (Mishra,).

However, the industry of soap-making also depends on how the products can attract customers. Since today's customers are attracted to the appearance and attractive shapes of soap. But of the appearance of the soap depends on the stamping and punching operation as it gives shape and a proper look to the soap. The stamping machine is very important to increase the market value of the soap. Hence, the stamping machine is one of the effective equipment to fulfill these customers' requirements (Salwe, et al., 2014).

The machine for stamping of soap fabricated by (Deshmukh, 2019) has solved several concerns within the industry and it also fulfills the requirement of industry. The growing needs of people called for mechanization and automation, hence, to fulfill those needs, industries are aiming to have higher production rates. In the age of Industrialization and Automation, there is a need to incubate the growing industries by providing them with sustainable environment to retain their existence in the global scenario. As there is a lot of competition in the global market and also consumers are very passionate about best product and its salient features. So, there is a need to develop an alternative method or process for effective manufacturing (Deshmukh, 2019). Moreover, in designing of the stamping and punching machine, focused on the economically cheap, readily available and strong local materials in fabricating the machine in order to make it available in low cost for cottage industry in rural areas (Salwe, Dahake, & Jibhakate, 2014).

There are already several model of cutting machine and stamping machine available in the market. Its operation mode can either manual or semi-automatic. The problem is that this machine is design separately so it can also be bought separately. Eze developed a manually operated soap tableting and stamping machine. Ajoa et al developed a set of shop floor size pedal-powered soap mixer, mould, cutting and stamping machines for making homemade laundry soap (Nwankwojike, 2012).

However, the developed Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is capable to perform the basic automation involving cutting, pushing, stamping, releasing, and ejecting. The implementation of this project expected to have drastic impact in the soap industry as it addresses the issues encountered by the soap making industries. It also addresses the reduction of the work force, production hours, energy consumption as well as the cost associated with the overall process in soap making.

This machine used the principle of pneumatic systems as it is considered as one of the most commonly use methods of driving industrial machines. The working medium in the form of compressed air has many advantages. Compressed air can be easily stored in tanks, does not cause explosion hazard, can be used in hazardous environments and unlimited resources are some of its advantages. The compressed air could also be the carrier of information, that is used in fully pneumatic-based control system. The other possibility is to use electric energy in the control system and the compressed air in actuators. The use of electric components opens the way for applying the programmable logic controller (PLC) that allows implementing more advanced control strategies (Foit, Banaś, & Ćwikła, 2018).

The control of pneumatic components using electrical impulses is known as electro-pneumatics. In an electro-pneumatics control system, there are three major circuits identified: a pneumatic circuit, a control circuit (electric) and a power circuit. The control circuit and power circuit are electric. Pneumatic system design contains two parts: pneumatic and electrical. FESTO FluidSim software is used for simulation of pneumatic power system. FluidSIM is a comprehensive software for the creation, simulation, instruction, and study of electro-pneumatic, electro-hydraulic, digital and electronic circuits. All the program functions interact smoothly, combining different media forms and sources of knowledge in an easily accessible manner. FluidSIM unites an intuitive circuit diagram editor with detailed descriptions of all components, component photos, sectional view animations and video sequences. Pneumatic components are explained with textual descriptions, figures, and animations that illustrate underlying working principles (Vujičić, Dragićević , Ocokoljić , Milićević, & Popović, 2020).

Methods and Materials

To test the acceptability of the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine. The study utilized a quasi- experimental design. The target respondents are twenty-five (25) instructors or technology experts and twenty-five (25) selected students. Instructors are those teaching in CTU-Main Campus. Technology experts are those professionals that are exposed in the field of technology, automation, robotics and mechatronics. Selected students are student representatives from different courses under the college of technology who are currently enrolled in the same university.

Moreover, the study utilized a researcher-made questionnaire based from the different related researches. The questionnaire sought the acceptability of the respondents regarding the Performance, Features, Serviceability, and Aesthetics of the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine.

Procedure for Data Gathering

The procedure of gathering data is to administer the questionnaires to the identified respondents. The authority to conduct the study was sought from the office of the Campus Director. Before the distribution of the questionnaire to the respondents, the researcher explains the purpose of the study and an actual demonstration was performed to show how the project works. The respondent can raised a question for clarification anytime during answering the questionnaire. The questionnaire was personally collected by the proponent for data treatment and analysis.

Results

This chapter presents, analyzed, and interprets the data gathered based on the survey questionnaires on the identified respondents. This includes the technical requirements and acceptability of the developed machine.

