Innovations in Design for Manufacturing

Let's walk through the Innovation in Design for manufacturing using real life product case :

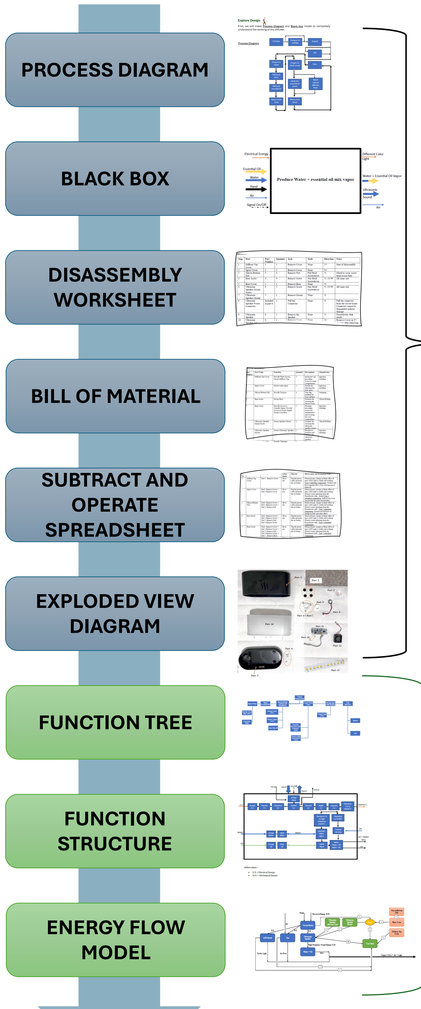
The ultrasonic room diffuser and humidifier. These diffusers don't use heat, so the steam they produce is a vapor or water mist. Ultrasonic vibrations hit the water at a frequency that humans can't hear, creating a cold, concentrated vapor. The vibrations carry upwards toward the essential oil, which is floating on top, and vaporize it into steam.

To implement Innovations in Design for Manufacturing, we need to :

First Step – Explore Design
Second Step – Identify Manufacturing Process
Third Step – Identify Gap in Design and Manufacturing
Fourth Step – Implement Innovation in Design for Manufacturing

Explore Design

For design exploration (or Product Teardown) we will follow this flow chart:



Steps for Assessing Product Design and Manufacturing Insights

Overview of Product and Component Functionality

Identify Manufacturing Process

Manufacturing processes are the primary determinants of the blueprint of the final design. To understand the rationale behind a specific manufacturing process, the following steps are undertaken :

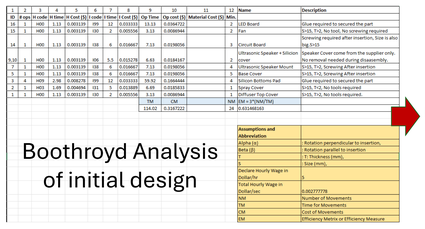
Identifying the Product Architecture and Portfolio → Fixed Unshared Platform

Fixed unshared platform products are generally seen with mass production. The diffuser in this case is also high-volume product. The Product Architecture of diffuser gives insights about the type of manufacturing process and material selection. Using reference from the book "**Selection of Materials and Processes**" the following can be identified about the materials and adopted manufacturing process.

Part	Material	Manufacturing Process
Diffuser Base	ABS (Acrylonitrile Butadiene Styrene)	Injection Molding
Diffuser Top	ABS (Acrylonitrile Butadiene Styrene)	Injection Molding
Ultrasonic Speaker Mount	Nylon6,6	Injection Molding
Core Base	High-Density polyethylene (HDPE)	Injection Molding

Identify Gap in Design and Manufacturing

So far, we have gained a comprehensive understanding of the product design and its architecture. Moving forward, our focus is to refine the design and optimize the manufacturing process in alignment with **lean design** principles. The initial step in this process will be conducting a Boothroyd Analysis. This analysis will enable us to quantify the design parameters, forming the foundational basis for our proposed design modifications.



Boothroyd Analysis of initial design

With a calculated EM (Efficiency Metric) value of 63.2%,

Our current objective is to implement strategic design changes that will enhance the Efficiency Metric. Additionally, we need to conduct a **cost analysis** of the existing design to better understand its objectives and identify any gaps.

Part	Procurement or Manufactured	Cost / Unit
LED Board	Procured	0.12 $
Fan	Procured	0.18 $
Circuit Board	Procured	0.91 $
Ultrasonic Speaker	Procured	0.30 $
Diffuser Base + Diffuser Top + Core Base + Speaker Mount	Manufactured	1.5 $

Cost Analysis of Diffuser

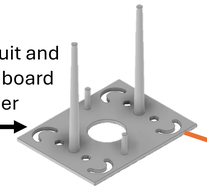
Logistic Cost (11$) + Risk (0.5$) + Assembly Cost (0.32$) + Profit (5.2$) = Total Cost ***20$***

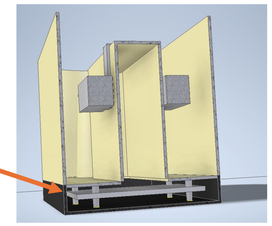
Implement Innovation in Design for Manufacturing

Three innovative design changes were proposed and subsequently implemented, each anchored to core principles: **Design for Quality**, **Cost Minimization**, and **Design for Disassembly**. In addition, two more design modifications were put forward to promote modularity and to integrate Design for Manufacturing and Assembly **(DFMA)** for informed **material selection**. Following a thorough review of all prior steps and principles, a series of design changes have been introduced:

