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Design for Manufacturing of a Portable Air Conditioner

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***Abstract*—The concept of DFM will be applied for the evaluation of assembly and bridge techniques. These are studied in the perspective of manufacturing principles which yields characteristics for a particular part. The effective involvement of these principles can increase the productivity. In the present project, a portable AC is designed based on the constraints such as manufacturing process, maintenance, capability and human factors. The design for mounting the components is done in such a way to reduce the vibrations of the entire unit. Possible design considerations are taken into account to reduce the weight of the unit. The entire study aims to minimize the material usage and develops a product that meets all the functional needs and its ease of manufacturing a portable air conditioner.**

***Index Terms*—portable air conditioner**

I. Introduction

Portable air conditioner is an innovative product originally derived from standard window air conditioner running on vapour compression refrigeration cycle. Standard window air conditioner or Split Air conditioner is limited to be used in room or inside a closed environment, once fixed it cannot be mobilized. Centralized air conditioning systems are very expensive and consume lot of power to operate even for a small space, at the same time it is not possible to fix air conditioners in every part of the house, office or workspaces. Portable air conditioner gives the luxury of air conditioning where ever we want. It can be moved as per the requirement like an air cooler. Portable air conditioner runs on vapour compression refrigeration cycle with rotary compressor. Unlike conventional air conditioners which run in a closed environment, portable air conditioners can be used in both closed environment and open environments like a retail outlet or a showroom or in any open hall with air conditioner focused on specific location. In addition to that portable air conditioner gives localized air conditioning effect which cannot be achieved with conventional type air conditioners.

This paper summarises the basic design of a portable air conditioner followed by implementation of design for manufacturing (DFM).

The concept of DFM (Design for Manufacture) is not new, it dates back as early as 1788 when LeBlanc, a Frenchman, devised the concept of inter-changeable parts in the manufacture of muskets which previously were individually handmade. DFM is the practice of designing products keeping manufacturing in mind. “Design for manufacture” means the design for ease of manufacture for the collection of parts that will form the product after assembly. So design for Manufacture is as shown in the Fig. 1.

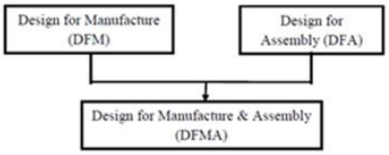

Fig. 1. Definition of Design for Manufacture (DFM)

A. Advantages of applying DFM during product design

Today products are

- Tending to becoming more complex
- Made/required in increasingly large number
- Intended to satisfy a wide variation in user population
- Required to compete aggressively with similar products
- Required to consistently high quality

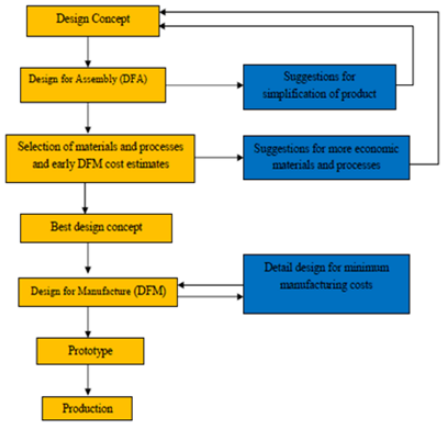

Fig. 2. Common steps taken in a DFM study

Through DFM it is possible to produce competitively priced, high performance product at a minimal cost. The advantages of applying DFM during product design are as follows:

- DFM not only reduces the manufacturing cost of the

product but it helps to reduce the time to market and quality of the product.
- DFM provides a systematic procedure for analyzing a proposed design from the point of view of manufacture.
- Any reduction in the number of parts reduces the cost as well as the inventory.
- DFM tools encouraged the dialogue between the designer and manufacturing engineer during the early stages of design.