Figure 1. Mechatronics Based 2" Circular Soap Cutting and Stamping Machine

In figure 1, the researcher developed a Mechatronics Based 2" Circular Soap Cutting and Stamping Machine in the year 2021 at Cebu Technological University–Main Campus. The machine is capable of performing basic automation involving, cutting, pushing, stamping, releasing, and ejecting. The machine is the integration of mechanical technology, electronics technology, pneumatics technology, control system, industrial motor Control (IMC), Computer-Aided Design (CAD), Computer Aided Manufacturing (CAM), and industrial automation, which are one of the foundations of mechatronics.

Moreover, the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is composed of different assembly parts such as the magazine assembly, cutter assembly, push and eject mechanism assembly, stamp assembly, 3D plastic mold chamber assembly, frame assembly, control system assembly, and control panel assembly. The frame holds the entire components and mechanisms of the machine. The magazine assembly is where the molded cylindrical soap is placed ready for cutting/slicing. The cutter assembly slices the soap to a specified thickness. Push and Eject Mechanism Assembly pushes a sliced soap to the stamp assembly and ejects the soap after stamping. The stamp assembly stamps the sliced soap to transfer an embossed text from the stamp die. The 3D plastic mold chamber assembly releases the molded soap from the mold chamber ready for ejection.

Table No.	Description	Cost	Percentage
4	Bill of Material for the Frame	₱ 18,491.00	48%
5	Bill of Material for the Machine Assembly	₱ 6,662.00	17%
6	Bill of Materials for the Control System, Electrical Devices and Electro-Pneumatic Devices	₱ 10,104.00	26%
7	Bill of Material for the Consumables	₱ 3,475.00	9%
	Total	**₱ 38,732.00**	**100%**

Table 1. Cost of the Project

Table 1 showed the summary of cost accumulated which is the Bill of Materials of the Frame and Casing, the Bill of Material for the Machine Assembly, the Bill of Materials for the Control System, Electrical Devices and Electro-Pneumatic Devices and the Bill of Material for the Consumables.

2.1. Performance	HA 5	MA 4	FA 3	LA 2	NA 1	$\bar{X}$	S	k	Z.LSL	VD
2.1.1. Less noise during operation	45	5	0	0	0	4.9	0.303	1.645	6.270	HA
2.1.2. Less vibration during operation	43	7	0	0	0	4.86	0.351	1.645	5.299	HA
2.1.3. Good cutting quality	39	11	0	0	0	4.78	0.418	1.645	4.258	HA
2.1.4. Good stamping quality	40	10	0	0	0	4.8	0.404	1.645	4.455	HA
2.1.5. Production rate average of 5pcs/min.	31	19	0	0	0	4.62	0.490	1.645	3.306	HA
Average Percentage	**79.2**	**20.8**	**0**	**0**	**0**					
Average Weighted Mean						**4.79**	**0.393**	**1.645**	**4.718**	**HA**
Overall Decision	**Since the results meets the condition where Z.LSL values should indicates higher than critical value, thus, the overall decision is to accept lot.**									

Table 2. Summary of Acceptability as to Performance (n=50)

Legend:

HA – Highly Acceptable
MA – Moderately Acceptable
FA – Fairly Acceptable
LA – Least Acceptable
NA – Not Acceptable

$\bar{X}$– Weighted Mean
S – Standard Deviation
k – Critical Value
VD – Verbal Description
Z.LSL – (mean – lower spec) / S

The first to be determine in the survey was the performance of the prototype. The result are shown in Table 2. The identified are the most common performances observed during the utilization of the machine. Furthermore, all these performances were carefully observed through repeated simulation and testing and validated through survey. The first performance identified was "less noise during operation" with a rated mean of 4.9. The second was "less vibration during operation" with a rated mean of 4.86 The third was "good cutting quality" with a rated mean of 4.78. The fourth was "good stamping quality" with a rated mean of 4.8, and last was "production rate of 5pcs/min" with a rated mean of 4.62. All of these performances were identified as highly acceptable. It was also found out that the machine's performance level based on the result has an average weighted mean of 4.79.

