

DFMA Analysis of XYZ Earphone

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Abstract: Using of earphones has become a daily need in our life. Started with wired headphones, then wired earphones, later then wireless headphones and earphones, now ear buds are in trending. In every stage people find some problems and betterment in using that is what technology leads us upto now. Likewise, I found some problems and betterment in wireless earphone, and came up with new idea of concept. In order to achieve that I used “Boothroyd” software for analysis, also “Solidworks” software for designing and modelling. Here in this I mostly concentrated on reducing failure of product, manufacturing process and product cost.

Keywords: DFMA, DFA, DFM, DFX, DFFMA, DFS, earphone, wireless earphone, single cable wireless earphone, aesthetic earphone, good quality earphone, non-wear and tear earphone.

1. Introduction

This earphone is an audio device where we can listen to the music, videos. Also, we can attend the calls and speak to the opposite person. This is a Bluetooth base connecting device, where it connects to phone, laptop, android TV, etc., electronic devices that have Bluetooth option. This has the features of controlling the audio range and playing the wanted audio file to listen. Also, one can attend/hang call by pressing one button in this device. It is worn on the neck and speakers are hanged on through the shoulders on both left and right. The band that is used to wear on neck is so flexible and easy to carry.

2. Function

First of all, ON the device by long press of the power button. Now connect it to any device through Bluetooth. Wear it on the neck and put ear buds in ears. Play the audio that you want to listen. Therefore, in this way it is used. It gives much comfort to the ears while using because of soft rubber material ear buds. Also, additional feature is that to not get slip from ear there is a supporter to the ear at ear buds, were the ear buds fits into the ear and won't get out of the ear.

Also, the speaker will emit the sound frequency of 20 Hz to 20,000 Hz where it is the comfort range of human to hear. Also, there is a button for taking call and hanging the call in the earphone. It is easy to access the button and use. There are buttons for controlling the volume range by long press of the button in the earphone. We can also control the playing audio file by using same button of the volume, by just pressing the button once the audio file get change. All of the above is the function of the earphone.

Table 1
Specifications

S.No.	Name	Values
01	Bluetooth version	5.0
02	Battery life	8 hrs
03	With mic	yes
04	Qualcomm chipset	yes
05	Super extra bass	yes
06	Headphone type	In the ear
07	IPX5 water and sweatresistance	yes
08	Battery capacity	110 mAh
09	Frequency	20 Hz – 20 kHz
10	Bluetooth range	10 m
11	Charging time	2.5 hrs

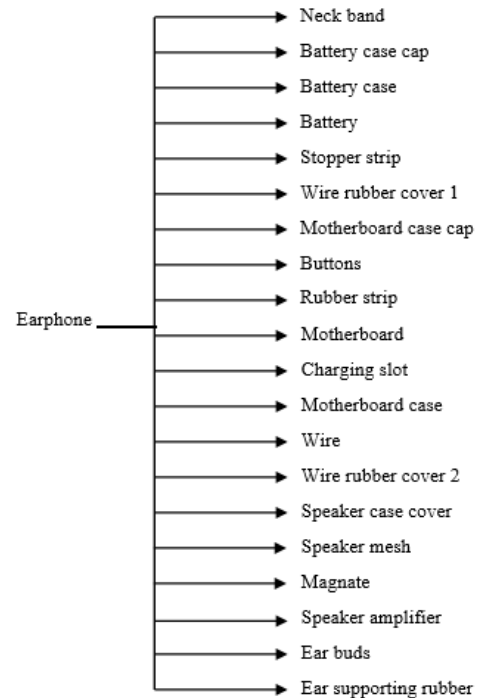


Fig. 1. Product structure

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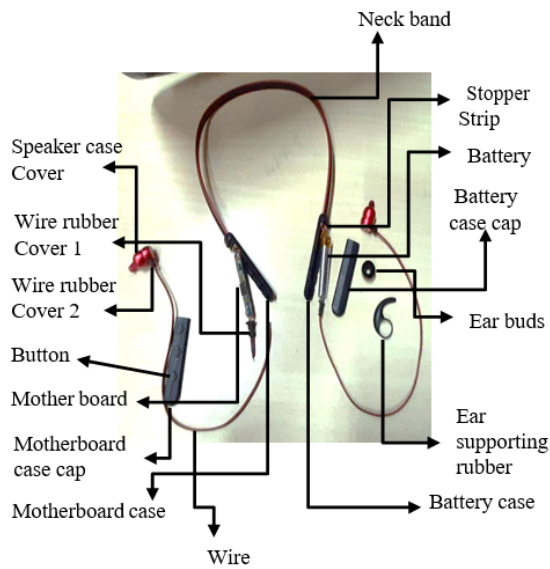


Fig. 2. Product components

3. Guidelines of DFA Followed with Redesign and Improvement: (Guidelines are referred by class notes)

Guideline 1: Minimizing overall component count.

Part count is reduced by deleting unwanted components like wire rubber stopper, rubber strip and wire rubber stoppers. Also, by merging some components like buttons, battery case and cap, motherboard case and cap, wire, speaker case and neckband. Therefore, the overall component count is reduced.

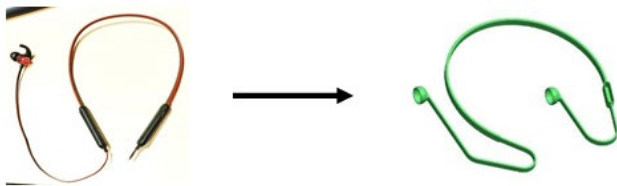


Fig. 3.

This guideline is not applicable to this product because there are no fasteners contain in this product.

Guide Line 3: For locating other components design product with base component.

This product is already following this guideline, the components like battery and motherboard has particular space for them to assemble.



Fig. 4.

Guideline 4: During assembly base should not be repositioned.

This guideline is not applicable to this product, therefore the product does not have specific base component also the assembly is done in a sequential manner without any repositioning.

Guideline 5: Efficient assembly sequence is required.

The assembly sequence of the product is efficient, no need to consider this guideline.

Guideline 6: Component characteristics that complicate the retrieval should be avoided.

There is no component that makes complicate in retrieval, therefore no need to consider this guide line.

Guideline 7: For a specific type of retrieval, handling and insertion method components has to be designed.

Here a specific design has been done to the cap of the case, in such a way that the cap can be fitted in either of the direction. It is fitted by press and snap fit.

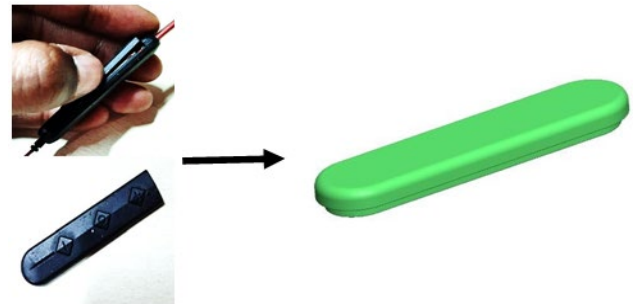


Fig. 5.

Guideline 8: End to end symmetry design should be done for components wherever possible.

Here the case cap is been with an asymmetric profile design and by using this guideline it has been changed into symmetric profile design.

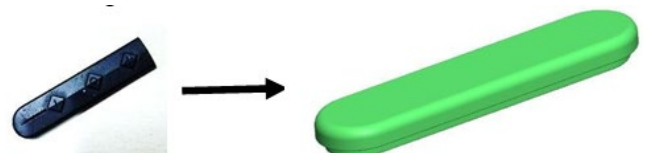


Fig. 6.

Guideline 9: About their axes of insertion components should be designed for symmetry, wherever possible.

Here components are already been in symmetric about their axis, therefore no need to consider this guideline.



Fig. 7.

Guideline 10: About their axes of insertion components should be designed for not symmetric, to be clearly asymmetric.

The case cap component is clearly following this guideline, i.e., the profile of the case cap is asymmetric.



Fig. 8.

Guideline 11: The components Design should be done in such a way that all from the same direction mate through straight line assembly.

This product components are tough to assemble in a straight line but they will assemble in a sequential manner, therefore no need to consider this guide line for this product.

Guideline 12: To facilitate insertion, alignment and overcome handling difficulties make use of chamfers and fillets and compliance

The product components all are having chamfers and fillets at required edges, so no need to consider this guideline for this product.

