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DESIGN OF ELEVATOR CAR DOORS FOR ASSEMBLY

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ABSTRACT
There are several well-known quantitative evaluation methods in design for assembly. The best known design for assembly methods are Boothroyd-Dewhurst method, the Hitachi method, the Lucas method and IPA Stuttgart method. A case study of implement design for assembly principles on elevator car doors has been conducted. Based on a concurrent engineering type of design project plan, design objectives and constraints for elevator cars were evaluated and performance criteria for economical installation and maintenance were listed. Analytically criticizing commonly used designs, an innovative design were developed on a CAD package. The advantages and limitations of the new design have been comparing with two conventional designs in a systematic benchmark scheme. In this study conventional and proposed car door mechanisms are compared according to their parts number, cost and processes.
Keywords: elevator car door, concurrent engineering, design for assembly

1. INTRODUCTION
Universal elevator car doors are described as doors which are applied after the complete elevator installations and used for protection of passengers inside the car during the vertical movement of elevator. The choice of car and hoistway door affects the speed and quality of elevator service considerably. Doors for passenger elevators are power operated and are synchronized with the leveling controls so that the doors are fully opened by the time a car comes to a complete stop at the landing [1]. There are various types of universal elevator car doors in the market. The basic elevator car door mechanism consists of two main parts: drive unit and door panels. In the drive unit, there is a dc motor, main board for control and mechanical components for opening and closing [2].
Based on a concurrent engineering type of design project plan, design objectives and constraints for elevator cars were evaluated and performance criteria for economical installation and maintenance were listed. Analytically criticizing commonly used designs, an innovative design were developed on a CAD package. The advantages and limitations of the new design have been comparing with two conventional designs in a systematic benchmark scheme. A case study of implement design for assembly principles on elevator car doors has been conducted. In this study conventional and proposed car door mechanisms are compared according to their parts number, cost and processes.

2. DESIGN FOR ASSEMBLY METHODOLOGY
Design for Assembly (DFA) is now a well established technique for cost reduction at the design-manufacture interface [3]. There are many of published studies on design for assembly application in computer aided engineering [3-7]. Design for assembly (DFA) is a product of the automation endeavors of the late seventies and early eighties when moves toward high levels of automated assembly highlighted deficiencies in current product design with respect to automation capability. There are a number of designs for assembly techniques and evaluative mechanisms [7]. The three best-known and also the most well-documented DFA methods are the Boothroyd Dewhurst System, the Lucas DFA Methodology and the Hitachi Assemblability Evaluation Method [8,9]. Boothroyd-

Dewhurst Method is based on two principles: (a) the application of criteria to each part to determine if it should be separate from all other parts, and (b) estimation of the handling and assembly costs for each part using the appropriate assembly process [10].

The design for assembly analysis flowchart is shown in Figure 1. The Functional Analysis facilitates part count reduction by evaluation of each component in order to determine whether it is essential for the performance of the product. The Manufacturing Analysis determines the relative cost of producing each component based on the manufacturing processes used. The Handling Analysis evaluates the suitability of a component for manual handling and automated feeding to the point of assembly. The Assembly Analysis is used to highlight problems and inefficient operations associated with the build sequence and component interfaces, and to identify the tooling requirements of the design [10].