II. Design Concept

The basic idea of portable air conditioner is to have flexibility of moving wherever it is needed. Hence it is required that all the components of the AC must be enclosed in a single unit unlike split AC where it has separate indoor and outdoor unit. The primary design concept is to have a two stage tower type metal frame enclosed with sheet metal or fiberglass outer body.

Vents are provided for evaporator, condenser inlets and outlets. For condenser outlet, a circular hole has been provided to a hose pipe. Hot air from the condenser outlet should be released to the atmosphere i.e. through window or any other provision. Adjustable vanes are provided for evaporator outlet for controlling the outlet flow direction of evaporator. Wheels are mounted on the frame for portability.

Considering the function, weight and cycle of operation of components, they are placed on each stage of the frame. The compressor being heaviest, is placed at the bottom stage to make sure the center of gravity of the AC is low, and doesn't topple while moving. Which includes blower, motor, motor mount and condenser outlet duct are also fixed at the bottom stage as shown in figure. Evaporator which consists of Evaporator, Blower, motor, motor mount are placed at the top stage. Control panel is placed at the top face of the body cover, and power distribution board is placed beside evaporator.

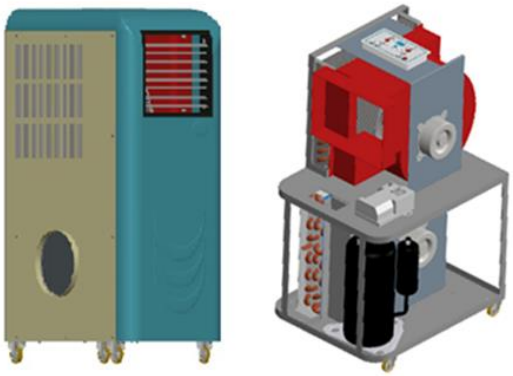

Fig. 3. Frame and internal arrangement of various components of portable AC

III. Design Modifications for Two Designs

Initial design of portable Ac has been studied and various changes have been incorporated based on DFM principles.

Manufacturing processes of all the components have been studied and are simplified/ optimized wherever possible. Frame, Condenser Assembly, Evaporator Assembly & Body parts have been modified primarily.

A. Frame

Frame is initially made of 2mm thick mild steel sheet, which is reduced to 1.5mm. Structure has been changed to make is more stiff by adding members and adding flanges. Mounting holes are provided on the flanges to mount other components such as evaporator & condenser. Direction of flanges at the bottom level

TABLE I
Frame

Model	Thickness	Weight
Initial	2	8.8 kg
Final	1.5	6.3 kg
Reduction	28.4 %	

Water collection tray:

In the initial model the water is collected in the tray fixed to the frame itself, in this case the maintenance and the electrical hazards are more as it is of metal, is replaced with a fiber glass tray fabricated separately. In the original design each component was mounted to the frame separately and motor was mounted on a separate mounting which is causing vibrations. No proper insulation has been provided between evaporator and evaporator duct.

Changes:

- The motor mounting plate or support plate is removed and the motor is mounted directly to the chamber unlike of the initial model to compensate the vibration and to increase the cooling of motor.
- Even the height of the chamber where evaporator is fixed is also increased to minimize leakage of air into the chamber body and a plate is provided on the top. The blower dimensions are increased so that tolerance is adjusted.

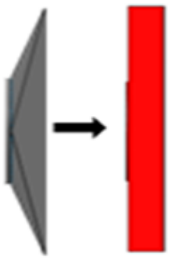

Fig. 4. Design model

- Evaporator assembly is assembled separately as a single unit and mounted to the frame as a single component which reduces the complexity and effort.
- Every component is fastened to each other by self-tapping screws of 3mm dia.

- The entire design of the condenser flow out chamber is changed by considering the complexity in the manufacturing of part. The cross section is modified to attain maximum pressure at the outlet so that cooling of condenser is done efficiently.
- In the initial design the condenser is fixed to the metal strip provided to the frame, but in the modified design the metal strip is removed and the condenser is fixed to the frame bottom with nuts and bolts.

