MIT 2.810 Manufacturing Processes and Systems

Fall 2013

Homework 9 – Design for Assembly

Last edited: November 13, 2013

Problem 1

1. Based on your study of this diagram, identify the assembly step which would take the most time to complete.

Answer:
The screw assembly step highlighted in figure 1 will take the longest to complete. There are three screws which fasten the metal frame sub-assembly to the plastic cover. The access to these three screws is obstructed by the side walls of the plastic cover, and by other components. Also, the screw is not easy to align with the tapped holes.

Finally, note the number of fasteners required for this design, and the use of flexible components like the connector, earth leads, and the tube assembly.

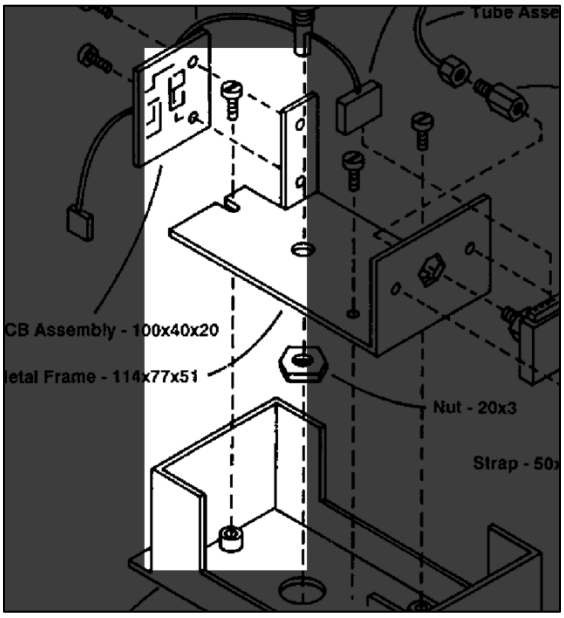


Figure 1: Screw assembly

2. How many times does the assembly have to be re-oriented to complete various part insertions? Note: reorientation takes 4.5 sec of "insertion" time.

Answer:

The reorientations are described below:

i. Metal frame will be turned over once to assemble the nut on the pressure regulator. It is then turned over again to assemble other parts.
ii. The entire assembly is turned over once to assemble the knob onto the pressure regulator. It is then turned over again to assemble the screws.

3. Write the assembly sequence, the handling and insertion times for each step, the total time needed to assemble this product, and the minimum part count. Calculate the assembly efficiency. Assume that you need 2.9 seconds to acquire a tool. Use the DFA time sheets provided in class. Cite any other reference that you use to estimate the times.

Note: To assemble the sensor, a tape has to be applied to the threads of the sensor, after which the adaptor nut can be fastened on. Applying tape takes 7 sec of "insertion" time.

Answer:

The assembly sequence and the step times are given in the worksheet below.

