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DESIGN & DEVELOPMENT OF A PRESSURE COOKER-WHISTLE USING BOOTHROYD DEWHURST METHOD

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ABSTRACT
The pressure cooker is the most efficient energy-saving cooking equipment and plays a hand to glove with working women/men. The conventional pressure cooker consists of many parts that need to be assembled in the factory and consumes precious time. The paper's novelty is to identify the difficulty of the assembly and eliminate unnecessary parts in the pressure cooker and also remodelling of the pressure whistle with the help of Boothroyd Dewhurst Method. Finally, a comparison study is done between the conventional and the new designs of the pressure whistle to show the optimal time to assemble the final product and also a porotype of the pressure whistle is created.
Keywords— Pressure cooker, Design for Assembly, Boothroyd Dewhurst Method, Design Efficiency

1. Introduction

India houses the most significant number of pressure cookers that have been used in the world. To meet the needs of the growing demand for pressure cookers, pressure cooker industries have scaled up their assembly lines to be more efficient by implementing machines for operations like drawing, trimming, and grinding [1], thus, reducing labor work and increasing profit.

There has been a versatile increase in the design and development aspect of the pressure cooker. A significant problem in the pressure cooker was keeping track of the number of whistles occurring during cooking. An alternative design for this problem was suggested in 2014 [2]. A four-bar mechanism is attached to the head of the whistle the other end is attached to a mechanical counter. As the whistle moves up, it excretes force on the four-bar mechanism recorded on the counter.
Increasing heat dissipation is important when cooking food in a pressure cooker. A modified LID of a pressure cooker was suggested in 2015 [3]. The change was to alter the inner lid of the pressure cooker from an elliptical to a circular profile. The thermal and stress analysis showed significant heat dissipation from the food to the atmosphere, which will help in higher cooling rates of the food.
Another design modification to the pressure whistle was patented in 2017 [4]. The modified Pressure cooker's whistle works as a whistles counter. This counter is achieved by using two cylinders inside the whistle. The inner cylinder has a saw tooth arrangement long in its peripheral region, which guides a pin attached to the external cylinder. The up and down motion due to the pressure causes the pin to displace along with the deadweight, produces causes a stepper motion to count the number of whistles.

Assembly plays a significant role when mass-producing pressure cookers. A study conducted in 2015 [5] uses an assembly line balancing problem of the production of rice cookers manufactured by a Japanese company to drive an algorithm to arrange the elements in the workstation. So, each component of the rice cooker will have less service time, thus increasing the assembly efficiency.
All these were the fundamental building blocks for the paper. This paper focuses on improving the assembly efficiency by implementing industry-level techniques and also fabricates a prototype of the redesigned part of the pressure cooker, which has a higher assembly efficiency.

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2. Experimental Methods

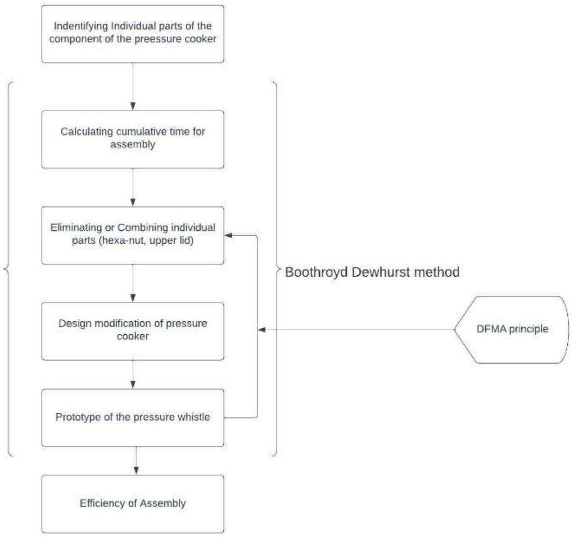

Figure 1: methodology of the experiment

The flow diagram shows the chronological process of the experiment conducted. First the individual parts of the pressure cooker are identified and labelled. To reduce the assembly, DFMA principle is used.

The design of manufacturing and assembly (DFMA) is a methodology that prioritizes reducing time and costs by combining the ease of manufacture for the product's parts and the simplified assembly line to create the end product [6]. A few principles are followed in DFMA, such as minimizing the number of components, design for ease of part fabrication, reducing the usage of flexible features, ease of assembly, and eliminating or reducing adjustments [7].