The Table also shows that an average of 79.2 percent of the chosen respondent rated highly acceptable and the remaining 20.8 percent rated moderately acceptable. This means that the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is considered to be highly acceptable in terms of performance

Table 2. Summary of Acceptability as to Features (n=50)

2.2. Features	HA 5	MA 4	FA 3	LA 2	NA 1	$\bar{X}$	S	k	Z.LSL	VD
2.2.1. Low power consumption	41	9	0	0	0	4.82	0.388	1.645	4.690	HA
2.2.2. Start/Stop operation	43	7	0	0	0	4.86	0.351	1.645	5.299	HA
2.2.3. Time-Based Initialization	36	13	1	0	0	4.7	0.418	1.645	4.067	HA
2.2.4. Continuous process cycle	33	16	1	0	0	4.64	0.404	1.645	4.059	HA
2.2.5. Completion of cycle prior to stop	32	18	0	0	0	4.64	0.485	1.645	3.381	HA
2.2.6. Emergency stop ready	42	8	0	0	0	4.84	0.370	1.645	4.973	HA
2.2.7. Variable magazine height up to 60cm	25	23	2	0	0	4.46	0.579	1.645	2.522	HA
2.2.8. Costumized embossed on stamp	41	9	0	0	0	4.82	0.388	1.645	4.691	HA
2.2.9. Portable during transportation	40	9	1	0	0	4.78	0.465	1.645	3.828	HA
Average Percentage	**74**	**24.9**	**1.1**	**0**	**0**					
Average Weighted Mean						**4.73**	**0.451**	**1.645**	**4.168**	**HA**
Decision	**Since the results meets the condition where Z.LSL values should indicates higher than critical value, therefore the overall decision is to accept lot.**									

Legend:

HA – Highly Acceptable
MA – Moderately Acceptable
FA – Fairly Acceptable
LA – Least Acceptable
NA – Not Acceptable

$\bar{X}$– Weighted Mean
S – Standard Deviation
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The second to be determined in the survey was the features of the prototype. Feature is another very important aspect of any product should have as this is the costumer basis before purchasing any machine. The features identified are the most common functions that are utilized from the machine being developed. The survey result and the statistical interpretation result are shown in Table 2.

"Low power consumption" with a rated mean of 4.82, "start/stop operation" with a rated mean of 4.86, "time-based initialization" with a rated mean of 4.7, "continuous process cycle" with a rated mean of 4.64, "completion of cycle prior to stop" with a rated mean of 4.64, "emergency stop ready" with a rated mean of 4.84, " variable magazine height up to 60cm" with a rated mean of 4.46, "customized embossed text on stamp" with a rated mean of 4.82, and " portable during transportation' with a rated mean of 4.78. The machine has an average weighted mean of 4.73. All these ratings on features have a common verbal description result of "Highly Acceptable". 59 The Table also showed that an average of 74 percent of the respondents rated highly acceptable, 24.9 percent rated moderately acceptable while the remaining 1.1 percent rated fairly acceptable. This means that the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is considered to be highly acceptable in terms of features.

Table 3. Summary of Acceptability as to Serviceability

2.3. Serviceability	HA 5	MA 4	FA 3	LA 2	NA 1	$\bar{X}$	S	k	Z.LSL	VD
2.3.1. Easy to assemble and disassemble	36	14	0	0	0	4.72	0.454	1.645	3.789	HA
2.3.2. Easy to maintain	35	15	0	0	0	4.7	0.463	1.645	3.672	HA
2.3.3. Easy replacement of parts	35	14	1	0	0	4.68	0.513	1.645	3.275	HA
2.3.4. Circuit design is easy to troubleshoot	31	18	1	0	0	4.6	0.535	1.645	2.991	HA
Average Percentage	**68.5**	**30.5**	**1**	**0**	**0**					
Average Weighted Mean						**4.68**	**0.491**	**1.645**	**3.432**	**HA**
Decision	**Since the results meets the condition where Z.LSL values should indicates higher than critical value, therefore the overall decision is to accept lot.**									

Legend:

HA – Highly Acceptable
MA – Moderately Acceptable
FA – Fairly Acceptable
LA – Least Acceptable
NA – Not Acceptable

$\bar{X}$– Weighted Mean
S – Standard Deviation
k – Critical Value
VD – Verbal Description
Z.LSL – (mean – lower spec) / S

Another feature of the machine that is being rated is the acceptability level of serviceability. The tabulated summary of survey result and statistical data analysis summary are shown in Table 14. "Easy to assemble and disassemble" has a weighted mean of 4.72, "easy to maintain" has a weighted mean of 4.7, "easy replacement of parts" has a weighted mean of 4.68 and "circuit design is easy to troubleshoot" has a weighted mean of 4.6. It appears that each of the identified serviceability factor has a common verbal description result in which it is labeled as highly acceptable.

68.5 percent of the respondents rated highly acceptable; 30.5 percent rated moderately acceptable while the remaining 1 percent rated fairly acceptable. The slightly decreasing of ratings in this factor were expected. This is due to the fact that the user may not have the basic knowledge in assembling or disassembling, maintaining the machine, replacing of damage parts or troubleshooting the machine. Nevertheless, Serviceability has an average weighted mean of 4.68. This means that the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is still considered to be highly acceptable in terms of serviceability.