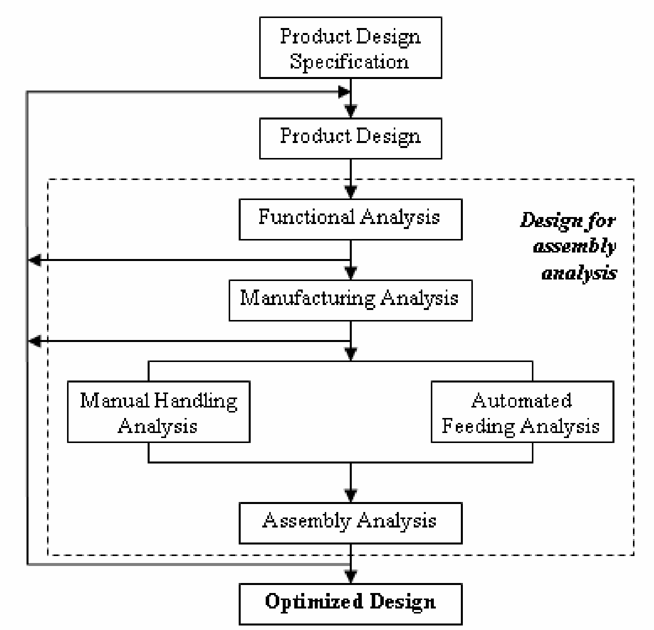


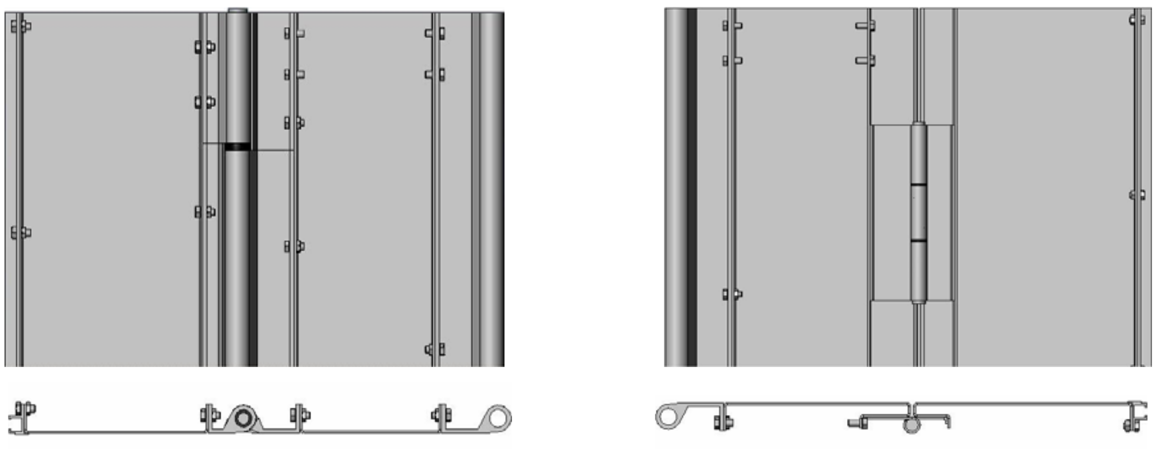
Figure 1. Flowchart of design for assembly analysis.

3. ELEVATOR CAR DOOR DESIGN

Elevator cars must be provided with car doors to be in compliance with EN 81-1. Despite this accidents occurred so protection was provided in the form of railings. The present standards recognize various types of doors and their equipments as satisfactory for passenger elevators [2]. The presence of a car door is preferable in all installations [11]. The most common type of collapsible doors is steel or aluminum shutter doors, consisting of vertical elements (panels) [11, 12]. The panels are mechanically interlinked by pivoted pins; at least every fourth member must be guided at the top and every second at the bottom. Door panels should have a substantially flush surface without recessed or raised moldings. Where cost and space are at a premium, manually or power operated collapsible doors may be used. They are simple and rugged. The space required for bunching will vary according to the widths of opening and panel size used.

4. ELEVATOR CAR DOOR AFTER DFA

Current elevator door mechanism is divided two main parts: drive unit and door panels. In the drive unit there is a dc motor, control circuit and mechanical components. Front and top views of current elevator car door panel and those of redesigned elevator car door panel are depicted in Figure 3 [12]. Rubber rail apparatus are inserted between two connection parts to minimize the vibration and noise occurred during opening and closing of door panels and positioning. Three different type of rubber apparatus are used in the assembly procedure the total number of those are 16 for door assembly. Finally door rods with diameter of 8 mm and the length of 1970 mm are used for connecting the panels each other and pivoting during the rotation. Parts of assembled door panels for installing inside the elevator car is illustrated in Figure 4.



Current design New design

Figure 3. Elevator car door panel views

They are connected each other with aluminum fixing components which are illustrated in Figure 4. Most time consuming job in door assembling procedure is connection of these door panels each other in the process of universal elevator car door assembly. Therefore design for assembly rules are discussed and applied into door panel's assembly.

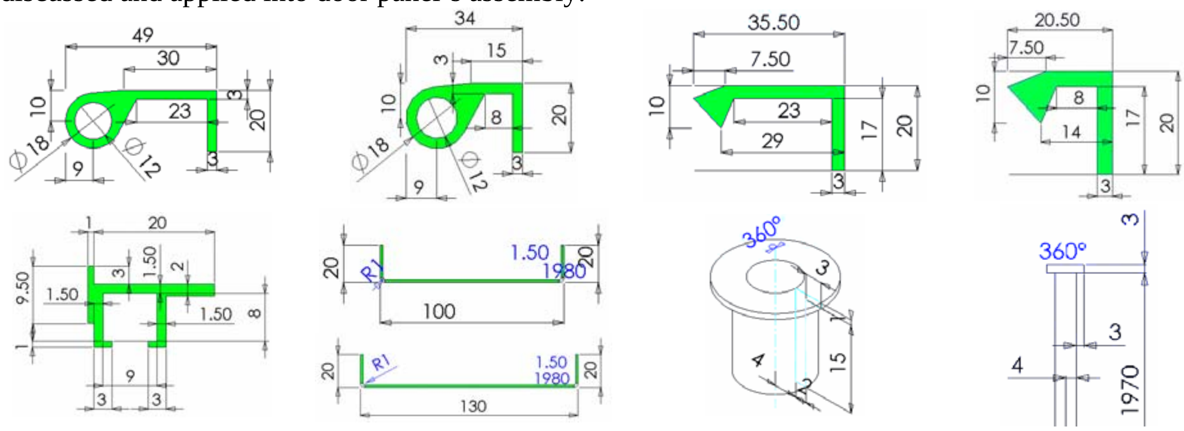


Figure 4. Assembly components of current design

For two door mecahnism, 5 different type of cross-section and 24 connection parts are needed for assembling. Elevator car door assembly is considered in this study consist of 250 units. For connecting door panels with aluminum components, the total number of holes with M5 diameter is 212 in the current design. In this design considered parts have complex cross-section and the total number of components. Therefore there are too much assembly operations during mounting of current door mechanism. They also have to be careful for positioning the panels. The first aim of this work is minimizing the number of drilling and then considering standardization principle of design for assembly concept.