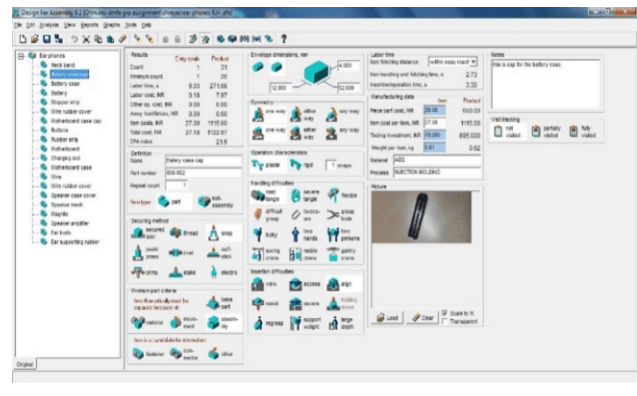
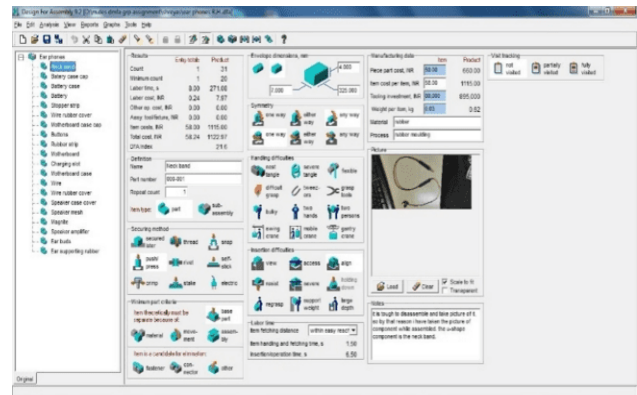
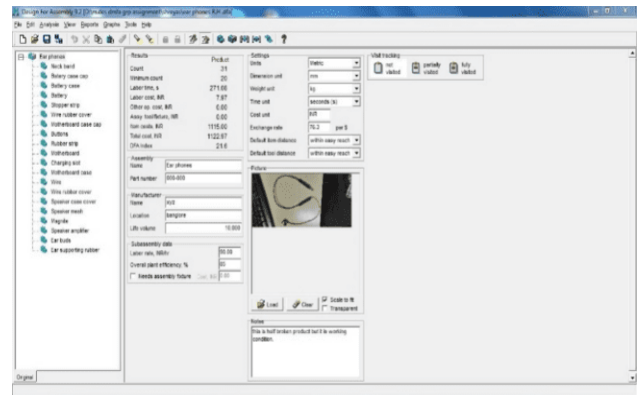
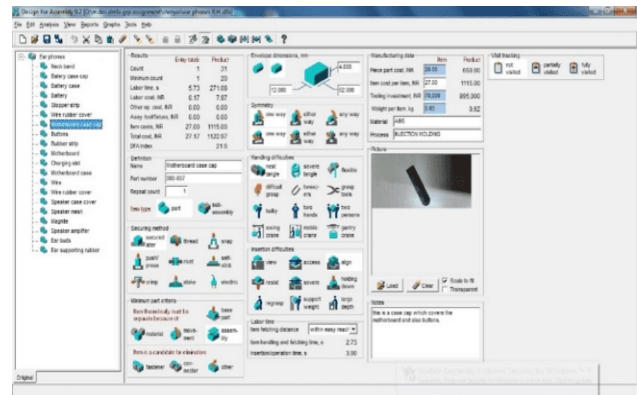
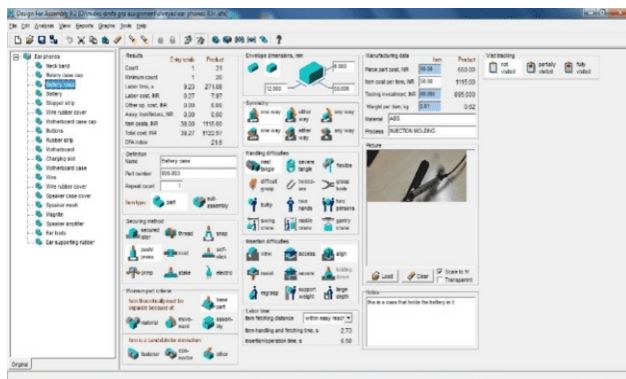


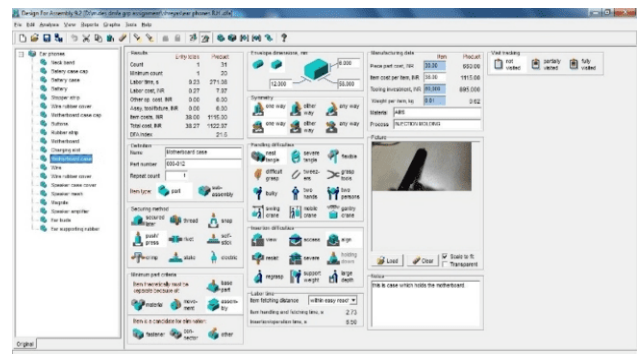
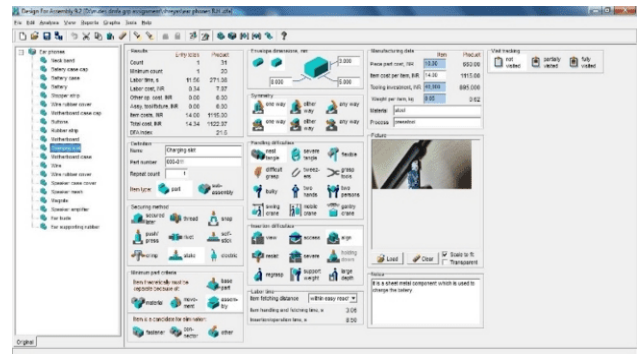
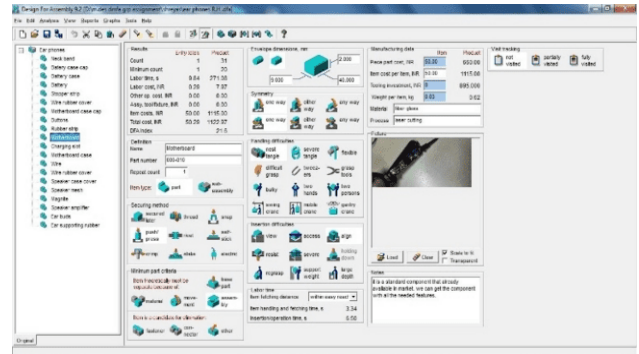
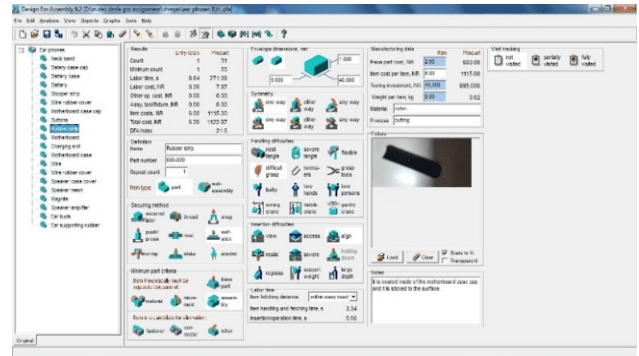
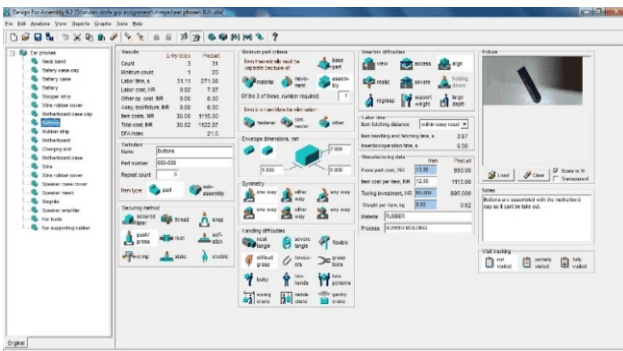
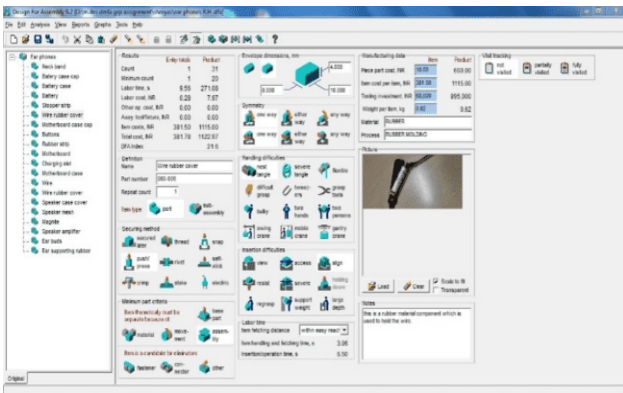
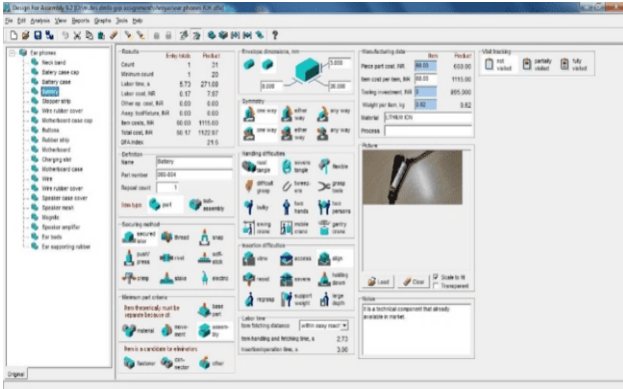
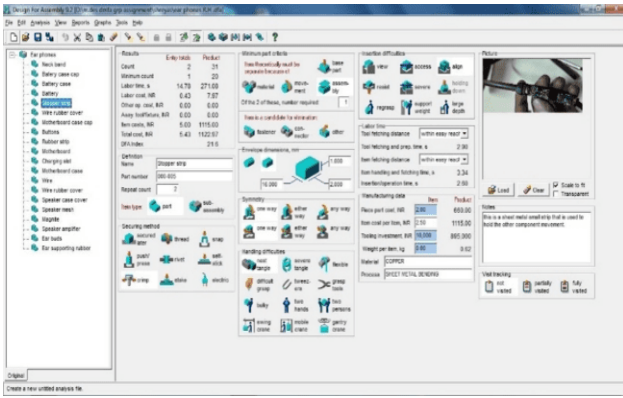
Fig. 9.

