Design For Assembly Approach For Electronic Control Unit Assembly Analysis

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Abstract — Paper analyzes all design parameters of mechanical components of Electronic Control Unit assembly with assembly aspect so that the product is designed to have ease and ergonomic assembly. Design for assembly ensures consistency and completeness in its evaluation of product assimilability. It also eliminates subjective judgment from design assessment, allows free association of ideas, enables easy comparison of alternative designs, ensure that solutions are evaluated logically, identify assembly problem areas, and suggests alternative approaches for simplifying the product structure, thereby reducing manufacturing and assembly costs. Paper elaborates use of a statistical DFA tool generates action points against design.

I. INTRODUCTION

The design methodology of ECU Casing involves various Phases of product cultivation from processing of inputs till validation of the product. Requirement Analysis being first phase, analyses all PCB requirements. Architecture Conceptualization being second phase, analyses layout optimization, Material Category, Manufacturing Category. Design being third phase, analyses all aspects of Engineering Design, Manufacturing Design, and Feasibility Design. Validation being fourth phase includes prototyping, physical testing and Optimization [1].

Feasibility Design is analytical study of assembly aspect of design and respective processes which leads to optimization. Part of feasibility analysis - Design for Assembly Approach for Electronic Control unit assembly is elaborated in the paper.

II. DESIGN FOR ASSEMBLY – CONSIDERATIONS

The process of manual assembly can be divided into two separate areas, handling (acquiring, orienting and moving the parts) and insertion / fastening (mating a part to another part or group of parts). In addition to these two areas, for evaluation of DFA, Complexity of assembly (No. of components assembled, no. of interfaces created by subcomponents), Functional analysis (criticality of requirement of parts in assembly), Error Proofing (part design to avoid assembly in wrong way, Secondary operations (external operations required during assembly), time (time required for assembly each component) plays an important role [2].

A. DFA Complexity

DFA complexity factor (DCF) is used for assessing complexity of a product design. It includes following two parameters [2].

1) No. of Parts (Np)No. of interfaces (Ni)  

\[ DCF = \sqrt{\left( \sum N_p \sum N_i \right)} \]  \hspace{1cm} (1)

Multiply the two and take the square root of the total, this is known as the DFA Complexity Factor

B. Functional Analysis

Functional analysis evaluates functional aspects of all components in assembly. It includes three parameters [2].

1) Theoretical minimum parts
2) Standardization of parts
3) Cost

C. Error Proofing

Error Proofing evaluates features in design which avoids

1) Assemble Wrong Part
2) Assemble part in wrong way around

D. Handling

1) Tangling of parts
2) Delicate / Flexible /Sharp
3) Accessories required for assembly (Plier / glass)

E. Insertion
1) Difficult to align
2) Holding down requirement
3) Resistance to insertion
4) Obstructed access

F. Secondary Operations
1) Reoriented work place
2) Screw / Rivet / weld / solder /Test / measure / adjust

G. Time
1) Manual Assembly
2) Semi-Automatic /Automatic assembly

III. ECU ASSEMBLY ANALYSIS

ECU assembly shown in figure 1 is analysed against above considerations in a comparative – Worksheet (table 1) [1].

![Fig. 1. Assembly View](image)

In worksheet, the left column indicates the components in assembly as per sequence, while right columns shows considerations such as DFA complexity, functional analysis, Error Proofing, Handling, Insertion, Secondary Operations, Time.

For ECU Casing, No. of interfaces is six since it has contact with other six components in assembly. Theoretical minimum part is only one and ECU casing design cannot be replaced with a standard design hence marked as N, cost of casing is highest in assembly, hence marked as H. Casing cannot be assembled in wrong way, Casing will not get tangled with other components, hence marked N in all cases similarly results for all components are filled against common considerations.

<table>
<thead>
<tr>
<th>No. Part Name</th>
<th>Action Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Casing</td>
<td>1. Avoid Sharp edges in model</td>
</tr>
</tbody>
</table>
| 2 PCB Resting Pad | 1. Increase hardness of part  
|               | 2. Improve design to avoid tangling issues  
|               | 3. Mechanism to ensure assembly of all PCB resting pad required |
| 3 Thermal Pad | 1. Decrease delicacy of part, it should not stick to cover during peeling  
|               | 2. Shape of part should not be irregular  
|               | 3. Extra cut for ease in peeling required |
| 4 Main Gasket | 1. Identification codes of top and Bottom Side required to ensure perfect orientation  
|               | 2. Avoid small sections in the part  
|               | 3. Improve design to avoid tangling issues |
| 5 PCB Assembl y | 1. Touching connector during assembly should be avoided  
|               | 2. Design should be self adjustable, requirement to check should be avoided |
| 6 PCB Washers | 1. Improve design to have ease in insertion |

The areas marked with yellow (Y) indicates the scope of change in design to have better assemblility. Like thermal pad have Y rating in four considerations since it is delicate, difficult to align, prone to get assembled in wrong way and need special tool. In such cases, the action points are summarised in other table 2.

TABLE II. DESIGN FOR ASSEMBLY - ACTION POINTS

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|               | 2. Avoid small sections in the part  
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| 5 PCB Assembl y | 1. Touching connector during assembly should be avoided  
|               | 2. Design should be self adjustable, requirement to check should be avoided |
| 6 PCB Washers | 1. Improve design to have ease in insertion |
2. Improve design to avoid fouling with electronic components

| PCB Mounting Fasteners | 1. Improve design to have ease in insertion
|                         | 2. Improve design to avoid fouling with electronic components
|                         | 3. Optimize screwing time
|                         | 4. Optimize torquing values and orientation to avoid PCB warpage issue
|                         | 5. Tool slippage should be restricted

| Plastic Cover | 1. Avoid Sharp edges in model
|              | 2. Design should be self adjustable, requirement to check should be avoided

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REFERENCES