Boothroyd Dewhurst is a part of DFMA and is used to measure the assembly efficiency of any product. It was developed by Dr Geoffrey Boothroyd and Dr Peter Dewhurst in 1970s [8]. The Boothroyd Dewhurst method involves analyzing the part count and geometry to calculate theoretical assembly time, compared to the minimum academic assembly time to determine design efficiency.

3. EXPERIMENT

3.1 Selection of the Product

The product that was selected for the project is a pressure cooker. The model is the prestige company pressure cooker used for cooking purposes. The motto to choose this product is to reduce the number of parts in the assembly process and reduce the cost of production and improve the design. The figure 2 shows us the cooker used for the cooking.

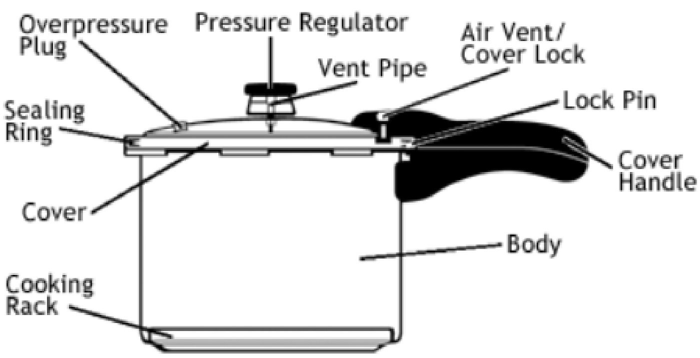

Figure 2: Pressure cooker

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3.2 Identification of number of Parts

The product is dismantled and the number of the parts present in the product is calculated and each of the parts is numbered. The below fig 10, displays the dismantling of the cooker and the no of parts present. Most of the parts are made of aluminium, rubber, nuts and bolts.

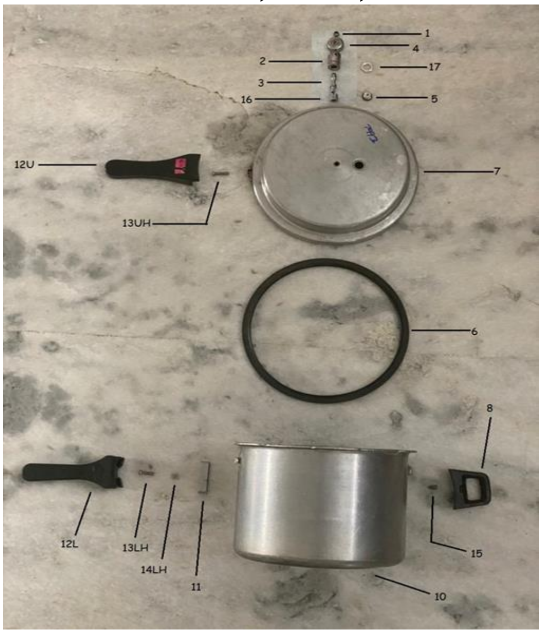

Figure 3: DISMANTLED IMAGE OF PRESSURE COOKER FOR THE NUMBER OF PARTS IDENTIFICATION

There are total of 17 parts presents.

1. Hexagonal Nut,2. Vent Weight,3. Vent tube,4. Lid of vent weight,5. Safety valve,6. Gasket,7. Lid,8. Short body handle,9. Bracket,10. Cooker body,11. handle bracket,12. Primary handle,13. Screw,14. Nut,15. Screw and Nut integration,16. Hexagonal Nut with Exhaust Ports, and 17. Safety Valve Lid

3.4 Calculating the Handling and Insertion time

To calculate the handling and the insertion time for each part in the cooker, Boothroyd Dewhurst technique was used. The handling and insertion codes are given as a two-digit number that indicates the row number and the column. For example: The Handling code of the base container is 91. That means the assembly time is found in the table in 9th row and 1st column. The insertion code is also done similarly using the both insertion tables in the fig 4. All the parts are categorized whether they are an essential part or not. The total operating time is calculated by the sum of the handling time and the insertion time. The cumulative time is adding the total operating time in a sequential manner till which you are present calculating.