The door panels are remained in the new design and aluminum component are examined and redesigned for using design for assembling rules. The main problems of using former components are high costs, assembly difficulties, high employee costs and lots of process numbers. They affect the competition in the market. The special hinge whose materials are the same with the door panels are designed with bearing to work more silent and properly and applied into the current door assembly in this work. It is a useful component for minimizing the total number of components and minimizing the workmanship. In this new design, the sub-assembly is defined and consists of left hinge and right hinge and connection rod. From former design only Section G 1980 and rubber guide are remained and the others are eliminated. They are connected each other with aluminum fixing components which are illustrated in Figure 6.

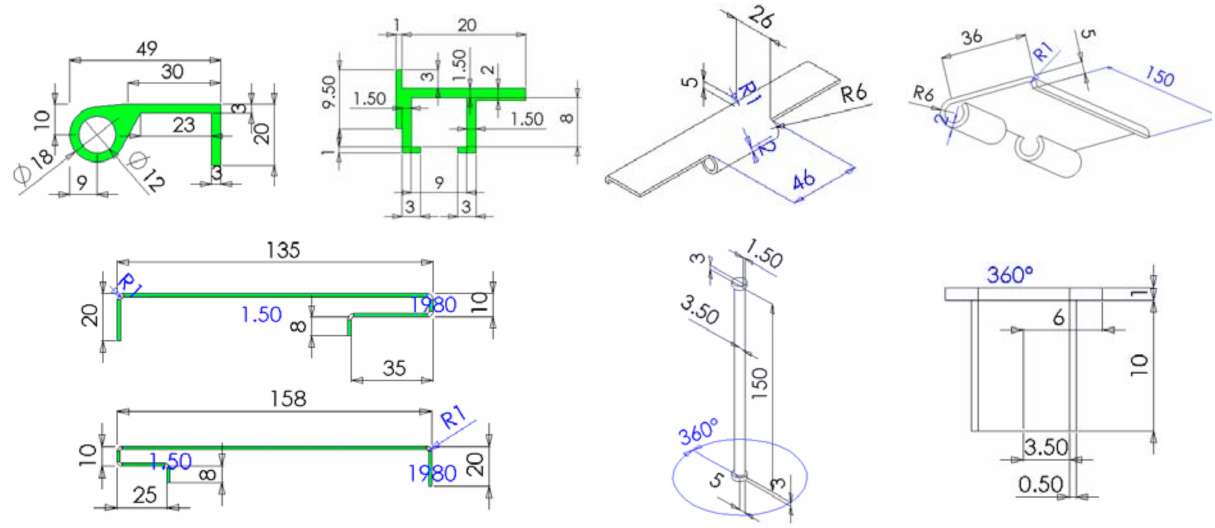
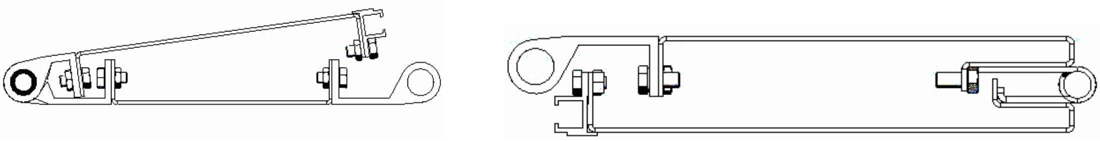


Figure 6. Assembly components of new design

After applied design for assembly rules into elevator car door mechanism, the new assembly is considered in this study consist of 168 units. Although 212 drilling processes are needed in current design of car door, the proposed design consists of only 108 drilling processes. The total cost of current design of elevator car door is approximately 187 Euro (or 308 YTL) and that of new design is approximately 148 Euro (or 244 YTL). The ability of folding of door panels is depicted in Figure 7.



Current design New design

Figure 7. Ability of door panel folding

5. CONCLUSIONS

Design for assembly encourages the design of products that can be produced at minimum cost and maximum quality and reliability. The advantages and limitations of the new design have been comparing with two conventional designs in a systematic benchmark scheme. In this study, a case study of implement design for assembly principles on elevator car doors has been conducted. The application of DFA has proven to be a significant influence in achieving efficient manufacture and assembly through optimized design. On average, the application of DFA techniques yields a 20%-30% reduction in assembly costs and a 10%-15% reduction in manufacturing costs. This results in a more competitive product with lower costs, yielding higher profits.

6. REFERENCES

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