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DESIGN FOR AUTOMATIZATION ASSEMBLY PROCESS

This paper deals with product designs, which form one of the key factors in achieving successful production. Improved designs with respects to manufacture can reduce the number of components parts, the amount of work and the costs of the production equipment by tens of percentage points. In addition the organization of production can be considerably simplified. After a brief description of the origin and purposes of the „Design for Assembly"method an example is given to show the extent of the results which can be achieved.

1. INTRODUCTION

Research and publications relating to technological renewal and industrial policy are constantly emphasizing that the design of the products to be sold is one of the cornerstones of a successful enterprise. In spite of the many studies which have been devoted to the design process and the repeated calls from the Engineering department for products which are easier to make, there is still much to be desired.

Even the most prominent of the methods for getting good products, value analysis, is only occasionally effective in achieving what is expected of it.

Can „Design for Assembly" add something or make improvements ? Based upon practical experience involving about thirty product designs and several hundred staff and line people the answer is an unequivocal yes.

What is new about DFA? Value analysis broadens the field of view, DFA narrows it. Not like a magnifying glass but like binoculars. DFA lays no preconditions on a design, but shows the vast possibilities and the corresponding extensive consequnces of improving designs with respect to produceability.

Critical examination of a number of products showed that the familiar methods, including „design rules" were not sufficient. The search began for a method of analysis which had the following characteristics:

- Rapid to perform, i.e. not more than one to two days for a product consisting of 20 to 200 mechanical components,
- Independent of the place where the products are assembled,
- Reasonably independent of the person who makes the analysis,
- No specialised knowledge of means of production required.

At the time two methods were put forward, i.e.:

- AEM (Assemblability Evaluation Method). It seems that AEM is primarily directed at reducing the number of parts in a design and not so much at improving parts. It makes no distincion between manual assembly and automatic assembly.
- DFA. This method was at the development stage, but looked attractive, particularly because of the distincion it makes between manual assembly and automated assembly, and the possension of all the above-mentioned characteristics

1.1. Type of products

DFA is intended for products which are made up of mechanical parts put together by an assembly process. It is less suitable for assembly processes of electronic components on printed circuit boards.
The dimensions of the products should be somewhere between those of watches and cars. Heavy industrial products are as such excluded.
There one limitation to the method, resulting from the condition that the parts are fed to the assembly machines from vibratory hoppers and the like. This means that the size of the parts is limited to a range of approximately 1 to 150 mm. However there is room for exceptions.
This limitation does not apply to manual assembly. Account can be taken of large parts which require two people to handle them.
The rules for the reduction of the number of parts in a product can be applied in all cases. These rules are the same for manual and automatic assemblyy, and are independent of the dimensions.

1.2. Process of analysis

The time required for the analysis varies from 1 to 2 days, depending on the experience of those who carry it out and the nature of the design. Starting point is a product design that already exists in some form or another. This may vary from a rough design sketch whose details only exist in the imagination of the designer to a worrking model or prototype. The more tangible the design the more detailed the analysis can be. It is possible to perform ana analysis at a very early stage, but it will than have to be repeated later on when an actual model or prototype is available. It is very useful to carry out this last analysis together with those who will have to put the design into production, so that it can then serve as the guiding thread for the discussion concerning the so-called zero date or consolidation of a product. In addition, it may be very advantageous to apply DFA to products which are undergoing a „face-lift".
The design in dissected down to the individual parts and manufacturing operations, which are made visible in the form of an assembly diagram. The following questions must be answered for all parts and operations:

- Is it possible in principle to eleiminate the part or operation?
- What does it cost to bring the part from the packaging to the place of assembly and to give it the correct spetial orientation and position required for being assembled?
- What does it cost to carry out the actual assembly of the part?

These questions are answered with the help of tables. The answers are recorded on a worksheet and finally added together. From this worksheet the expected problem points in the assembly process can be discovered. These are recorded on the assembly diagram which then becomes a problem diagram. The analysis is then completed and the improvement of the design can begin. The reduction of parts suggested by the analysis is carried out as far as possible and the remaining parts are optimised for simple assembly with the help of the same tables. Thereafter the analysis is carried out once again order to quantify the result of the action.
The degree of success in approaching the „ideal assemblability" is expressed by a number which is called the „design efficiency". Within certain product groups, e.g. vacuum cleaners, these numbers can be compared as a first indication of the ease of assembling various product-types.

1.3. Results to be expected

The most important results are as follows:

- A reduction in the number of component parts and in costs, both direct and indirect,
- In manual assembly, a shortening of the assembly time and a reduction in the number of assembly errors,
- An increase in the possibilities of mechanisation and automation,
- A dramatic reduction in the complexity and extent of assembly machines,
- Simplified logistics,
- A more effective cooperation in the development and reproduction phases.

To establish DFA's position among other the introduction already devoted attention to some differences and similarities. Here we review the following analytical aids:

a) Failure Mode and Effect Analysis (FMEA)
b) Ready Work Factor (RWF)
c) Value Analysis
d) Design Rules

a) Failure Mode and Effect Analysis (FMEA)
This analytical method is directed both at improving process control during production and at increasing the operational reliability of the product. It is a quality control instrument. Its similarity with DFA is that it „narrows the gaze“ onto these quality aspects and is thus rapidly effective. DFA and FMEA should go hand in hand, both at an early stage of design.

b) Ready Work Factor (RWF)
RWF is a time and work study for the purposes of wages, budgeting and arrangement of workplaces for manual assembly. The method is based on detailed studies of the actions of the human body and has replaced the stopwatch in the practice of „setting rates“. RWF is thus primarily aimed at ergonomics and efficiency of manual assembly. DFA and RWF are not interchangeable. RWF is not usable for analysis of mechanised assembly.

c) Value Analysis
The main purpose of Value Analysis is to analyse the functions of a design and to compare the value of these functions with the corresponding costs in order to be able to achieve the desired functions at minimum costs. In contrast to DFA, Value Analysis covers the whole process of production. DFA, RWF, FMEA and braimstorming can be viewed as partial studies within Value Analysis.

d) Design Rules
There are generally valid rules for simplifying assembly such as: „ensure that a part is symetrical“ and „make it clearly asymetrical if it cannot be symmetrical“. These rules have not been quantified, and exceptions to the rules are not indicated. DFA does quantify such design rules.

Literature

[1] JURKO,J.-MONKA,P.: Mathematical modeling of automatic assembly manufacturing process.In: "Modern techniques of statistical data analysis on PC and quality control". Košice, TU Košice, 1996, s. 207- 212

[2] JURKO,J.-MONKA,P.: The Importance of Design for Assembly in Automatized Manufacturing. In: "DAAAM Symposium". Vieden, TU Vieden, 1996, s.195 - 196