Cost-Effective Product Development: Boothroyd Software's DFA Approach to Tractor Cooling Design

1. Kapil Kumar, 2. Michael Freisleben 3. V. Pavan K. Reddy 4. Mayank Chaturvedi

[1]DFAM Lead & Advance Engineer, Large Tractor Engineering,
CNH Industrial Technology Center, Gurugram, India
Kapil.kumar@cnh.com[1]
[2]Chief Engineer, New Program,
CNH Industrial America, LLC Oak Brook, Illinois 60523, USA
michael.freisleben@cnh.com

ABSTRACT

Current case study performed at ongoing concept in new design project by utilizing Boothroyd software. As the part of new product development, during initial stage of cooling package design for tractor was facing a lot of challenges including high assembly complexity, extended assembly times, leading to increase in the overall cost of the production. By applying the DFA levers and using Boothroyd software, the design team implemented a series of strategic modifications aimed at simplifying assembly processes, reducing part count, removing the hardware, and enhancing overall manufacturability. The DFA levers, which were included using Boothroyd software were minimize the part count, removing the fasteners using alternate solutions, better design approaches to improved DFA index. As a result, the part count was reduced from 352 to 294, the assembly process time was decreased by 18%, DFA Index was improved from 9.93 to 11.53, resulting in a 1.2% total cooling package cost reduction. Therefore, it's benefits have been extended to the early stages of new product development across all products, aiming to achieve optimal design at the best cost and ultimately maximize product value.

Keywords: Design for Assembly (DFA), Assembly Time reduction, Part count reduction, Hardware reduction, DFA index

I. INTRODUCTION

The development of products in the automotive industry, particularly in tractor manufacturing, faces several challenges, including high assembly complexity and extended assembly times, which contribute to increased production costs. This study investigates the application of Boothroyd Dewhurst Design for Assembly (DFA) software in the early stages of a cooling package design project for tractors. The aim is to simplify the assembly process, reduce part count, eliminate unnecessary hardware, and enhance overall manufacturability, ultimately optimizing design efficiency and cost-effectiveness.

2. Background

2.1 Design for Assembly (DFA)

Design for Assembly (DFA) is a methodology aimed at simplifying the product structure to facilitate easier and faster assembly processes. By focusing on reducing part count and using fewer fasteners, DFA can significantly reduce manufacturing costs and assembly times.

2.2 Boothroyd Dewhurst DFA Software

Boothroyd Dewhurst DFA software provides a structured approach to evaluate and improve product designs. The software helps identify opportunities for reducing the number of parts, simplifying assembly operations, and improving the overall design for manufacturability and assembly (DFMA).

2.3 Cooling Package Design in Tractors

Cooling packages in tractors are crucial for maintaining optimal engine temperatures and ensuring reliable operation under various working conditions. Traditional designs often involve complex assemblies with numerous parts and fasteners, leading to high assembly times and costs.

3.Methodology

3.1 Initial Design Challenges

During the initial design phase of the cooling package for tractors, several challenges were identified: High assembly complexity with 352 parts.
Extended assembly times, leading to increased labour costs. Overall high production costs due to inefficiencies in design.

3.2 DFA Levers Applied

Using Boothroyd Dewhurst DFA software, the design team followed flowchart, DFA levers and implemented the following strategic modifications in design.

3.2.1 DFA flow chart

The Flowchart given in figure shows the basic steps to be followed in DFA.

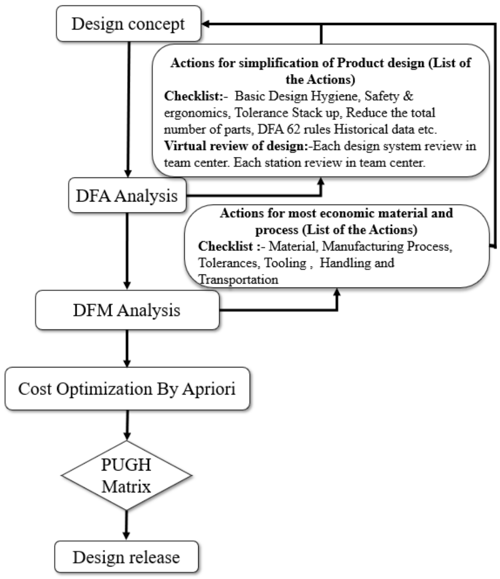


Fig.(a) DFA Flow chart

3.2.2 DFA Levers

DFA check levers for the designer to make the design as cost effective and robust design.