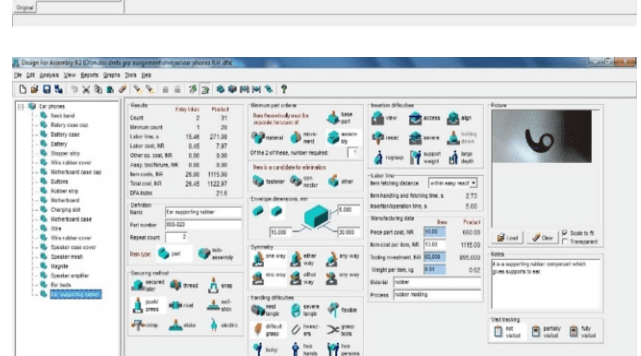
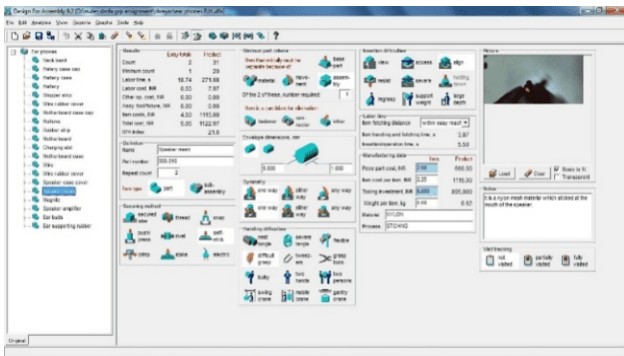
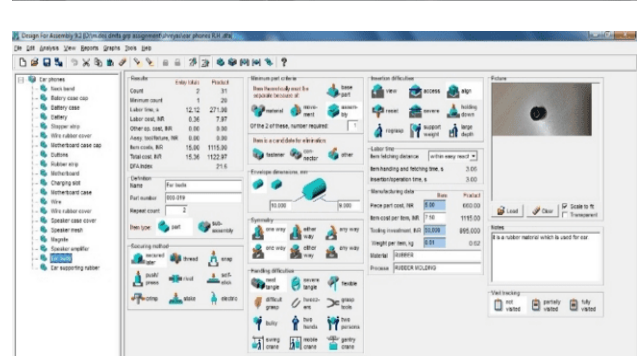
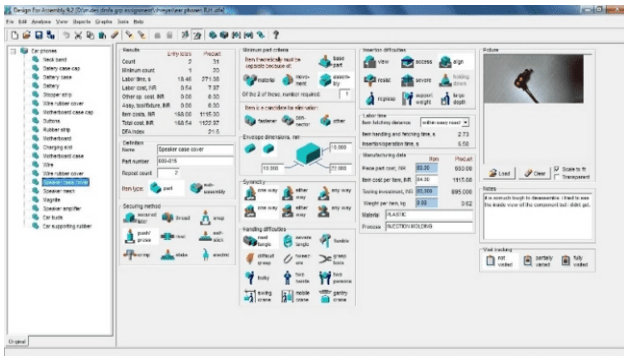
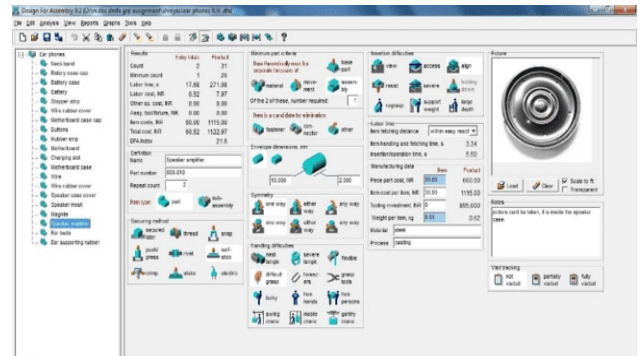
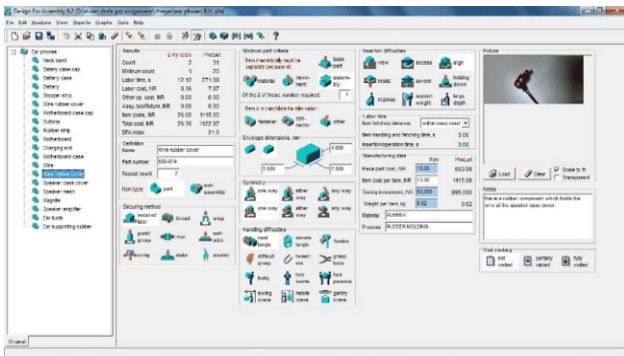
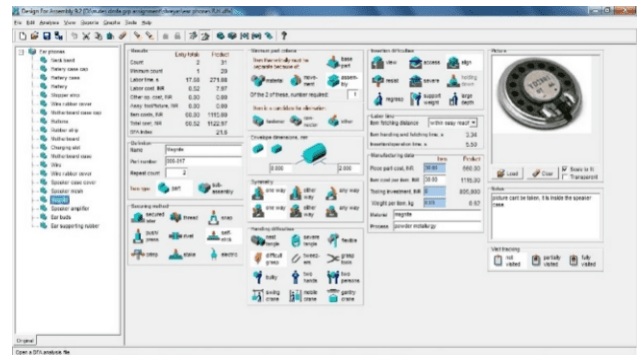
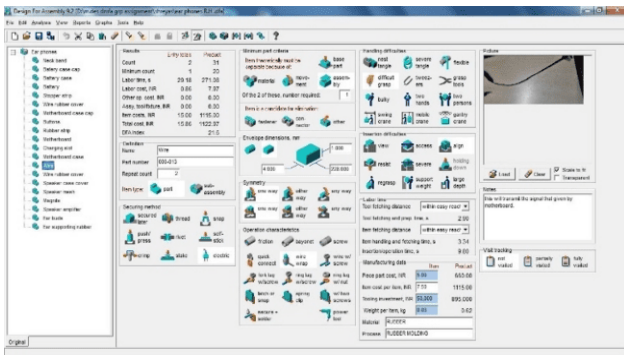
Guideline 13: Component accessibility has to be maximize. All components are easy to assess in this product, so no need to consider this guideline for this product.

4. Improvement in Product Assembly

Boothroid Analysis of Existing Product:







Boothroid Reports of Existing Product:



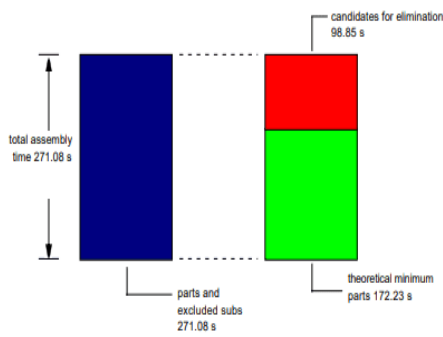
Executive Summary - DFA
Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:52 PM
Ear phones

ear phones R.H .dfa
Product: Original

Per Product data	Entries (including repeats)	Labor Time, s	Labor Cost, INR
Component parts	31	271.08	7.97
Subassemblies partially or fully analyzed	0	0.00	0.00
Subassemblies not to be analyzed (excluded)	0	0.00	0.00
Standard and library operations	0	0.00	0.00
Totals	31	271.08	7.97

The chart shows a breakdown of time per product



Design for Assembly: Structure Chart
Boothroyd Dewhurst, Inc.

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Product: Original



Design for Assembly: Product Worksheet
Boothroyd Dewhurst, Inc.

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Ear phones

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Product: Original

No.	Name	Part number	Type	Repeat count	Total count	Securing method	Minimum items	Minimum part criteria
1	Ear phones	300-000	Item					
2	Neck band	300-001	Part	1	1	Push	1	Base part
3	Battery case cap	300-002	Part	1	1	Snap	1	Assembly
4	Battery case	300-003	Part	1	1	Push	1	Base part
5	Battery	300-004	Part	1	1	Dep. up	1	Assembly
6	Stopper strip	300-005	Part	2	2	Clamp	1	Assembly
7	Wire rubber cover	300-006	Part	1	1	Push	1	Assembly
8	Motherboard case cap	300-007	Part	1	1	Dep. up	1	Assembly
9	Buttons	300-008	Part	3	3	Push	1	Assembly
10	Rubber strip	300-009	Part	1	1	Self-stick	1	Assembly
11	Motherboard	300-010	Part	1	1	Push	1	Assembly
12	Charging slot	300-011	Part	1	1	Stake	1	Assembly
13	Motherboard case	300-012	Part	1	1	Push	1	Assembly
14	Wire	300-013	Part	2	2	Electrical	1	Assembly
15	Wire rubber cover	300-014	Part	2	2	Dep. up	1	Assembly
16	Speaker case cover	300-015	Part	2	2	Push	1	Assembly
17	Speaker mesh	300-016	Part	2	2	Self-stick	1	Assembly
18	Magnets	300-017	Part	2	2	Self-stick	1	Assembly
19	Speaker amplifier	300-018	Part	2	2	Self-stick	1	Assembly
20	Ear buds	300-019	Part	2	2	Dep. up	1	Assembly
21	Ear supporting rubber	300-020	Part	2	2	Push	1	Assembly
22	Totals for Ear phones				31			20

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Executive Summary - DFMA
Boothroyd Dewhurst, Inc.

