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PRODUCT DESIGN ASSEMBLY APPLICATION ON DOUBLE DECK ELEVATOR SYSTEMS

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ABSTRACT
Elevator car design for the double deck systems is the subject of the study. Design for manufacturing and assembly methods are considered for the design. Original and revised elevator cars are evaluated by using Boothroyd- Dewhurst methodology. Design efficiency factor is calculated and the values of design efficiency for both designs are compared. Number of parts at the original car is tried to be halfed. The first one has 1188 parts. There are 26 different kind of parts and total time of manual handling and manual insertions is 8701,6 seconds. For the revised design, the number different kind of parts is 27 but there are totally 572 parts in the whole system for the double deck. Total time for handling and insertion is 4444,88 seconds. An analyze model and the calculations are given and the compare of the systems is shown in tables.
Keywords: double deck, elevator car, Boothroyd Dewhurst method, design efficiency

1. INTRODUCTION

Product manufacturing needs many steps up to the final product and these steps contain some others. Planning, product design and product development, material selection, management marketing are some of these processes [1, 3]. These processes involve the design process and designers need to use systematic approaches for the great design. For this reason, user involvement has become a widely accepted point of the usable systems. Product development aims to reduce the manufacturing steps depend on the time and cost [1]. The parts are considered by their elimination potential. If a part can be eliminated, the alternative way is considered and new design becomes to take its final shape. There are many ways to facilitate processes of manufacturing and assembly. Design for manufacturing and assembly method is one of them [2, 3]. In this work Boothroyd-Dewhurst method is considered and elevator car parts are tried to be designed by increasing the design efficiency factor. The formula is given and the results of the calculations are shown in tables. There are two types of designs and they are compared according to the number of part and design efficiency factors. The part number is reduced at the new design and total assembly and manufacturing times are decreased.

2. EVALUATION OF DESIGN EFFICIENCY FACTOR AND DESIGN APPLICATION

Design efficiency factor is calculated with the values of total operation time, total operation cost and elimination probability value of the parts. Average assembly time for a part is taken 3, so it is shown as the 3 at the formula. TM is taken as the total operation time and NM is the total number of part types that will not be eliminated. The formula can be expressed as follows [3];

$$EM = 3NM / TM \qquad (1)$$

Quantities, manual handling and insertion times are determined via the related tables after different designs and the first is taken from the measurements that are done in this study. The original car measurements and part types are tried to be optimized depending on the assembly method and the original design parts are adapted to the design that has greater properties for the efficiency factor. There are a great number of fasteners in the original design that are eliminated by replacing with welding processes for the revised design. Side sheets of the one single car are modular but their number is high. Welding processes provides the lower number of fasteners and part number is also lowered. Determined NM and TM values are put the formula and efficiency factor is obtained.

3. MODELING OF ELEVATOR CAR WITH LOWER NUMBER OF PARTS

The original design is considered to decrease the part number and side sheets with three parts become single sheet by adding the welding with support parts. Total number of parts is 1188 at the original design. There are 372 fasteners and all the modular sheets are joined by using fasteners. Figure 1 shows the revised and original elevator car designs. The original design can be seen at the right and higher number of the fasteners is reduced significantly at the revised design on the left.

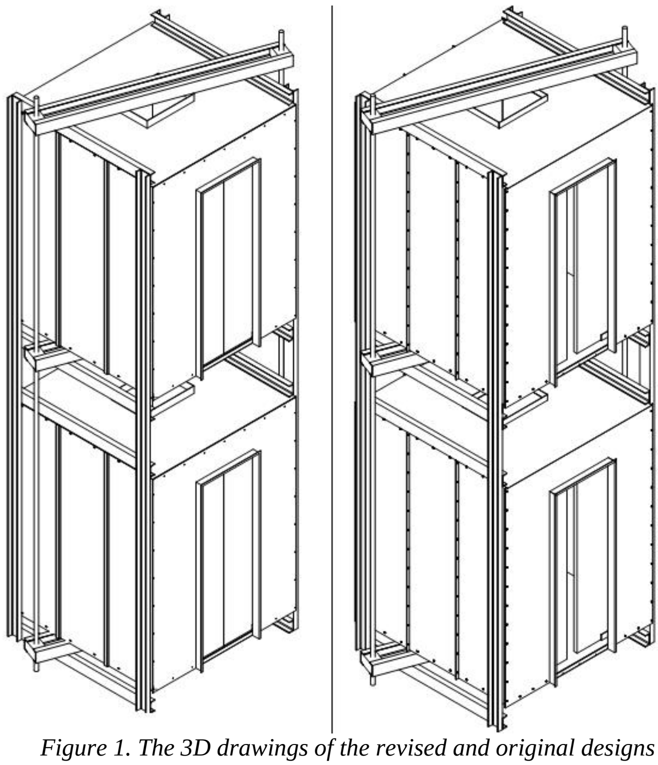

Figure 1. The 3D drawings of the revised and original designs

Adding welding processes to the design provides the lower number of fasteners and the number becomes 166. Total part number is 572 at the new design. Table 1 shows the parts and the quantities for the original and revised double deck car. Also, reducing of the bolt number can be seen at Table 1.