- Less the Number of Parts
- Standardization- Carryover Parts, Standard Parts
- Modular Design
- Multifunctionality- Combining Function
- Poka-Yoke-Error Proofing
- Self-Guiding/Adjusting- minimize Assy instructions.
- Minimize Handlings
- Avoid Fasteners
- Use Affordable and Standard Material
- Use Available Process Capabilities
- Limit Tolerance – avoid overspecification.
- Design For Ease for Fabrication
- Complete Compliance – in Drawings and ASSY sheet.

3.2.3 Utilization of the software

This software focuses on simplifying product structures, directly leading to substantial cost savings by reducing part counts and labour-intensive assembly steps.
The basic steps to use the software includes the importing Bill of Materials (BOM) as form of .CSV file into the software, then importing CAD model files into the software to fetch the envelope dimensions of the parts and assemblies for analysis.

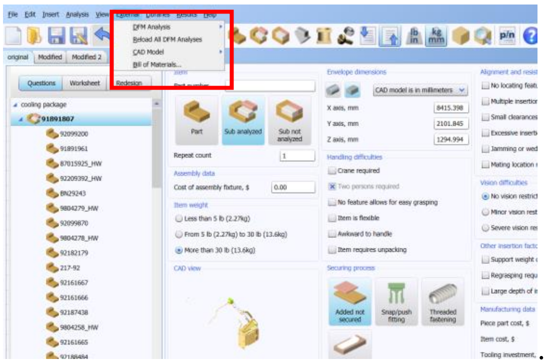


Fig.(b) BOM import option - software interface picture

Users need to select options provided by interface for every part and sub-assemblies based on criteria which followed by actual assembly process.

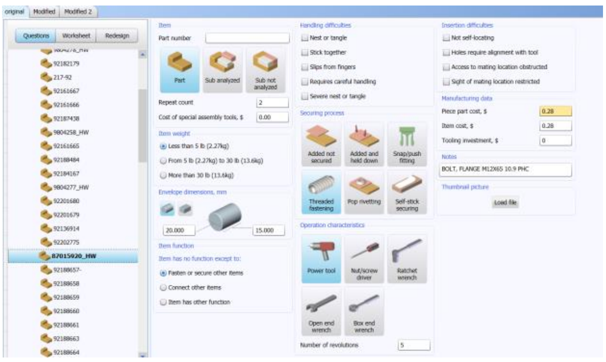


Fig.(c) Software interface pictutre

In the software, for each component, there was options to select whether this part can be connected or remove for the imrovement prosepctive.Based on selection criteria, the software analyze and suggests the results of components, which were candidates for elimination as caterories as shown in Fig.(d) . This suggestions result in improvements in product design because any associated fasteners, connectors, and joining operations will also be eliminated.

Category 1: Candidates for Elimination

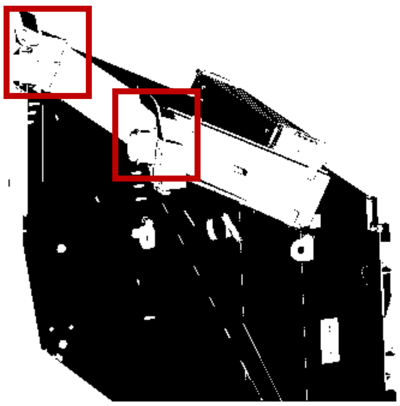
Eliminate the listed items by incorporating features into other parts that serve the function of these listed items. These suggestions will typically result in the largest improvements in your product design because any associated fasteners, connectors, and joining operations will also be eliminated when the separate part is eliminated. These suggestions should have the highest priority and should always be considered first before continuing on to the Category 2 and then Category 3 suggestions.

Name	Notes	Part number	Total quantity	Process time per product, s	Parent assembly
51428466	CAP, NUT, M8, HIGH-TEMP		65	163.67	91891807
92161665	PLATE WA, CAC SUPPORT		1	14.71	91891807
92191429	BRACKET WA, HYD MOUNT		1	14.71	91891807
92187485	SUPPORT WA, HYD LINE		1	14.71	91891807
92175553	BRACKET, FRONT RH GUIDE PLATE		1	14.71	91891807
92175587	BRACKET, FRONT LH GUIDE		1	14.71	91891807
92188140	BRACKET WA, SEALING		1	14.71	91891807
92188693	BRACKET WA, SEALING		1	14.71	91891807

Fig.(d) Software suggested componets which are candidates for elimination.

By selecting the checklist and question for each component we go through the phase of design imrovement, whether the part can be eliminated by providing concept design with part commonizatoin.

Some of the functional components and the items with different material were not candidates for elimination. In this assembly the components like foam (gives sealing effect) and side panels are functional and connecting components. For these component there no action was taken.



Fig(e). Seals which are acts as a sealing effect

3.2.4 Strategic modifications:

For the selected case, there 10 DFA improvement points had been identified. These improvement points also include the material improvement, part elimination, hardware removal etc. points.