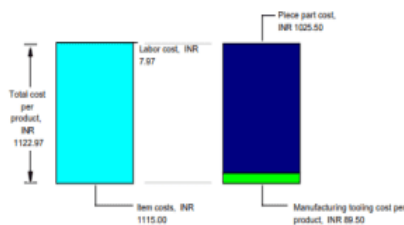
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Product: Original

Product life volume	10,000
Number of entries (including repeats)	31
Number of different entries	20
Theoretical minimum number of items	20
DFA Index	21.6
Total weight, kg	0.82
Total assembly labor time, s	271.08
Total cost for manufactured items (including tooling), INR	1115.00
Total assembly labor cost, INR	7.97
Other operation cost per product, INR	0.00
Total manufacturing piece part cost, INR	860.00
Total cost per product without tooling, INR	1033.47
Assembly tool or fixture cost per product, INR	0.00
Manufacturing tooling cost per product, INR	88.50
Total cost per product, INR	1122.97

*Note: Item weight not given for some items. Total weight may be incomplete.

The chart shows a breakdown of cost per product



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Design for Assembly: Product Worksheet
Boothroyd Dewhurst, Inc.

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Ear phones

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Product: Original

No.	Name	Handling problems	Insertion problems	Ergonomic problems	Tool finishing and preparation time, s	Item handling time, s	Insertion/operation time, s	Total labor time, s	Labor cost, INR
1	Ear phones								
2	Neck band	X	X		0.00	1.50	6.00	8.00	0.24
3	Battery case cap	X	X		0.00	2.73	3.20	6.03	0.18
4	Battery case	X	X		0.00	2.73	6.50	9.23	0.27
5	Battery	X	X		0.00	2.73	3.00	5.73	0.17
6	Stopper strip	X	X		2.80	3.34	2.80	14.78	0.43
7	Wire rubber cover	X	X		0.00	3.06	6.00	9.06	0.26
8	Motherboard case cap	X	X		0.00	2.73	3.00	5.73	0.17
9	Buttons	X	X	X	0.00	3.87	6.00	31.11	0.92
10	Rubber strip	X	X	X	0.00	3.34	5.50	8.84	0.26
11	Motherboard	X	X		0.00	3.34	6.00	9.34	0.28
12	Charging slot	X	X		0.00	3.06	8.50	11.56	0.34
13	Motherboard case	X	X		0.00	2.73	6.50	9.23	0.27
14	Wire	X	X	X	2.80	3.34	9.80	29.18	0.85
15	Wire rubber cover	X	X		0.00	3.06	3.00	12.12	0.36
16	Speaker case cover	X	X		0.00	2.73	6.50	18.46	0.54
17	Speaker mesh	X	X	X	0.00	3.87	5.50	18.74	0.55
18	Magnets	X	X	X	0.00	3.34	5.50	17.88	0.52
19	Speaker amplifier	X	X	X	0.00	3.34	5.50	17.88	0.52
20	Ear buds	X	X		0.00	3.06	3.00	12.12	0.36
21	Ear supporting rubber	X	X		0.00	2.73	5.00	15.40	0.45
22	Totals for Ear phones							271.08	7.97

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Design for Assembly: Product Worksheet
Boothroyd Dewhurst, Inc.



Thursday, April 28, 2022 5:53 PM
Ear phones

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Product: Original

No.	Name	Special assembly tool or fixture cost	Piece part cost per item, INR	Tooling investment, INR	Tooling cost per item, INR	Part or item cost, INR	Total item cost, INR	Other operation cost, INR
1	Ear phones	0.00						
2	Neck band	0.00	50.00	60,000	8.00	58.00	58.00	
3	Battery case cap	0.00	20.00	70,000	7.00	27.00	27.00	
4	Battery case	0.00	30.00	80,000	8.00	38.00	38.00	
5	Battery	0.00	60.00	0	0.00	60.00	60.00	
6	Stopper strip	0.00	2.00	10,000	0.50	2.50	2.50	
7	Wire rubber cover	0.00	10.00	60,000	6.00	381.50	381.50	
8	Motherboard case cap	0.00	20.00	70,000	7.00	27.00	27.00	
9	Buttons	0.00	10.00	60,000	2.00	12.00	36.00	
10	Rubber strip	0.00	2.00	40,000	4.00	6.00	6.00	
11	Motherboard	0.00	50.00	0	0.00	50.00	50.00	
12	Charging slot	0.00	10.00	40,000	4.00	14.00	14.00	
13	Motherboard case	0.00	30.00	80,000	8.00	38.00	38.00	
14	Wire	0.00	5.00	50,000	2.50	7.50	15.00	
15	Wire rubber cover	0.00	10.00	60,000	3.00	13.00	39.00	
16	Speaker case cover	0.00	80.00	80,000	4.00	84.00	168.00	
17	Speaker mesh	0.00	2.00	5,000	0.25	2.25	4.50	
18	Magrite	0.00	30.00	0	0.00	30.00	60.00	
19	Speaker amplifier	0.00	30.00	0	0.00	30.00	60.00	
20	Ear buds	0.00	5.00	50,000	2.50	7.50	15.00	
21	Ear supporting rubber	0.00	10.00	60,000	3.00	13.00	26.00	
22	Totals for Ear phones	0.00	660.00	850,000	96.00		1116.00	

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Design for Assembly: Analysis Totals
Boothroyd Dewhurst, Inc.



Thursday, April 28, 2022 5:54 PM
Ear phones

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Product: Original

Per product data

	Entries (including repeats)	Number of different parts	Total time, s	Labor cost, INR	Item costs (including tooling)	Weight, kg
Parts	31	20	271.08	7.97	1115.00	6.62
Subassemblies:						
Partially or fully analyzed	0	0	0.00	0.00	0.00	0.00
Named only	0	0	0.00	0.00	0.00	0.00
Excluded	0	0	0.00	0.00	0.00	0.00
Operations:						
Standard	0	0	0.00	0.00	-	-
Library	0	0	0.00	0.00	-	0.00
Column Totals	31	20	271.08	7.97	1115.00	6.62

Cost totals based on a product life volume of 10,000

	Labor cost, INR	Other operation costs, INR	Manuf. piece part cost, INR	Total cost without tooling, INR	Asy. tool or fixture cost, INR	Manuf. tooling cost, INR	Total cost, INR
Cost per product	7.97	0.00	660.00	1033.47	0.00	89.90	1123.97
Production life cost	79.729	0	6,600,000	10,334,729	0	895,000	11,229,730

**Note: Weight not given for some items. Total weight may be incomplete.

DFA Index

Theoretical minimum number of items	20
DFA Index	21.6
Production data	
Overall plant efficiency, %	85.00
Labor rate, INR/hr	90.00

Design for Assembly: Suggestions for Redesign
Boothroyd Dewhurst, Inc.



Thursday, April 28, 2022 5:54 PM
Ear phones

ear phones R.H. dfa
Product: Original

Reduce the number of items in the assembly by combining with others or eliminating the following parts or subassemblies. Note that combining an item with another may eliminate further items such as fasteners or operations, resulting in much larger time reductions than those indicated.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Stopper strip	1	14.79	5.45
	Buttons	2	31.11	11.46
	Wire	1	29.18	10.76
	Wire rubber cover	1	12.12	4.47
	Speaker case cover	1	18.46	6.81
	Speaker mesh	1	18.74	6.91
	Magrite	1	17.66	6.52
	Speaker amplifier	1	17.66	6.52
	Ear buds	1	12.12	4.47
	Ear supporting rubber	1	15.46	5.70
Totals			187.33	69.11

Add assembly features such as chamfers, lips, leads, etc., to make the following items self-aligning.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Neck band	1	1.50	0.55
	Battery case cap	1	1.50	0.55
	Battery case	1	1.50	0.55
	Battery	1	1.50	0.55
	Stopper strip	2	3.00	1.11

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Design for Assembly: Product Worksheet
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Ear phones

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Product: Original

No.	Name	Total other operation cost, INR	Total cost, INR	Weight per item, kg	Total weight, kg	Material
1	Ear phones					
2	Neck band	58.24	0.03	0.03		rubber
3	Battery case cap	27.18	0.01	0.01		ABS
4	Battery case	38.27	0.01	0.01		ABS
5	Battery	60.17	0.02	0.02		LITHIUM ION
6	Stopper strip	5.43	0.00	0.01		COPPER
7	Wire rubber cover	381.78	0.03	0.03		RUBBER
8	Motherboard case cap	27.17	0.03	0.03		ABS
9	Buttons	36.00	0.00	0.01		RUBBER
10	Rubber strip	6.26	0.00	0.00		nylon
11	Motherboard	49.29	0.03	0.03		clear glass
12	Charging slot	14.34	0.05	0.05		steel
13	Motherboard case	38.27	0.01	0.01		ABS
14	Wire	15.86	0.03	0.06		RUBBER
15	Wire rubber cover	20.36	0.03	0.06		RUBBER
16	Speaker case cover	160.54	0.08	0.10		PLASTIC
17	Speaker mesh	5.05	0.00	0.00		NYLON
18	Magrite	60.50	0.03	0.06		magrite
19	Speaker amplifier	60.50	0.03	0.06		steel
20	Ear buds	15.36	0.01	0.02		RUBBER
21	Ear supporting rubber	26.45	0.01	0.02		rubber
22	Totals for Ear phones	0.00	1123.97		6.62	

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Design for Assembly: Product Worksheet
Boothroyd Dewhurst, Inc.



