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USING RAPID PROTOYPING TO VERIFY DESIGN FOR ASSEMBLY

Campbell, R.I. and Balc, N.

Abstract: *Design for assembly (DFA) is a well-establish technique that has proved beneficial in many companies in different manufacturing sectors. It aims to simplify the assembly of a product by reducing the number of components and by making sure that they fit together easily. Often, a DFA analysis will show a theoretical improvement in the assemblability of a product, but the re-design is not implemented because there is no way of verifying the findings of the analysis. Rapid prototyping (RP) enables physical models to be made directly from CAD data in a relatively short period of time. Using RP, it is possible to build the re-designed product and test the accuracy of the DFA analysis. This paper describes the procedure that can be followed to achieve this and demonstrates its practicality through use of a case study.*

Key words: Design for assembly, r*apid prototyping, design verification.*

1. INTRODUCTION

Design for Assembly (DFA) is a technique that started as a paper-based methodology and has developed into several commercial software packages. It is now widely used in Western companies, especially in larger firms. It has proved useful in many sectors of manufacturing industry, from consumer products to heavy-duty off-road vehicles. DFA aims to reduce the cost of assembly of a product by making the assembly process less complex and easier. This is typically achieved by reducing the number of components in a product, making them easier to handle (either manually or automatically) and making them fit together more easily.

One problem associated with using DFA is that some of the judgements made about ease of assembly are subjective and may vary from one analyst to the next. Another problem is that the cost of implementing the recommended design changes is difficult to estimate and can often be more than was expected. Both of these issues mean that even when a DFA analysis shows that a significant increase in assembly efficiency can be obtained, companies are sometimes reluctant to take the risk of making the design change. This is where rapid prototyping (RP) can be of immense benefit. Firstly, it can remove some of the subjectivity from the process by producing models of the new design and testing its ease of assembly. The new assembly times, and hence costs, can be more accurately estimated. Secondly, the RP models can be presented to suppliers (internal or external) and used to obtain more accurate component manufacturing cost estimates. This will give the company more confidence that the cost of introducing the new product design will be more than outweighed by the reduction in assembly costs over a given period of time. The aim of this paper is to describe how this can be undertaken and to demonstrate the practicality of this approach using a case study.

2. ORIGINAL PRODUCT DESIGN

The product that this case study is based upon was a two-way pneumatic valve device produced by the Armatura company in Cluj-Napoca, Romania. The main characteristics of the valve were:

- Function – to distribute compressed air alternatively to two different devices
- Working pressure – 1 to 10 bar
- Working temperature – 5 to 60 degrees Celsius
- Electro-magnetic switch control, 220 volts
- Switching frequency – 30 switched per minute

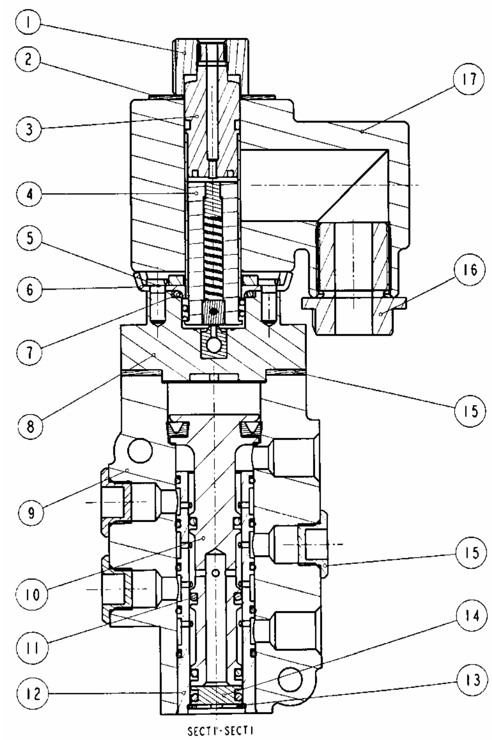

Fig. 1. Cross-sectional view of original product design

The complexity of the design can be clearly seen. The number of components in the original design was 33 and the assembly sequence included 8 machining operations. The cost of assembly was unacceptable to the company and the Technical University of Cluj-Napoca was asked to analyse the design and recommend improvements to it.

3. DESIGN FOR ASSEMBLY ANALYSIS

A commercial software package incorporating the Boothroyd-Dewhurst DFMA methodology (Boothroyd 1997) was used to perform a DFA analysis of the valve. The objectives of the analysis were

1. To reduce the number of components
2. To simplify the valve's main body shape in order to reduce manufacturing costs
3. To reduce the number of operations required within the assembly process in order to decrease the cost of assembly.