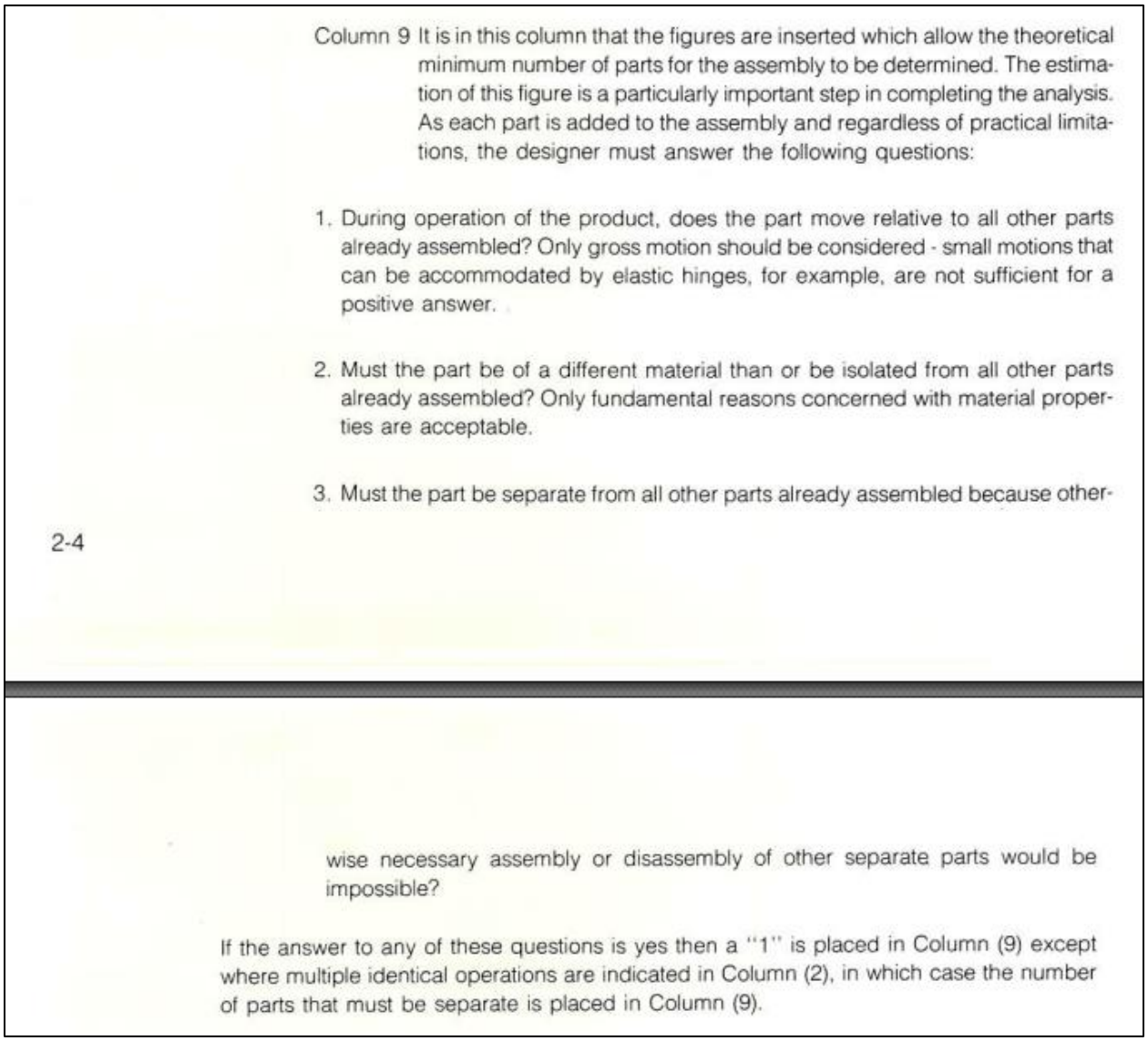
	No. of items RP	Tool aquire time TA	Hand-ling code	Hand-ling time TH	Insert-ion code	Insert-ion time TI	Total time TA+RP*(TH+TI)	Mini-mum part count	
1. Pressure regulator	1	-	30	1.95	00	1.5	3.45	1	Place in fixture
2. Metal frame	1	-	30	1.95	02	2.6	4.55	1	Add
3. Nut	1	2.9	00	1.13	31	5.3	9.33	0	Add and screw fasten
4. Reorientation	1	-	-	-	61	4.5	4.50	-	Reorient and adjust
5. Sensor	1	-	30	1.95	03	5.2	7.15	1	Add
6. Strap	1	-	20	1.80	03	5.2	7.00	0	Add and hold down
7. Screw	2	2.9	11	1.80	31	5.3	17.10	0	Add and screw fasten
8. Apply tape	1	-	-	-	62	7.0	7.00	-	Special operation
9. Adapter nut	1	2.9	10	1.50	51	10.7	15.10	0	Add and screw fasten
10. Tube assembly	1	-	42	5.60	10	3.7	9.30	0	Add and screw fasten
11. Screw fastening	1	2.9	-	-	60	5.2	8.10	-	Standard operation
12. PCB assembly	1	-	42	5.60	03	5.2	10.80	1	Add and hold down
13. Screw	2	2.9	11	1.80	31	5.3	17.10	0	Add and screw fasten
14. Connector	1	-	30	1.95	05	3.3	5.25	0	Add and snap fit
15. Earth lead	1	-	42	5.60	05	3.3	8.90	0	Add and snap fit
16. Reorientation	1	-	-	-	61	4.5	4.50	-	Reorient and adjust
17. Knob assembly	1	-	30	1.95	03	5.2	7.15	1	Add and hold down
18. Screw fastening	1	2.9	-	-	60	5.2	8.10	-	Standard operation
19. Plastic cover	1	-	30	1.95	03	5.2	7.15	0	Add and hold down
20. Reorientation	1	-	-	-	61	4.5	4.50	-	Reorient and adjust
21. Screw	3	2.9	11	1.80	51	10.7	40.4	0	Add and screw fasten
							206.43	5	Totals

Figure 2: Assembly procedure

From assembly lecture slides (#38):

Assembly efficiency = 3 * (number of theoretically needed parts)/total predicted assembly time

The theoretical number of minimum parts can be determined using the rules on page 2-4 of the Boothroyd et al handout on Design for Assembly. The relevant excerpt is shown in figure 3.