Thursday, April 28, 2022 5:53 PM
Ear phones

ear phones R.H. dfa
Product: Original

No.	Name	Manufacturing process	Visual tracking	Notes
1	Ear phones			
2	Neck band	rubber molding	<input type="checkbox"/>	this is half broken product but it is working cond
3	Battery case cap	INJECTION MOLDING	<input type="checkbox"/>	it is tough to disassemble and take picture of it.
4	Battery case	INJECTION MOLDING	<input type="checkbox"/>	this is a cap for the battery case.
5	Battery		<input type="checkbox"/>	this is a case that holds the battery in it.
6	Stopper strip	SHEET METAL BENDING	<input type="checkbox"/>	it is a technical component that already available
7	Wire rubber cover	RUBBER MOLDING	<input type="checkbox"/>	this is a sheet metal small strip that is used to ho
8	Motherboard case cap	INJECTION MOLDING	<input type="checkbox"/>	this is a rubber material component which is use
9	Buttons	RUBBER MOLDING	<input type="checkbox"/>	this is a case cap which covers the motherboard
10	Rubber strip	cutting	<input type="checkbox"/>	Buttons are assembled with the motherboard cap
11	Motherboard	laser cutting	<input type="checkbox"/>	it is located inside of the motherboard case cap
12	Charging slot	press tool	<input type="checkbox"/>	it is a standard component that already available
13	Motherboard case	INJECTION MOLDING	<input type="checkbox"/>	it is a sheet metal component which is used to c
14	Wire	RUBBER MOLDING	<input type="checkbox"/>	this is case which holds the motherboard.
15	Wire rubber cover	RUBBER MOLDING	<input type="checkbox"/>	this will transmit the signal that given by mothb
16	Speaker case cover	INJECTION MOLDING	<input type="checkbox"/>	this is a rubber component which holds the wire
17	Speaker mesh	STITCHING	<input type="checkbox"/>	it is somewhat tough to disassemble. I tend to see
18	Magrite	powder metallurgy	<input type="checkbox"/>	it is a nylon mesh material which stuck at the r
19	Speaker amplifier	coating	<input type="checkbox"/>	picture cant be taken, it is inside the speaker ca
20	Ear buds	RUBBER MOLDING	<input type="checkbox"/>	picture cant be taken, it is inside the speaker ca
21	Ear supporting rubber	rubber molding	<input type="checkbox"/>	it is a rubber material which is used for ear.
22	Totals for Ear phones			it is a supporting rubber component which give

www.dfma.com

Page 5 of 5

	Wire rubber cover	1	0.81	0.30
	Motherboard case cap	1	0.78	0.29
	Buttons	3	2.61	0.96
	Rubber strip	1	0.83	0.31
	Motherboard	1	0.83	0.31
	Charging slot	1	0.81	0.30
	Motherboard case	1	0.78	0.29
	Wire	2	1.66	0.61
	Wire rubber cover	2	1.62	0.60
	Speaker case cover	2	1.56	0.58
	Speaker mesh	2	1.74	0.64
	Magnite	2	1.66	0.61
	Speaker amplifier	2	1.66	0.61
	Ear buds	2	1.62	0.60
	Ear supporting rubber	2	1.56	0.58
Totals			24.53	9.05

Review the following items and operations that may cause ergonomic difficulties for the assembly worker.

Parent assembly	Name	Repeat count
Ear phones	Buttons	3
	Rubber strip	1
	Wire	2

	Speaker mesh	2
	Magnite	2
	Speaker amplifier	2
	Ear supporting rubber	2

5. Modified Product

By considering guidelines, reports that generated modifications has been done. Some components have been eliminated and some are merged and made into single component. Important thing in this is ‘body’, the material used is rubber. Except the wire region, the material in all region will be made hard. By making into single component the problems like breaking wire connection and material usage got less. Also, by keeping mother board and battery in one cavity material usage got less. Therefore, the product is modified effectively.

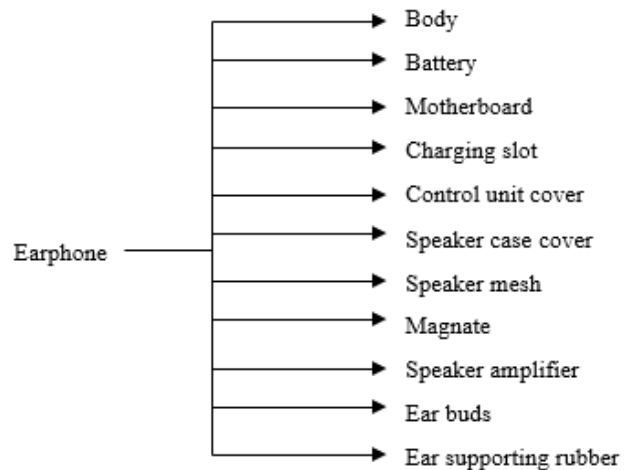


	Wire rubber cover	1	1.50	0.55
	Motherboard case cap	1	1.50	0.55
	Buttons	3	4.50	1.66
	Rubber strip	1	1.50	0.55
	Motherboard	1	1.50	0.55
	Charging slot	1	1.50	0.55
	Motherboard case	1	1.50	0.55
	Wire	2	0.00	0.00
	Wire rubber cover	2	3.00	1.11
	Speaker case cover	2	3.00	1.11
	Speaker mesh	2	3.00	1.11
	Magnite	2	3.00	1.11
	Speaker amplifier	2	3.00	1.11
	Ear buds	2	3.00	1.11
Totals			40.50	14.94