Table 1. Part list for the original and revised designs

PART NO	PARTS OF THE REVISED DESIGN	QUANTITY
1	ground sheet	2
2	door slide left	4
3	door slide right	2
4	door right	2
5	door left	2
6	washer iso 7089 - 6	120
7	hexagon nut iso - 4034 -	120
8	iso 4017 - m6x16-n	120
9	back sheet	2
10	support	12
11	iso 4017 - m6x35-n	46
12	hexagon nut iso - 4034 -	46
13	washer iso 7089 - 6	46
14	side sheet left	2
15	side sheet right	2
16	top sheet	2
17	top sheet fl1	4
18	top sheet fl2	4
19	top sheet fl3	4
20	top sheet fl4	4
21	front sheet	2
22	front sheet flange left	2
23	front sheet flange right	2
24	front sheet flange top	2
25	ground frame beam-1	4
26	ground frame beam-2	4
27	ground frame beam-3	10
	TOTAL	572

PART NO	PARTS OF THE ORIGINAL DESIGN	QUANTITY
1	top sheet	2
2	top sheet fl 1	4
3	top sheet fl 2	4
4	top sheet fl 3	4
5	top sheet fl 4	4
6	door slide right	2
7	door slide left	2
8	door right	2
9	door left	2
10	bolt iso 4017 - m6x16-n	306
11	hexagon nut iso - 4034	306
12	washer iso 7089 - 6	306
13	bolt iso 4017 - m6x35-n	66
14	hexagon nut iso 4034 - m	66
15	washer iso 7089 - 6	66
16	modular sheet	14
17	back sheet -r	2
18	back sheet -l	2
19	ground frame Beam-1	4
20	ground frame Beam-2	4
21	ground frame Beam-3	10
22	ground sheet	2
23	front sheet-	2
24	front sheet - flange L	2
25	front sheet - flange R	2
26	front sheet- flange Top	2
	TOTAL	1188

All the fastener parts are groups and a bolt needs washer and nut to complete the assembly. So, one part of fastener causes three parts to the design. Also, table 1 shows the modular sheet number at the original design. It is significantly reduced by the support elements. There are just 12 parts support element for the double deck added to the design for reducing the side sheet number. The other parts have the same value in both designs. Total mass of the revised deck is almost the half of the mass of the original design. So, the same functional product is designed with the half mass for the whole design. This is one of the benefits of the related method[3].

4. COMPARISON OF ORIGINAL AND REVISED DESIGNS

Part number of the new design is less than the half of the original design. The original one was with fastener design and there were too many parts on the car. So, the cost and assembly time were higher. The revised car was designed to reduce the number of parts and so the cost became lower at the new design and efficiency factor becomes higher [4, 5, 6]. Table 2 shows the total assembly times for both designs and calculated values of the total assembly times of double deck designs.

Table 2. Original and revised systems design efficiencies

	Part number	Total assembly time	Design efficiency %
Original design	1188	8701,06 s	0.586
Revised design	572	4444,88 s	1.214

The design efficiency value for the original design is doubled and system efficiency is improved. On calculations; if a part is decided to be eliminated, it takes the value of zero for that part [3]. Fasteners are eliminated for the efficiency calculation via the elimination rule.

5. CONCLUSION

A double deck car is designed by using the related software for this study and it was examined depending on the ease of design. The spended cost and time are evaluated and the values of cost and time are tried to be reduced under the specific rules of design for manufacturing and assembly processes. Boothroyd-Dewhurst approach is applicated to the original parts of a double deck car. Old and new designs are compared depend on the design efficiency. The principles of the system are applicated to the both designs. The relation between design and cost factors can be interpreted. The cost considerations for this study show that the cost of the whole designs are automatically reduced by decreasing part number. Lowered complexity of the parts also increases the efficiency and cost factors especially in multi-parted products. Total assembly cost is an important factor on manufacturing as total assembly time.

6. REFERENCES

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