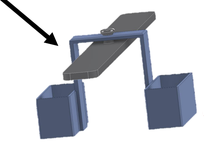
1. **LED Board Redesigned**
2. **Redesigned Core Base Mount for Circuit Board**
3. **Redesign Silicon Bottom Pads**
4. External Power Adapter
5. **Enhanced Design for Modularity and Flexibility**
6. Use of Polypropylene (PP) for Internal Structural Components
7. Transition to Thermoformed Polystyrene for the Water Reservoir
8. Use of Fireproof Material in core base design
9. Use of Acrylic in Top Cover

Circuit and LED board holder

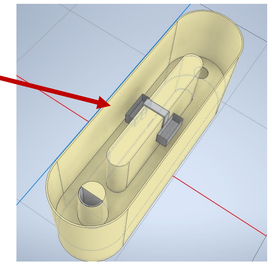




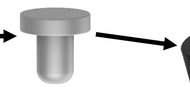
This will hold the circuit board without screwing and LED board without glue.



Aroma Pod Diffuser



Storage for Aroma Pods



Silicon Pad

Motive Behind adopting these changes:

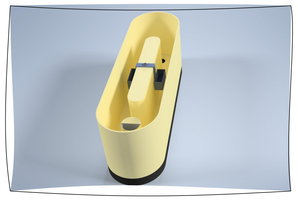
1	2	3	4	5	6	7	8	9	10	11	12	Name	Description
ID	# ops	H code	H time	H Cost ($)	I code	I time	I Cost ($)	Op Time	Op cost ($)	Material Cost ($)	Min.		
16	1	H00	1.13	0.003139	I99	12	0.033333	13.13	0.0364722		2	LED Board	Glue required to secured the part
15	1	H00	1.13	0.003139	I30	2	0.005556	3.13	0.0086944		2	Fan	S>15, T>2, No tool, No screwing required
14	1	H00	1.13	0.003139	I38	6	0.016667	7.13	0.0198056		3	Circuit Board	Screwing required after insertion, Size is also big.S>15
9,10	1	H00	1.13	0.003139	I06	5.5	0.015278	6.63	0.0184167		2	Ultrasonic Speaker + Silicion cover	Speaker Cover come from the supplier only. No removal needed during disaasembly.
7	1	H00	1.13	0.003139	I38	6	0.016667	7.13	0.0198056		4	Ultrasonic Speaker Mount	S>15, T>2, Screwing After insertion
5	1	H00	1.13	0.003139	I38	6	0.016667	7.13	0.0198056		5	Base Cover	S>15, T>2, Screwing After insertion
3	4	H09	2.98	0.008278	I99	12	0.033333	31.92	0.1664444		4	Silicon Bottoms Pad	Glue required to secured the part
2	1	H03	1.69	0.004694	I31	5	0.013889	6.69	0.0185833		1	Spray Cover	S>15, T<2, No tools required
1	1	H00	1.13	0.003139	I30	2	0.005556	3.13	0.0086944		1	Diffuser Top Cover	S>15, T>2, No tools required.
								TM	CM		NM	EM = 3*(NM/TM)	
								114.02	0.3167222		24	0.631468163	

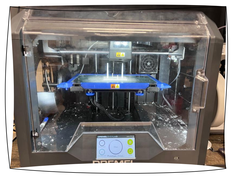
In the Original Design Boothroyd analysis, the cells highlighted for their lengthy Op Time draw our attention to components that necessitate design alterations.

Improved Innovative Design:

1	2	3	4	5	6	7	8	9	10	11	12	Name	Description
ID	# ops	H code	H time	H Cost ($)	I code	I time	I Cost ($)	Op Time	Op cost ($)	Material Cost ($)	Min.		
16	1	H00	1.13	0.003139	I31	5	0.013889	6.13	0.0170278		1	LED Board	Snap fit to Core Base
16.1	1	H00	1.13	0.003139	I31	5	0.013889	6.13	0.0170278		1	Diffuser Pod Storage	Snap fit to LED Board
15	1	H00	1.13	0.003139	I30	2	0.005556	3.13	0.0086944		2	Fan	S>15, T>2, No tool, No screwing required
14	1	H00	1.13	0.003139	I30	2	0.005556	3.13	0.0086944		3	Circuit Board	Screwing required after insertion, Size is also big.S>15
9,10	1	H00	1.13	0.003139	I06	5.5	0.015278	6.63	0.0184167		2	Ultrasonic Speaker + Silicion cover	Speaker Cover come from the supplier only. No removal needed during disaasembly.
7	1	H00	1.13	0.003139	I38	6	0.016667	7.13	0.0198056		4	Ultrasonic Speaker Mount	S>15, T>2, Screwing After insertion
5	1	H00	1.13	0.003139	I38	6	0.016667	7.13	0.0198056		5	Base Cover	S>15, T>2, Screwing After insertion
3	4	H09	2.98	0.008278	I31	5	0.013889	31.92	0.0886667		4	Silicon Bottoms Pad	Glue required to secured the part
2	1	H03	1.69	0.004694	I31	5	0.013889	6.69	0.0185833		1	Spray Cover	S>15, T<2, No tools required
1	1	H00	1.13	0.003139	I30	2	0.005556	3.13	0.0086944		1	Diffuser Top Cover	S>15, T>2, No tools required.
								TM	CM		NM	EM = 3*(NM/TM)	
								81.15	0.2254167		24	0.887245841	

In the New Design Boothroyd analysis, the cell highlighted shows a significant drop-in Op time and great improvement in Efficiency Metric i.e. 88.72 % from 63.2 %.





Prepared by : Shubhendra Pratap Singh
Prepared for : Mechanical Engineering Department