3.5 Note

The solution was to eliminate the 11,13UH, 13LH, 14UH, and 14LH parts mentioned in fig 10 (i.e., Handle bracket, screw of upper and lower head and the nut of upper and lower head) and combine it with part 10 (i.e., Cooker body). There were two solutions for combining these parts: Snap fit and reverts [10]. However, Snap-fit cannot withstand the stress caused when handling the pressure cooker by the user. Riveting is also impossible because the two components are made of different material (handle bar, cooker vessel). The efficiency of this pressure cooker cannot be increased as it is the maximum obtained. The only area of improvement was in the pressure whistle. So, the same experiment procedure was repeated for the pressure whistle

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Part Name	Handling Code	Handling Time	Insertion Code	Insertion Time	Total Operating Time	Essential Part	Cumulative time	Comment
Base Container	91	3			3	Y	3	Handling only
Gasket	16	2.57	01	2.50	5.07	Y	8.07	
Upper Lid	10	1.5			1.5	Y	9.57	Handling only
Lower Handlebar	30	1.95	30	2	3.95	Y	13.52	
Upper Handlebar	30	1.95	30	2	3.95	Y	17.47	
Bracket	20	1.8	40	4.5	6.3	Y	23.77	
Lower Half Screw	15	2.25	58	10	12.25	N	36.02	
Lower Handlebar Nut	06	2.17	50	6	8.17	N	44.19	
Lower Small Handlebar	30	1.95	30	2	3.95	Y	48.14	
Lower Small Handlebar Screw	16	2.57	48	8.5	11.07	N	59.21	
Lower Small Handlebar Nut	06	2.17	50	6	8.17	N	67.38	
Upper Handlebar Screw	15	2.25	48	8.5	10.75	N	78.13	
Upper Handlebar Nut	06	2.17	50	6	8.17	N	86.3	
Safety Valve Lid	05	1.84	49	10.5	12.34	Y	98.64	
Safety Valve	10	1.5	50	6	7.5	Y	106.14	
Hexagonal Nut with Exhaust Ports	11	1.8	40	4.5	6.3	Y	112.44	
Vent Tube	10	1.5	31	5	6.5	Y	118.94	
Vent Weight	10	1.5	30	2	3.5	Y	122.44	
Lid of Vent Weight	10	1.5	30	2	3.5	Y	125.95	
Hexagonal Nut	16	2.57	39	8	10.57	Y	136.51	

Figure 4: ASSEMBLY TIME OF THE COOKER

3.6 Selection of the Product

The pressure whistle was chosen as the product of improvement. The material is made of brass or stainless steel. The product is chosen to improve its design as shown in fig 5 [11].

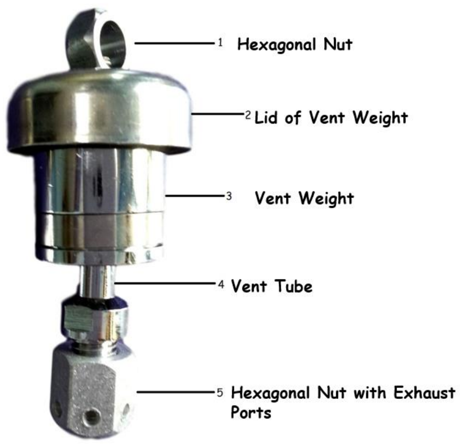

Figure 5: Pressure whistle

For the given five parts in order to calculate the total operating time, the insertion and the handling had to be summed together. The handling time is calculated with the factor that the part can be handled with one or two hands. The handling code indicates exactly where in the table the value is presented which is shown in table 6. The insertion time and code is also done similarly as handling is done and based from Boothroyd Dewhurst Method [10]. By adding all the operating time gives us the final cumulative time i.e., assembly time of the Whistle. The total cumulative time is 30.37 secs.

The assembly time of the pressure whistle is calculated in table 7. There a total of 5 vital parts to the whistle and the cumulated sum of the operating time of individual components are summed to get the total assembly time of 30.37 sec.

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PART ADDED but NOT SECURED				After assembly no holding down required to maintain orientation and location (3)				Holding down required during subsequent process to maintain orientation and location (3)			
				easy to align and position during assembly (4)		not easy to align and position during assembly		easy to align and position during assembly		not easy to align and position during assembly	
				no resistance to insertion	resistance to insertion (5)	no resistance to insertion	resistance to insertion (5)	no resistance to insertion	resistance to insertion (5)	no resistance to insertion	resistance to insertion (5)
				0	1	2	3	6	7	8	9
Addition of any part (1) where neither the part itself nor any other part is finally secured immediately	part and associated tool (including hands) can easily reach the desired location		0	1.50	2.50	2.50	3.50	5.50	6.50	6.50	7.50
	part and associated tool (including hands) cannot easily reach the desired location	due to obstructed access or restricted vision (2)	1	4.00	5.00	5.00	6.00	8.00	9.00	9.00	10.00
		due to obstructed access and restricted vision (2)	2	5.50	6.50	6.50	7.50	9.50	10.50	10.50	11.50