The analysis was first performed on the original design and then iteratively upon several design revisions.

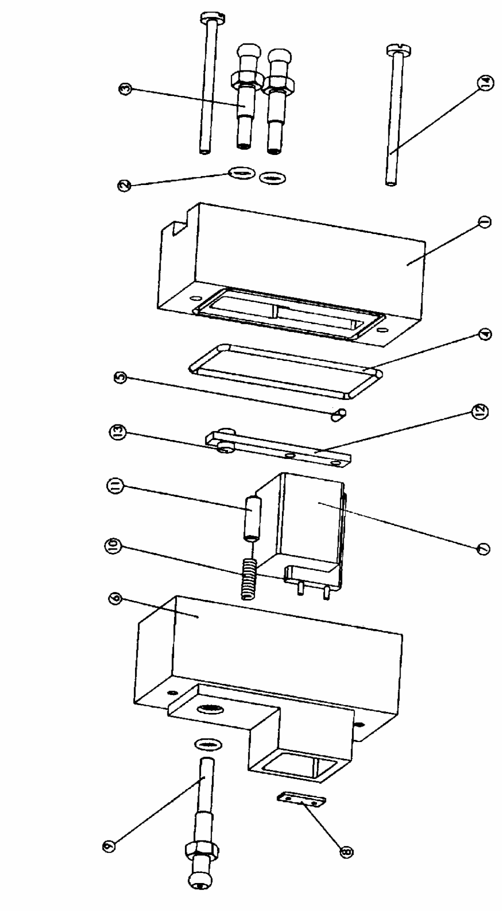

Fig. 2. Exploded view of new product design

This clearly shows a large reduction in component count (down to 14) and a less complex geometric shape. Consequently, there was a major simplification in the assembly process.

The results of the DFA analysis were output from the DFMA software in the form of a comparative table (see table 1). Using the Boothroyd-Dewhurst standard measurement, there was an increase in assembly efficiency from 5% to 29%. This was mainly due to the reduction in component count and the elimination of machining operations during the assembly process. The conclusion drawn from the analysis was that Armatura should consider a major redesign of the valve. However, there was still the problem of justifying the investment that this would require.

4. VERIFICATION USING RP MODELS

RP models of the new valve components were made using the FDM-1650 system. These were presented to the product development team at Armatura and used to evaluate the new assembly process. The estimates of ease of assembly could now be verified with actual operators. The savings in assembly time and cost could now be quantified. The RP models also gave a clear picture of the shape of complexity of the new components required enabling accurate production cost estimates or quotations to be obtained. The payback period or return on investment could now be calculated and a decision made on whether or not to pursue the new design. In this case, a favourable outcome resulted. However, even if the investment had not been justified, the RP models would still have played a vital role in avoiding unmerited expenditure.

Comparison Criteria		Original Valve	Redesigned Valve
Number of valve's components		33	14
Number of machining operations to be required at the assembly stage (drilling, threading, cutting)		8	0
Assembly efficiency - percent		5%	29%
Number of parts and sub-assemblies	Individual parts	9	3
	Sub-assemblies	6	3
Assembly efficiency for the sub-assemblies	General Assembly	17%	45%
	Lower Body sub-assembly	2%	56%
	Upper Body sub-assembly	2%	23%
	Mobile Device sub-assembly	45%	44%
	Static Device sub-assembly	10%	-

Table 1. Output from DFMA software

5. CONCLUSIONS

The case study presented here has shown that RP (and possibly RT) has an important role to play in verifying the results of DFA analyses and helping to justify subsequent design changes. This is a benefit that is additional to the more often quoted reductions in lead-time and cost for new product development.

6. REFERENCES

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Authors: Dr R Ian CAMPBELL, Department of Design and Technology, Loughborough University, Loughborough, Leicestershire LE11 3TU. Phone: 0044 1509 228312 Fax: 0044 1509 223999 Email: R.I.Campbell@Lboro.ac.uk.

Dr Nicolae Balc, Dept. of Manufacturing Engineering, TU of Cluj-Napoca, B-dul Muncii 103-105, 3400 Cluj-Napoca, Romania. Phone/Fax: +40-64-415653.

Email: Nicolae.Balc@tcm.utcluj.ro