2.4. Aesthetics	HA 5	MA 4	FA 3	LA 2	NA 1	$\bar{X}$	S	k	Z.LSL	VD
2.4.1. Modular design	41	8	1	0	0	4.8	0.452	1.645	3.982	HA
2.4.2. Component arrangement	45	5	0	0	0	4.9	0.303	1.645	6.271	HA
2.4.3. Wiring installation	41	9	0	0	0	4.82	0.388	1.645	4.691	HA
2.4.4. Good quality product output	34	15	1	0	0	4.66	0.519	1.645	3.198	HA
2.4.5. Parts are locally available and inexpensive	24	21	5	0	0	4.38	0.667	1.645	2.069	HA
Average Percentage	**74**	**23.2**	**2.8**	**0**	**0**					
Average Weighted Mean						**4.71**	**0.466**	**1.645**	**4.042**	**HA**
Decision	**Since the results meets the condition where Z.LSL values should indicates higher than critical value, therefore the overall decision is to accept lot.**									

Table 4. Summary of Acceptability as to Aesthetics (n=50)

Legend:

HA – Highly Acceptable
MA – Moderately Acceptable
FA – Fairly Acceptable
LA – Least Acceptable
NA – Not Acceptable

$\bar{X}$– Weighted Mean
S – Standard Deviation
k – Critical Value
VD – Verbal Description
Z.LSL – (mean – lower spec) / S

Table 4 reflects the summary of rating for "aesthetics". The factor "modular design has a weighted mean of 4.8, "component arrangement" has a weighted mean of 4.9, "wiring installation" has a weighted mean of 4.72, "good quality product output" has a weighted mean of 4.66 and "parts are locally available and inexpensive" has a weighted mean of 4.38. Moreover, the identified aesthetics factor still has a common verbal description result of highly acceptable and the average weighted mean is 4.71. 70 74 percent of the respondents rated highly acceptable, 23.2 percent rated moderately acceptable and the remaining 2.8 percent rated fairly acceptable. This means that the Aesthetic factor of the Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is commendable and still considered to be highly acceptable.

Table 5 Overall Summary of Acceptability

Criteria	HA %	MA %	FA %	LA %	NA %	$\bar{X}$	S	k	Z.LSL	VD
2.1. Performance	79.2	20.8	0	0	0	4.79	0.393	1.645	4.718	HA
2.2. Features	74	24.9	1.1	0	0	4.73	0.451	1.645	4.168	HA
2.3. Serviceability	68.5	30.5	1	0	0	4.68	0.491	1.645	3.432	HA
2.4. Aesthetics	74	23.2	2.8	0	0	4.71	0.466	1.645	4.042	HA
Overall Percentage	**73.9**	**24.9**	**1.2**	**0**	**0**					
Overall Average						**4.73**	**0.450**	**1.645**	**4.09**	**HA**
Overall Decision	**Since the results meets the condition where Z.LSL values should indicates higher than critical value, therefore the overall decision is to accept lot.**									

The data shows that the overall average weighted mean of the machine is 4.73, which fall under the verbal description of "Highly Acceptable". The Table also shows the breakdown of the overall percentage of ratings in which 73.9 percent of the chosen respondents rated the machine as Highly Acceptable, 24.9 percent rated Moderately Acceptable and only 1.2 percent rated Fairly Acceptable. The table also shows that the average mean is equal to 4.73, the average standard deviation is equal to 0.450 and the critical value is equal to 1.645. It also shows that all value of Z.LSL from the different criteria is greater than the critical value which

means that the machine is acceptable. Thus, the overall acceptance decision of the machine as to the performance, features, serviceability, and aesthetics to Accept Lot.

Discussion

The Study presented the acceptability of the developed Mechatronics Based 2" Circular Soap Cutting and Stamping Machine is capable of performing the basic automation process. In terms of performance, features, serviceability, and aesthetics, the circular soap cutting and stamping machine was found to be highly acceptable. Similarly, in the study of Issa et al (2015) the planning and fabrication of hand-driven soap cutting and scraping machines suited for medium-scale industries attempted to resolve the various issues faced by the usage of the machines used in the earlier version. The outcomes obtained inferred that the machine has an efficiency of 85%. Another study by Raj (2022) focused on the Design and Fabrication of Automated Soap Cutting Machine and found that the project is efficient in cost and can be used in small-scale industries. Also, It works smoothly and has precise soap cutting.

Conclusion

Reference

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