Column 9 It is in this column that the figures are inserted which allow the theoretical minimum number of parts for the assembly to be determined. The estimation of this figure is a particularly important step in completing the analysis. As each part is added to the assembly and regardless of practical limitations, the designer must answer the following questions:

1. During operation of the product, does the part move relative to all other parts already assembled? Only gross motion should be considered - small motions that can be accommodated by elastic hinges, for example, are not sufficient for a positive answer.

2. Must the part be of a different material than or be isolated from all other parts already assembled? Only fundamental reasons concerned with material properties are acceptable.

3. Must the part be separate from all other parts already assembled because otherwise necessary assembly or disassembly of other separate parts would be impossible?

2-4

If the answer to any of these questions is yes then a "1" is placed in Column (9) except where multiple identical operations are indicated in Column (2), in which case the number of parts that must be separate is placed in Column (9).

Figure 3: Excerpt from Boothroyd et al "Design for Assembly" handout, page 2-4

For this design, the theoretical number of minimum parts is five.
Therefore, assembly efficiency = 3 * 5/206.43 = 0.0726 or **7.26%.**

Boothroyd also suggests a redesign of this assembly and performs a DFA analysis on the new design. The new design and the DFA analysis are shown in figures 4 and 5. While the theoretical minimum number of parts is still five, the total number of parts is seven.

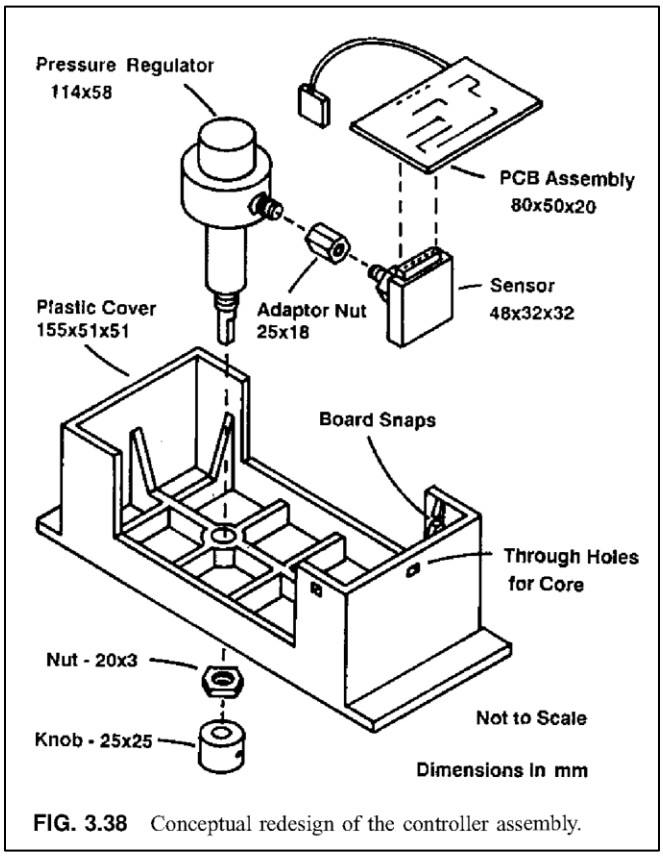


FIG. 3.38 Conceptual redesign of the controller assembly.

Figure 4: Redesign

	No. of items RP	Tool aquire time TA	Hand -ling code	Hand- ling time TH	Insert -ion code	Insert -ion time TI	Total time TA+RP* (TH+TI)	Mini- mum part count	
1. Pressure regulator	1	-	30	1.95	00	1.5	3.45	1	Place in fixture
2. Plastic cover	1	-	30	1.95	03	5.2	7.15	1	Add and hold down
3. Nut	1	2.9	00	1.13	31	5.3	9.33	0	Add and screw fasten
4. Knob assembly	1	-	30	1.95	03	5.2	7.15	1	Add and hold down
5. Screw fastening	1	2.9	-	-	60	5.2	8.10	-	Standard operation
6. Reorientation	1	-	-	-	61	4.5	4.50	-	Reorient and adjust
7. Apply tape	1	-	-	-	62	7.0	7.00	-	Special operation
8. Adapter nut	1	2.9	10	1.50	51	10.7	15.10	0	Add and screw fasten
9. Sensor	1	-	30	1.95	31	5.3	7.25	1	Add and screw fasten
10. PCB assembly	1	-	42	5.60	05	3.3	8.9	1	Add and snap fit
							77.93	5	Totals

FIG. 3.39 Completed analysis for the controller assembly redesign.

Figure 5: DFA analysis for the redesign

References

1. Boothroyd et. al "Product Design for Manufacture and Assembly". The e-book can be found here: http://www.crcnetbase.com/ISBN/978-0-8247-4158-7 courtesy of the MIT Libraries.