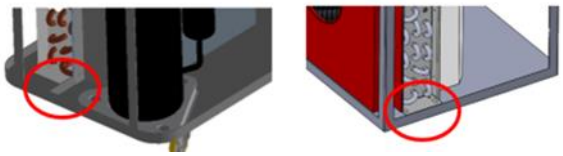

Fig. 5. Design

Mobility:

- In the initial design the wheels are directly fitted to the frame bottom plate which may deform the frame at the points where they are fixed due load and force exerted while moving from one place to other place.
- In the modified design the L- channels are welded to the frame bottom (the ribs are placed on bottom side as mentioned in the topic structural modifications of frame) and slots are provided for the better positioning of wheels as per requirement.

Compressor Specifications:
Type: rotary
Application: HBP/AC –Air Conditioning
Refrigerant: R-22
Voltage/Frequency: 220-240v / 50H

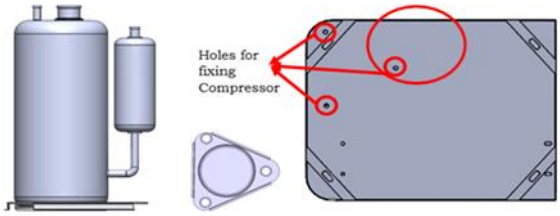

Fig. 6. Compressor and stand

Design changes in the outer body panels due to change in the other components:

For an aesthetic look the outer cover of the entire product must be designed carefully such that there are no intersections or unnecessary over lapping's. They should be designed carefully with the proper tolerance levels and manufactured with high level precision.

Front panels:

The AC outlet has been changed because of change in the dimensions of the evaporator blower casing and to maintain the stream lined flow for the uniform distribution of temperature in the confined space.

The vents in initial model has been removed in the modified designed to attain the structural strength and also that position is used for fastening with side panels. The vents are completely moved on to the side panels.

Side panels:

Initial design has three pieces which makes difficult for the assembly or during the maintenance. To avoid the difficulties all three panels are fused and formed single piece for the convenience.

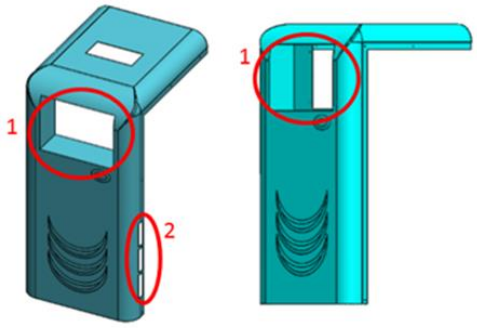

Fig. 7. Panels

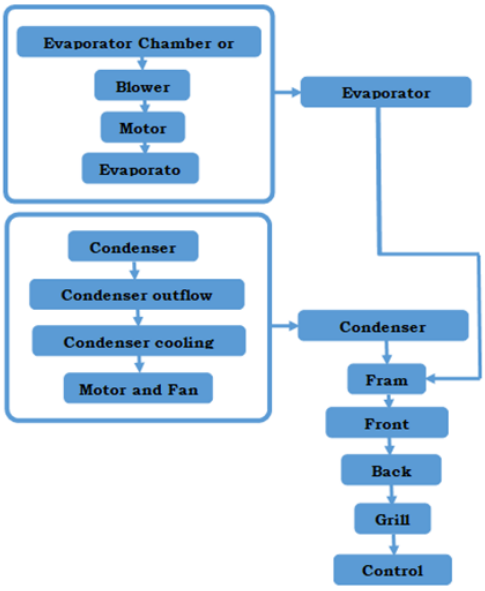

Fig. 8. Flow chart for manufacturing and assembly sequence

IV. Conclusion

Portable Air Conditioner has been designed and optimized base on DFM techniques. All the fabricated components of the Portable AC have been studied for optimum assembly and manufacturing techniques and implemented in design.

Acknowledgements

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