Figure 6: MANUAL HANDLING TIME

Part Name	Handling code	Handling Time	Insertion Code	Insertion Time	Total Operating Time	Essential Part	Cumulative Time	Comment
Hexagonal Nut with Exhaust Ports	11	1.8	40	4.5	6.3	Y	6.3	
Vent Tube	10	1.5	31	5	6.5	Y	12.8	
Vent Weight	10	1.5	30	2	3.5	Y	16.3	
Lid of Vent Weight	10	1.5	30	2	3.5	Y	19.8	
Hexagonal Nut	16	2.57	39	8	10.57	Y	30.37	

Figure 7: ASSEMBLY TIME OF WHISTLE

3.7 Efficiency of Whistle (old design)

The efficiency of the pressure whistle is calculated from Boothroyd Dewhurst method [11]. The variables of the efficiency formula is shown below.

$$E = (N_{min})\frac{t_a}{t_{tot}} = 5 * \left(\frac{3}{30.37}\right) = 49.39\%$$

In the formula the, N is total no of parts (i.e., **5** parts in total), t(a) is **3**, t(tot) is **30.37** (as the total tie to assemble the whistle and the cumulative time) The efficiency of the old design is calculated and obtained as **49.39%**

3.5 New design

In the new design we have eliminated two parts that are the lid of the vent and hexagonal nut. As it helps to increase the efficiency. Instead of the hexagonal nut it can be an empty sack with some roughness that can help the customer to hold the whistle.

Part Name	Handling code	Handling Time	Insertion Code	Insertion Time	Total Operating Time	Essential Part	Cumulative Time	Comment
Hexagonal Nut with Exhaust Ports	11	1.8	40	4.5	6.3	Y	6.3	
Vent Tube	10	1.5	31	5	6.5	Y	12.8	
Vent Weight	10	1.5	30	2	3.5	Y	16.3	

Figure 8: ASSEMBLY TIME OF WHISTLE (NEW DESIGN)

3.6 Efficiency of Whistle (new design)

$$E = (N_{min})\frac{t_a}{t_{tot}} = 5 * \left(\frac{3}{16.3}\right) = 55.21\%$$

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The efficiency of the new design is shown to be 55.21%. The results show that there has been an improvement comported to the conventional design.

3.7 PROTOTYPE OF THE NEW DESIGN

The prototype of the new design of the whistle is done in CATIA 3D [11]. In the prototype the holes designed at the top are used as exhaust holes to release the pressured air in the cooker

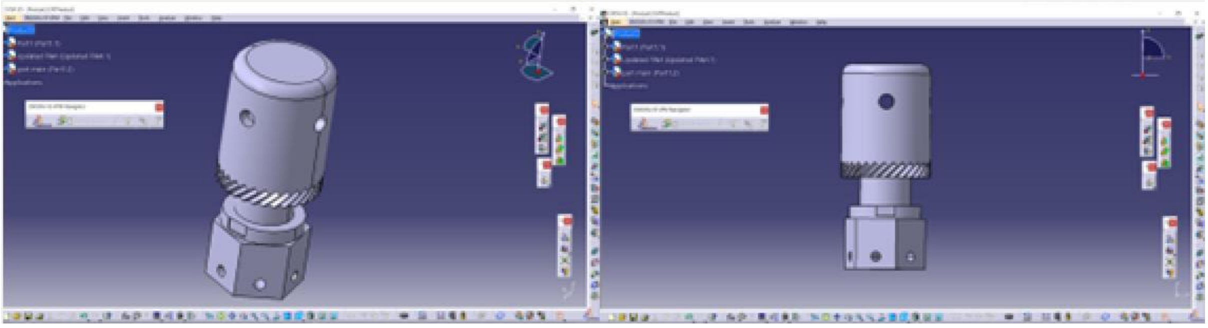

Figure 9: CATIA drawing of new design

3.8 MANUFACTURING

After the completion of the CAD models, the manufacturing of the whistle component was made using a 3-jaw chuck Lath machine [13]. The Lathe machine was chosen because many mechanical operations can be done in a cylindrical object. Operations like facing, boring taper turning, drilling and knurling were done on the whistle [14]. The drilling operations were done to make holes. Knurling was done on the sides of the whistle for better grip. The images of the manufactured new designed Whistle is shown in the fig 9.