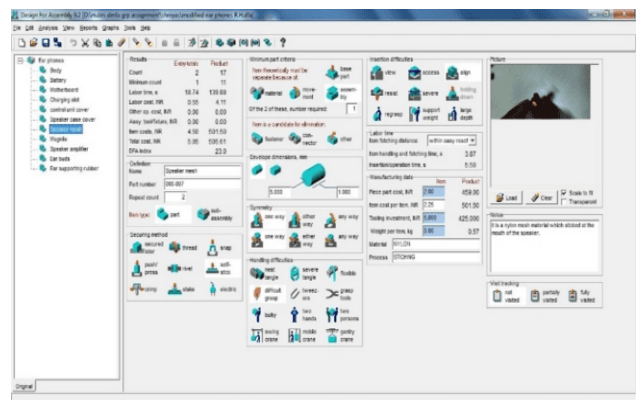
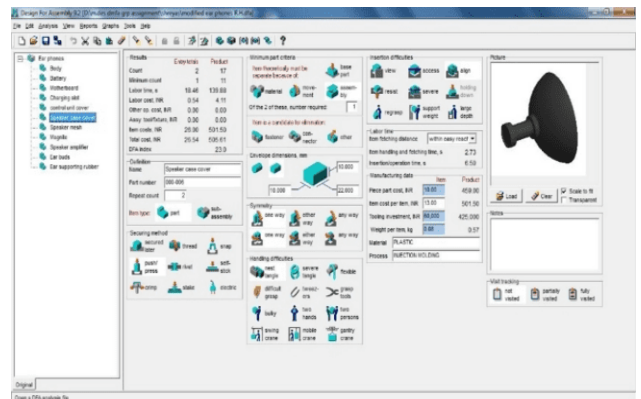
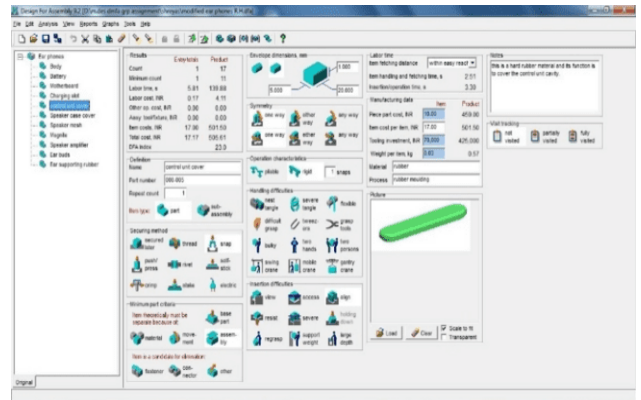
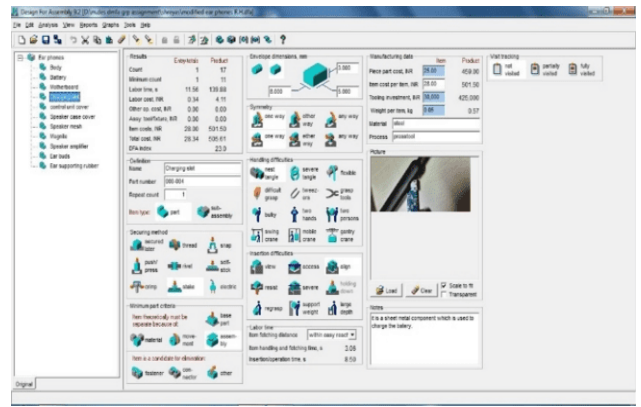
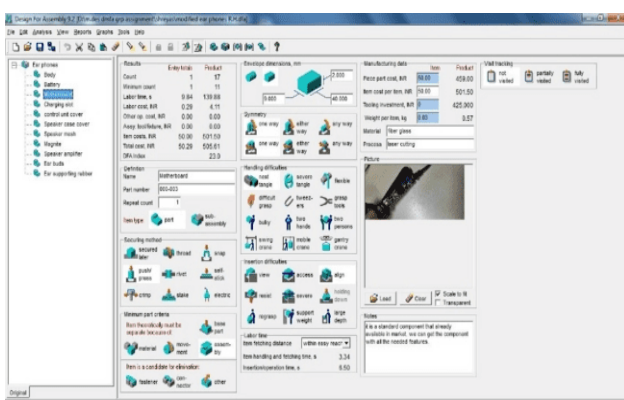
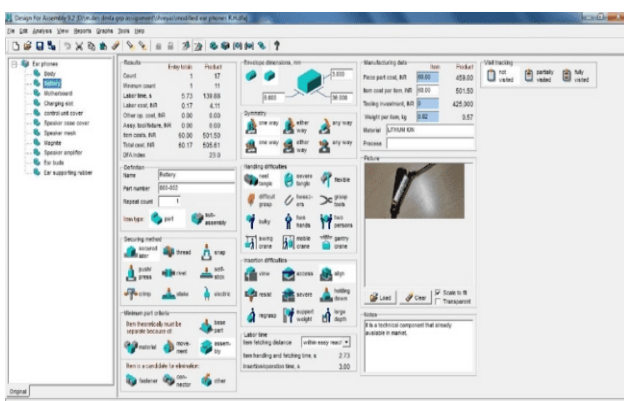
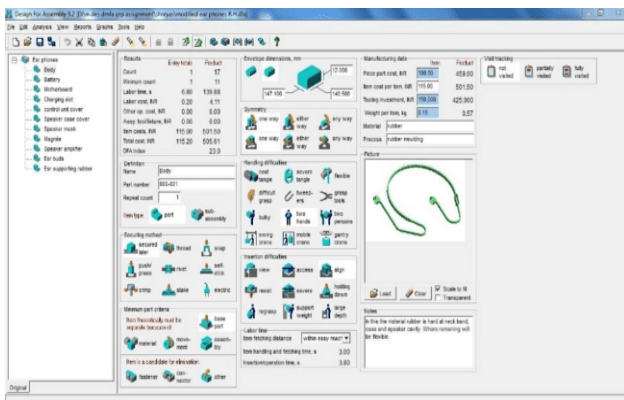
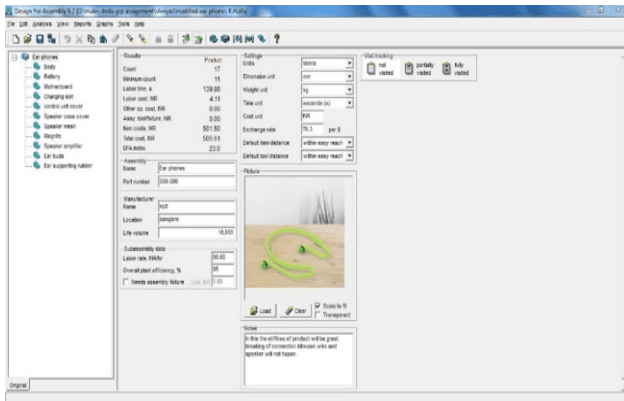
The individual assembly items listed below need or tangle and/or are difficult to grasp. Consider redesign of the items to eliminate or reduce their handling difficulties.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Battery case cap	1	0.78	0.29
	Battery case	1	0.78	0.29
	Battery	1	0.78	0.29
	Stopper strip	2	1.66	0.61

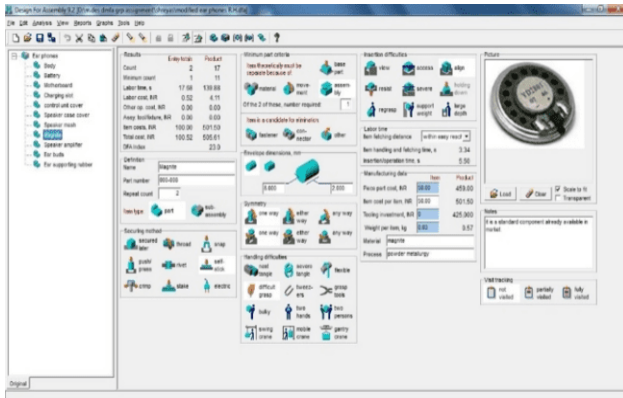
Structure:



6. Boothroid Analysis of Modified Product



7. Boothroid Reports of Existing Product



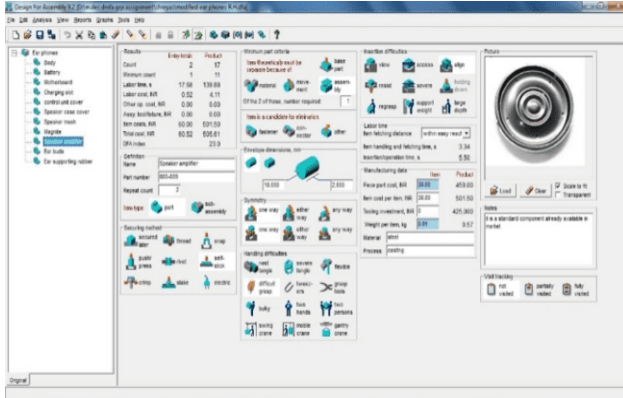
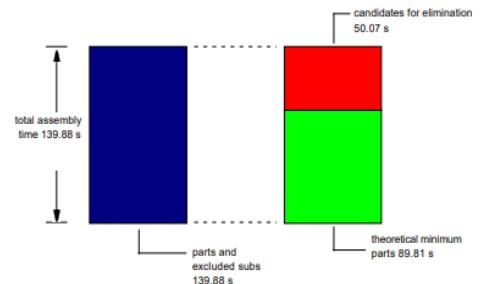
Thursday, April 28, 2022 5:56 PM
Ear phones

Executive Summary - DFA Boothroyd Dewhurst, Inc.

modified ear phones R.H.dfa
Product: Original

Per Product data	Entries (including repeats)	Labor Time, s	Labor Cost, INR
Component parts	17	139.88	4.11
Subassemblies partially or fully analyzed	0	0.00	0.00
Subassemblies not to be analyzed (excluded)	0	0.00	0.00
Standard and library operations	0	0.00	0.00
Totals	17	139.88	4.11

The chart shows a breakdown of time per product



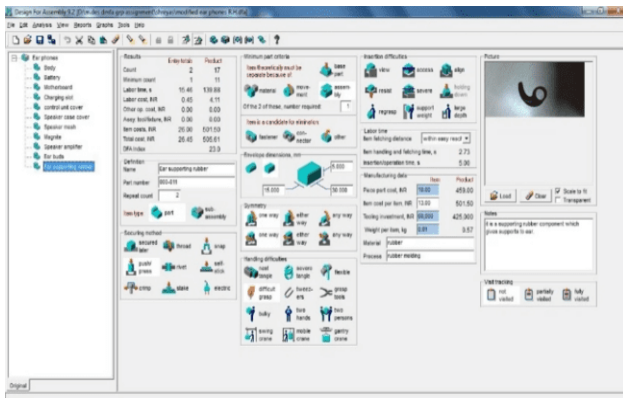
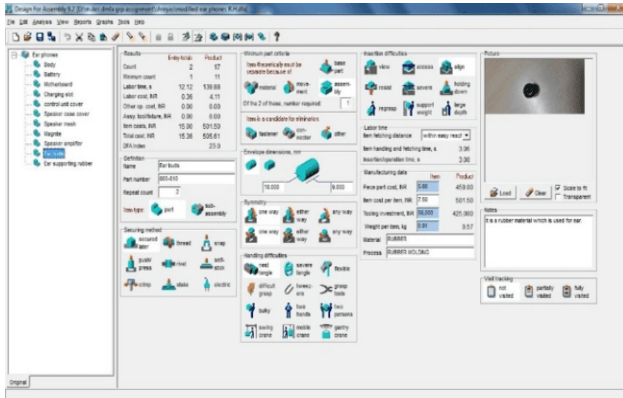
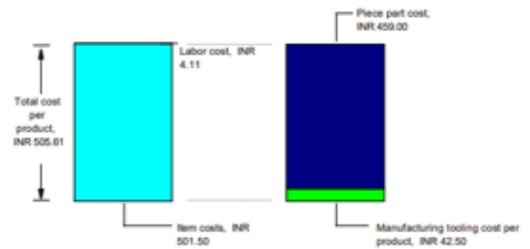
Thursday, April 28, 2022 5:56 PM
Ear phones

Executive Summary - DFMA Boothroyd Dewhurst, Inc.