Out of these examples, 2 significant examples were explained below.

Minimizing Part Count: Reducing the number of parts by combining functions and eliminating unnecessary components.

Example: 1

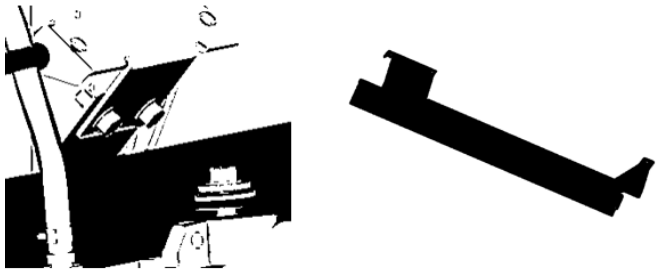


Fig.(f) Two parts combine into single with same functionality.

Removing Fasteners: Using alternative solutions such as snap fits and modular designs to reduce the use of fasteners.

Example: 2

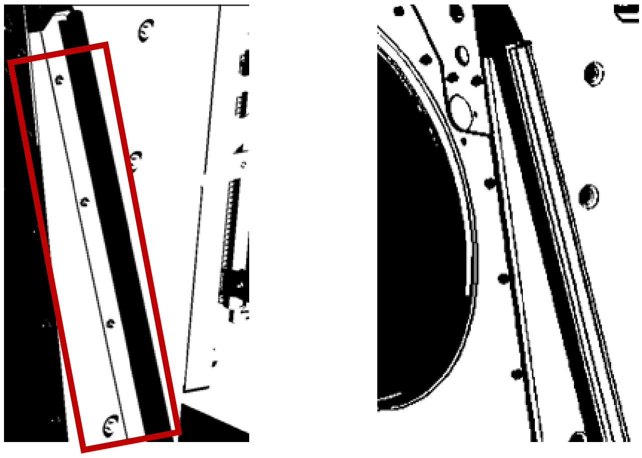


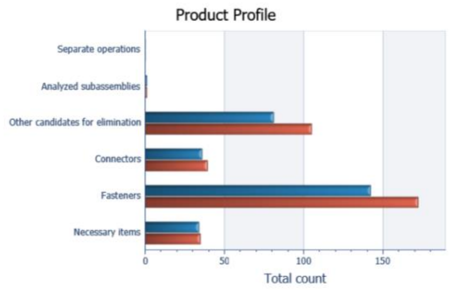
Fig.(g) Removed 12 hardware by combining two parts by intermittent weld.

Improving Design Approaches: Enhancing the design to improve the DFA index, making the assembly process more efficient.

4. Results

4.1 Part Count Reduction

The strategic application of DFA levers resulted in a reduction of part count from 352 to 294, a significant improvement in assembly simplicity.



	original	Modified 2
Necessary items	35	34
Fasteners	172.00	142.00
Connectors	39.00	36.00
Other candidates for elimination	105.00	81.00
Analyzed subassemblies	1.00	1.00
Separate operations	0.00	0.00
Total	352.00	294.00

Fig. (h) Part reduction of different product profiles

4.2 Assembly Time Reduction

The assembly process time decreased by 18%, contributing to faster production cycles and lower labor costs.

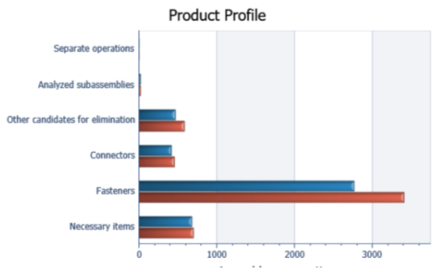


Fig.(i) Assembly Time Reduction of different product profiles

4.3 Improved DFA Index

The DFA index improved from 9.93 to 11.53, indicating a more efficient and manufacturable design.

4.4 Cost Savings

As a result of the material and assembly time improvements, the total cost of the cooling package is estimated to be reduced by ~1.2%. A significant savings on a high-value component at volume.

5. Discussion

The application of Boothroyd Dewhurst DFA software in the design of tractor cooling packages demonstrated significant benefits. By focusing on reducing part count, eliminating fasteners, and improving design for assembly, the design team was able to achieve substantial cost savings and efficiency improvements. These benefits are not limited to the cooling package but extend to the early stages of new product development across all products, aiming to achieve optimal design at the best cost and maximize product value.

6. Conclusion

This case study highlights the effectiveness of using Boothroyd Dewhurst DFA software to enhance the design and assembly of cooling packages in tractors. The significant reductions in part count, assembly time, and overall cost, along with improvements in the DFA index, underscore the value of integrating DFA principles early in the design process. Future work will focus on extending these principles to other components and product lines, further optimizing manufacturability and cost-efficiency.

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