Figure 10: manufactured pressure whistle

4. Results and Discussion

	OLD DESIGN	NEW DESIGN
NO.OF. PARTS	5	3
OPERATING TIME	30.37 sec	16.30 sec
EFFICIENCY	49.39%	55.20%

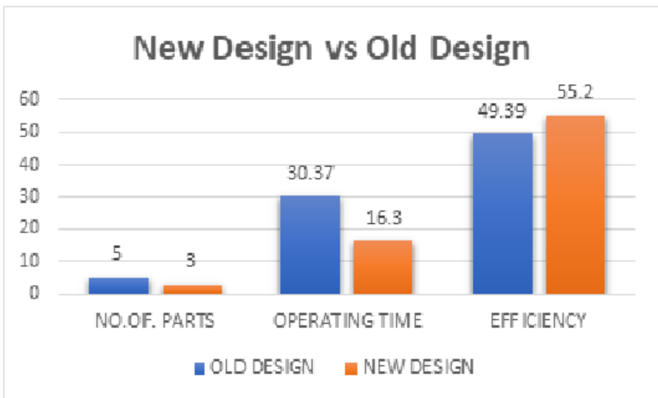

Figure 11: Table and graph to compare old vs new design

The comparison between the old and new design has reduction of operating time to by 14.07 sec and has an increased assembly efficiency of 5.81 %. The decrease in redundant parts increased the efficiency of the assembly of the product.

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5. Limitations

Boothroyd Dewhurst Inc [15] software could be implanted rather than manually using the insertion table to calculate the cumulative assembly time and the efficiency of the pressure cooker Modifications on the pressure vents in the new design of the presser whistle to improve safety.

6. Conclusions

The assembling time of the pressure cooker was calculated using the Boothroyd Dewhurst method. Redundant parts of the Pressure cooker whistle were removed by applying the DFMA principle. A prototype was created, which was fabricated from the existing commercial whistle. The improved pressure whistle design showed higher assembly efficiency than the previous design.

7. Reference

1. Groover, M., 2015. "*Fundamentals of Modern Manufacturing*. 4th ed. Wiley", pp.443-445

2. Saxena, S., Muralidharan, A., Kannan, A. and Joseph, S., 2014. "Novel mechanical Whistle Counter Device for Pressure Cooker. *International Journal of Modern Engineering Research (IJMER)*, 4(8)", pp.92-93

3. Date, D. D., & Tated, R. G. Design of Inner Lid of Pressure Cooker with Circular Shape Having Straight Edges. International Journal of Innovations in Engineering Research and Technology, 1-5.

4. Phiphatsomporn, P., & Pongchairerks, P. (2015). Double Assembly Line Balancing Algorithms on Real-world Instances of Producing Digital Rice Cookers and Digital Hot Pots. Progress in Applied Science and Technology, 5(2), 96-117.

5. Prashant Parashuram SATHE, "Pressure cooker regulator with whistle counter", World Intellectual Property Organization WIPO, Dec 17, 2017

6. Annamalai, K., Naiju, C., Karthik, S. and Prashanth, M., 2012. Early Cost Estimate of Product during Design Stage Using Design for Manufacturing and Assembly (DFMA) Principles. Advanced Materials Research, 622-623, pp.540-544

7. G. Boothroyd, P. Dewhurst, W. Knight: Product Design for Manufacture and Assembly, 2nd Edition, Marcel Dekker, New York, 2002.

8. Dfma.com. 2022. DFMA® Software and Services, Boothroyd Dewhurst, Inc. https://www.dfma.com/backgrd.asp

9. Discoverpressurecooking.com. 2007. Discover Pressure Cooking: How to Use a Pressure Cooker. http://www.discoverpressurecooking.com/use.html

10. Annamalai, K., Naiju, C., Karthik, S. and Prashanth, M., 2012. Early Cost Estimate of Product during Design Stage Using Design for Manufacturing and Assembly (DFMA) Principles. *Advanced Materials Research*, 622-623, pp.540-544.

11. indiamart.com. 2022. *Brass Pressure Cooker Whistle*.www.indiamart.com/proddetail/brass-pressure-cooker-whistle-10490271355.html

12. Koh, J., 2012. *CATIA V5 design fundamentals*. 2nd ed. Seoul: ONSIA, pp.25-30.

13. Madireddy, J., 2014. Importance of Lathe Machine in Engineering Field and its usage. *Global Journal of Researches in Engineering: A Mechanical and Mechanics Engineering*, 14(6), pp.27-28

14. Gupta, R., 2022. *What Is Lathe Chuck? Lathe Chuck Types, Different of Lathe Chucks*. Mechanical Jungle. https://mechanicaljungle.com/lathe-chuck-types

15. Dfma.com. 2022. *DFMA® Software and Services, Boothroyd Dewhurst, Inc* www.dfma.com/software/dfma.asp