modified ear phones R.H.dfa
Product: Original

Product life volume	10,000
Number of entries (including repeats)	17
Number of different entries	11
Theoretical minimum number of items	11
DFA Index	15.71
Total weight, kg	0.57
Total assembly labor time, s	139.88
Total cost for manufactured items (including tooling), INR	501.50
Total assembly labor cost, INR	4.11
Other operation cost per product, INR	0.00
Total manufacturing piece part cost, INR	459.00
Total cost per product without tooling, INR	463.11
Assembly tool or fixture cost per product, INR	0.00
Manufacturing tooling cost per product, INR	42.50
Total cost per product, INR	505.61

The chart shows a breakdown of cost per product



Design for Assembly: Structure Chart

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:57 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

- Ear phones
 - Body
 - Battery
 - Motherboard
 - Charging slot
 - control unit cover
 - Speaker case cover
 - Speaker mesh
 - Magrite
 - Speaker amplifier
 - Ear buds
 - Ear supporting rubber

Design for Assembly: Product Worksheet

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:57 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

No.	Name	Total other operations cost, INR	Total cost, INR	Weight per item, kg	Total weight, kg	Material
1	Ear phones					
2	Body	115.20	0.15	0.15		Rubber
3	Battery	60.17	0.02	0.02		LITHIUM ION
4	Motherboard	50.29	0.03	0.03		Fiber glass
5	Charging slot	28.34	0.00	0.00		Steel
6	control unit cover	17.17	0.03	0.03		Rubber
7	Speaker case cover	26.54	0.06	0.16		PLASTIC
8	Speaker mesh	5.05	0.00	0.01		NYLON
9	Magrite	100.52	0.03	0.06		Magrite
10	Speaker amplifier	60.52	0.01	0.02		steel
11	Ear buds	12.38	0.01	0.02		RUBBER
12	Ear supporting rubber	26.43	0.01	0.02		Rubber
13	Totals for Ear phones	6.08	606.41	0.67		

Design for Assembly: Product Worksheet

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:57 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

No.	Name	Part number	Type	Repeat count	Total count	Securing method	Mount items	Mount part criteria
1	Ear phones	300-000	Man					
2	Body	300-001	Part	1	1	Step up	1	Base part
3	Battery	300-002	Part	1	1	Step up	1	Assembly
4	Motherboard	300-003	Part	1	1	Push	1	Assembly
5	Charging slot	300-004	Part	1	1	Stake	1	Assembly
6	control unit cover	300-005	Part	1	1	Snap	1	Assembly
7	Speaker case cover	300-006	Part	2	2	Push	1	Assembly
8	Speaker mesh	300-007	Part	2	2	Self-stick	1	Assembly
9	Magrite	300-008	Part	2	2	Self-stick	1	Assembly
10	Speaker amplifier	300-009	Part	2	2	Self-stick	1	Assembly
11	Ear buds	300-010	Part	2	2	Step up	1	Assembly
12	Ear supporting rubber	300-011	Part	2	2	Push	1	Assembly
13	Totals for Ear phones				17			11

Design for Assembly: Product Worksheet

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:57 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

No.	Name	Manufacturing process	Visit tracking	Notes
1	Ear phones		<input type="checkbox"/>	In this the address of product will be great. line
2	Body	rubber moulding	<input type="checkbox"/>	In this the material rubber is hard at neck back
3	Battery		<input type="checkbox"/>	It is a technical component that already available
4	Motherboard	laser cutting	<input type="checkbox"/>	It is a standard component that already available
5	Charging slot	precision	<input type="checkbox"/>	It is a sheet metal component which is used to
6	control unit cover	rubber moulding	<input type="checkbox"/>	It is a hard rubber material and its function is
7	Speaker case cover	INJECTION MOLDING	<input type="checkbox"/>	
8	Speaker mesh	STITCHING	<input type="checkbox"/>	It is a nylon mesh material which attached at the
9	Magrite	powder metallurgy	<input type="checkbox"/>	It is a standard component already available in-
10	Speaker amplifier	welding	<input type="checkbox"/>	It is a standard component already available in-
11	Ear buds	RUBBER MOLDING	<input type="checkbox"/>	It is a rubber material which is used for ear
12	Ear supporting rubber	rubber moulding	<input type="checkbox"/>	It is a supporting rubber component which gives
13	Totals for Ear phones			

Design for Assembly: Product Worksheet

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:57 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

No.	Name	Handling problems	Insertion problems	Ergonomic problems	Tool testing and preparation time, s	Item handling time, s	Insertion operation time, s	Total labor time, s	Labor cost, INR
1	Ear phones								
2	Body	X	X	X	0.00	3.00	3.80	6.80	0.20
3	Battery	X	X	X	0.00	2.73	3.00	5.73	0.17
4	Motherboard	X	X	X	0.00	3.34	4.00	7.34	0.20
5	Charging slot	X	X	X	0.00	3.06	3.00	6.06	0.18
6	control unit cover	X	X	X	0.00	2.51	3.30	5.81	0.17
7	Speaker case cover	X	X	X	0.00	2.73	4.00	6.73	0.20
8	Speaker mesh	X	X	X	0.00	3.87	3.00	6.87	0.20
9	Magrite	X	X	X	0.00	3.34	3.00	6.34	0.18
10	Speaker amplifier	X	X	X	0.00	3.34	3.00	6.34	0.18
11	Ear buds	X	X	X	0.00	3.00	3.00	6.00	0.18
12	Ear supporting rubber	X	X	X	0.00	2.73	3.00	5.73	0.17
13	Totals for Ear phones							139.88	4.11

Design for Assembly: Analysis Totals

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:58 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

Per product data	Entries (including repeats)	Number of different parts	Total time, s	Labor cost, INR	Item costs (including tooling)	Weight, kg
Parts	17	11	139.88	4.11	501.50	0.57
Subassemblies:						
Partially or fully analyzed	0	0	0.00	0.00	0.00	0.00
Named only	0	0	0.00	0.00	0.00	0.00
Excluded	0	0	0.00	0.00	0.00	0.00
Operations:						
Standard	0	0	0.00	0.00	-	-
Library	0	0	0.00	0.00	-	0.00
Column Totals	17	11	139.88	4.11	501.50	0.57

Design for Assembly: Product Worksheet

Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:57 PM
Ear phones

modified ear phones R.H.dfa
Product: Original

No.	Name	Special assembly tool or fixture cost	Piece part cost per item, INR	Tooling investment, INR	Tooling cost per item, INR	Part or item cost, INR	Total item cost, INR	Other operation cost, INR
1	Ear phones	0.00						
2	Body	0.00	100.00	150,000	15.00	115.00	115.00	
3	Battery	0.00	40.00	0	0.00	40.00	40.00	
4	Motherboard	0.00	50.00	0	0.00	50.00	50.00	
5	Charging slot	0.00	25.00	30,000	3.00	28.00	28.00	
6	control unit cover	0.00	10.00	70,000	7.00	17.00	17.00	
7	Speaker case cover	0.00	10.00	40,000	3.00	13.00	26.00	
8	Speaker mesh	0.00	2.00	5,000	0.25	4.50	4.50	
9	Magrite	0.00	50.00	0	0.00	50.00	100.00	
10	Speaker amplifier	0.00	30.00	0	0.00	30.00	60.00	
11	Ear buds	0.00	5.00	50,000	2.50	7.50	15.00	
12	Ear supporting rubber	0.00	10.00	40,000	3.00	13.00	26.00	
13	Totals for Ear phones	0.00	428.00	425,000	42.00	501.50	501.50	

Cost totals based on a product life volume of 10,000

	Labor cost, INR	Other operation costs, INR	Manuf. piece part cost, INR	Total cost without tooling, INR	Assy. tool or fixture cost, INR	Manuf. tooling cost, INR	Total cost, INR
Cost per product	4.11	0.00	458.00	463.11	0.00	42.50	505.61
Production life cost	41,141	0	4,580,000	4,631,141	0	425,000	5,056,141

DFA Index

Theoretical minimum number of items	11
DFA Index	23.11

Production data

Overall plant efficiency, %	85.00
Labor rate, INR/hr	90.00

Design for Assembly: Suggestions for Redesign
Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:58 PM modified ear phones R.H.dfa
Ear phones Product: Original

Reduce the number of items in the assembly by combining with others or eliminating the following parts or subassemblies. Note that combining an item with another may eliminate further items such as fasteners or operations, resulting in much larger time reductions than those indicated.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Speaker case cover	1	18.46	13.20
	Speaker mesh	1	18.74	13.40
	Magnite	1	17.68	12.64
	Speaker amplifier	1	17.68	12.64
	Ear buds	1	12.12	8.66
	Ear supporting rubber	1	15.48	11.05
Totals			100.14	71.99

Add assembly features such as chamfers, lips, leads, etc., to make the following items self-aligning.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Body	1	1.50	1.07
	Battery	1	1.50	1.07
	Motherboard	1	1.50	1.07
	Charging slot	1	1.50	1.07
	control unit cover	1	1.50	1.07
	Speaker case cover	2	3.00	2.14
	Speaker mesh	2	3.00	2.14
	Magnite	2	3.00	2.14
	Speaker amplifier	2	3.00	2.14

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By considering the reports and guidelines of DFA the modifications and improvements has been done. The improved product can be seen in the figure.



Original product



Improved product

Design for Assembly: Suggestions for Redesign
Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:58 PM modified ear phones R.H.dfa
Ear phones Product: Original

	Ear buds	2	3.00	2.14
Totals			22.50	16.09

The individual assembly items listed below next or tangle and/or are difficult to grasp. Consider redesign of the items to eliminate or reduce their handling difficulties.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Battery	1	0.76	0.56
	Motherboard	1	0.83	0.59
	Charging slot	1	0.81	0.58
	Speaker case cover	2	1.50	1.12
	Speaker mesh	2	1.74	1.24
	Magnite	2	1.66	1.19
	Speaker amplifier	2	1.66	1.19
	Ear buds	2	1.62	1.16
	Ear supporting rubber	2	1.56	1.12
Totals			12.22	8.74

Consider redesign of the individual assembly items listed below to eliminate or reduce handling difficulties causing the items to be bulky, awkward or difficult to grasp or control or require two hands to control, carry, and manipulate.

Parent assembly	Name	Repeat count	Time savings, s	Percentage reduction
Ear phones	Body	1	1.80	1.32
Totals			1.80	1.32

www.dfma.com Page 2 of 3

Table 2

S.No.	Original	Modified
01	Number of parts 20	Number of parts 11
02	Total time taken(s) 271.08	Total time taken(s) 139.88
03	Cost per product (INR) 1122.97	Cost per product (INR) 505.61
04	Weight(kg) 0.62	Weight(kg) 0.57
05	DFA index: 21.6	DFA index: 23.0

Design for Assembly: Suggestions for Redesign
Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:58 PM modified ear phones R.H.dfa
Ear phones Product: Original

Review the following items and operations that may cause ergonomic difficulties for the assembly worker.

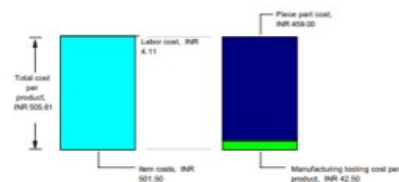
Parent assembly	Name	Repeat count
Ear phones	Body	1
	Speaker mesh	2
	Magnite	2
	Speaker amplifier	2
	Ear supporting rubber	2

Executive Summary - DFMA
Boothroyd Dewhurst, Inc.

Thursday, April 28, 2022 5:56 PM modified ear phones R.H.dfa
Ear phones Product: Original

Product life volume	10,000
Number of entries (including repeats)	17
Number of different entries	11
Theoretical minimum number of items	11
DFA Index	23.0
Total weight, kg	0.57
Total assembly labor time, s	139.88
Total cost for manufactured items (including tooling), INR	501.90
Total assembly labor cost, INR	4.11
Other operation cost per product, INR	0.00
Total manufacturing piece part cost, INR	498.00
Total cost per product without tooling, INR	498.11
Assembly tool or fixture cost per product, INR	0.00
Manufacturing tooling cost per product, INR	42.50
Total cost per product, INR	505.61

The chart shows a breakdown of cost per product



A. Conclusion

By considering the values of DFA index of both original and modified products i.e., 21.6 and 23 we can observe that modified product index value is greater than original product index value. Also, the component count has been reduced, time taken for assembly has been reduced, cost per product has been reduced and last weight has been reduced. So, we can say that the product modification increased efficiency, quality and durability. Also, we can observe that modified product is solution for problem of wear and tear between wire and speaker/battery/motherboard. In modified product the redesign consideration that generated by boothroid software has been taken. Also, it has followed the DFMA guidelines. Therefore, a better modified product from original product has been achieved.

8. Design for Manufacturing Analysis

Part name: Neck band

Part function: It comes at the neck part; were it hangs on the neck and balance whole product. It also connects the two-parts motherboard case and battery case.

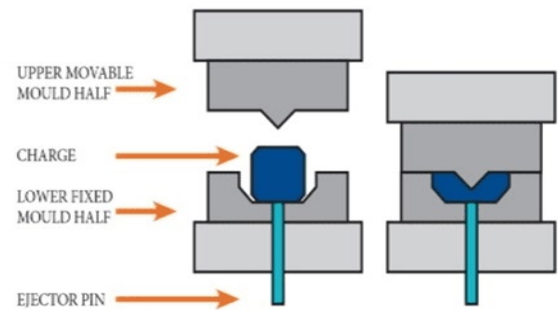
Material used: Rubber

Manufacturing process:

The manufacturing process that is used for this part is “Rubber moulding”. There are several types in this rubber moulding process. They are,

- 1) Compression moulding
- 2) Transfer moulding
- 3) Injection moulding

In those three-compression moulding is used to manufacture this part. The process is simple, initially moulds are designed and made so that we can get required shape. The vulcanized rubber material is allowed into the mould cavity. Immediately mould cavity is closed and starts heating. Using hydraulic press pressure is applied on it. As rubber is getting heat in mould it starts filling the cavity. When it reaches certain temperature, the rubber starts getting hard. That means the shape it formed will not change even by cooling. At that stage the rubber is taken out and allowed to cool. Therefore, the required shape has been formed.



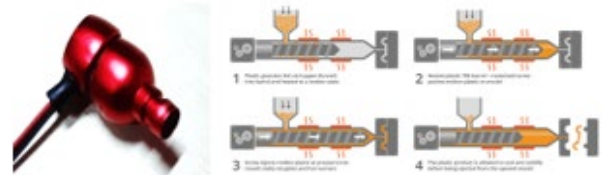
Part names: Speaker case cover

Part function: Its function is to cover and carry the speaker components. There will be an open mouth at one end were it is covered by mesh and the audio is passed out through that mouth of case.

Material used: ABS Plastic

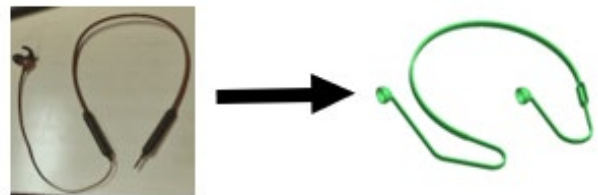
Manufacturing process:

The manufacturing process used for this part is “Injection moulding”. The process is simple, initially the small granules of plastic is feeded into the machine through hopper. The granules are feed forward by rotation of screw, thus it enters into the heating chamber were it gets melt and form into liquid state. Later it enters into the mould cavity. There it gets into the required shape and after sometime letting to cool it get into solid state and ejector pin ejects the plastic part out. Therefore, by following this process the required plastic shape parts are made.



9. Improvements in Part/Component Design

1) Here by considering the DFM guideline-3 multiple parts like Neck band, battery/motherboard case covers, wire, wire rubber covers 1 & 2, and speaker case has been merged together and formed into single part. By this the material usage will be reduced. Also, the quality of the product will be increased by this improved product.



2) Here by considering DFM guideline-7 product symmetry has been maximized. By that form of design there is no

confusion identifying the correct side of the part.

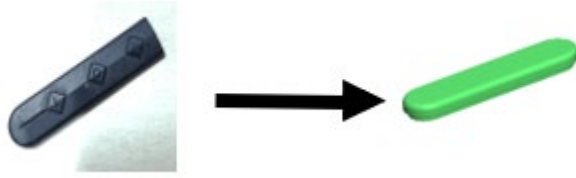
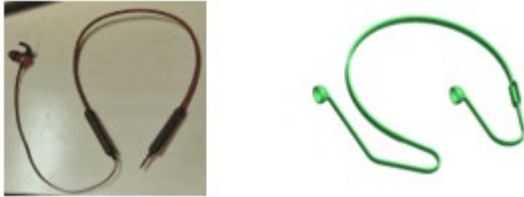
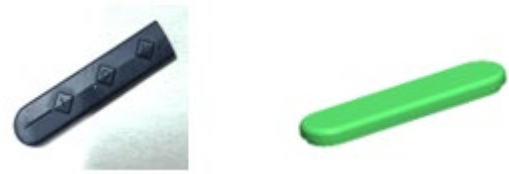


Table 3 Comparison



S.no	Neck band, battery/motherboard case covers, wire, wire rubber covers 1&2, and speaker case	Body
01	Each part has their own function.	Several functions can be performed by this part.
02	Each part is dependent on other.	This is a independent part.
03	By considering total cost of parts, it is more.	The cost is less.
04	The machine cost is more.	The machine cost is less.
05	Material usage is more	Material usage is less.
06	By considering total weight of parts, is more.	The weight is less.

Table 4 Comparison



S.no	Battery/Motherboard Case Caps	Control Unit Cover
01	Each part has their own function.	Reduced extra function and performing its own.
02	By considering total cost of parts, it is more.	The cost is less.
03	The machine cost is more.	The machine cost is less.
04	Material usage is more	Material usage is less.
05	By considering total weight of parts, is more.	The weight is less.

10. Conclusion

By considering the DFM guidelines the parts have been modified efficiently. Also, the component count has been reduced, cost per product has been reduced and weight has been reduced. So, we can say that the parts modification increased efficiency, quality and durability. Also, we can observe that modified parts is solution for problem of wear and tear between wire and speaker/battery/motherboard. Therefore, a better modified parts from original parts has been achieved.

References

[1] https://prezi.com/5ez0yvui_ymd/product-analysis-headphones/