A Concurrent Engineering Based Method for Developing a Baby Carriage

Shih-Wen Hsiao
Department of Industrial Design, National Cheng-Kung University, Tainan, Taiwan, Republic of China

An integrated concurrent engineering methodology for developing a baby carriage is proposed. The development process is divided into three stages for considering the design, manufacture, and assembly problems. The product is first designed based on design criteria to ensure the best matching of needs and requirements. Then the parts and machine tools are coded using group technology (GT). The machine groups and the parts to be processed are given in matrix form using the production flow analysis (PFA) method. The machine cells are arranged based on the balance analysis of process time, and a flexible manufacturing system (FMS) is planned. Finally, the assembly line is planned based on the relationship of the parts. Some related parts are collected as a subassembly system. After the subassembly is decided, the work stations are arranged based on the required assembly time to obtain a high-performance assembly line. The results show that not only is the production cost of the product reduced, but also that the competitive properties are improved. This model can also be applied to develop other products.

Keywords: Baby carriage; Concurrent engineering; Design for assembly; Design for manufacture; Group technology; Manufacturing process planning; Production flow analysis

1. Introduction

Concurrent engineering is defined as a systematic approach to the integrated concurrent design of products and related processes, including manufacture and assembly [1]. This definition is intended to emphasise, from the outset, consideration of all elements of the product life cycle from concept to disposal, including quality, cost, schedule and user requirements.

It recognises that a company cannot meet quality and cost objectives with isolated design and manufacturing engineering operations. To be competitive in today's marketplace requires an integrated effort from concept to production. The essence of the DFM (design for manufacture) and DFA (design for assembly) approaches [2] is, therefore, the integration of product design and process planning into one common activity. The objectives of the designed for manufacture approach are to identify product concepts that are inherently easy to manufacture, to focus on component design for ease of manufacture and assembly, and to integrate manufacturing process design and product design to ensure the best matching of needs and requirements.

During the design process, production information about a part, such as production cost and time, is usually not available because of the lack of integration of CAD, CAE, and CAM. It often happens that designs that satisfy performance requirements cannot be produced or are extremely expensive to manufacture. These problems can be avoided if the production problem can be considered by the designer or design team during the design process.

If a design can be developed concurrently with the planning of the manufacturing needs, several benefits result [3]. A concurrent design manufacturing philosophy provides for evaluation of design choices at the earliest practical time in the design process when the choices have the least impact on the total product cost. The impact of changes in design parameters can be evaluated from a manufacturing viewpoint before investments in prototype hardware and tooling are made. Design decisions can consider the effect on standardisation, cost, and production time when the decisions are based on information made available from manufacturing.

A representation of a design process that implements the concurrent engineering philosophy is shown in Fig. 1. The design process for a new product begins with a description of the customer's need for the product. The need description is translated through a set of design requirements (i.e. performance, function, cost, and quality) into a number of alternative design concepts. The design concepts are further developed using geometric and parametric techniques to permit their evaluation. With increasing interest in product customisation, the need for introducing innovation and capability into design concepts increases. Design parameterisation provides a way to examine more completely the trade-offs and benefits.

An assembly is a collection of independent parts. It is important to understand the nature and the structure of depen-
The ratio of material to volume (RMV), which denotes the volume ratio in the folded and unfolded conditions, is an important parameter for designing a baby carriage. In general, a baby carriage can be classified into two categories based on the type of folding. The first kind can be folded only in one degree of freedom while the other kind can be folded in two degrees of freedom. Although the structure of the first kind of carriage is more secure than that of the second one, it occupies a larger volume than the second one in the folded condition for the same desired unfolded volume. Thus the RMV of the first kind carriage is larger than that of the second one, suggesting that the former is more inconvenient in transportation than the latter, and is not best fitted for use in travel. In this study, the second kind of baby carriage is designed and an FMS and a high-performance assembly line are planned concurrently based on GT, PFA (production flow analysis), DFM and DFA technologies. Although no new theories are contained in this study, it is the original investigation for planning a manufacturing system with this integrated methodology.

2. Baby Carriages Parts Analysis

After finishing the market and customer's needs survey and analysis, a set of design requirements for a baby carriage result as follows:

1. Easy to operate.
2. Low price.
3. Reliable operation.
4. Good appearance.
5. Small value of RMV.
6. Comfortable.

Based on the above criteria, a baby carriage that can be folded in two degrees of freedom is designed. The parts of this baby carriage are classified into four kinds including steel tubes, plastic parts, cloth, and standardised parts such as bolts, nuts, rivets, and wheels. There are a total of 32 parts in this product, but only 19 parts (11 metals, 7 plastics, and 1 cloth) are to be processed with machine tools. The total processing methods include shearing, bending, punching, press, painting, cutting, and injection molding. The volumes of the designed baby carriage in the folded ($V_f$) and in the unfolded ($V_u$) conditions are respectively,

$$V_f = 560 \times 120 \times 135 = 907,200 \text{ mm}^3$$
and

$$V_u = 570 \times 410 \times 265 \times 61 = 930,500 \text{ mm}^3$$

Thus, the ratio of material to volume (RMV) is

$$\text{RMV} = \frac{907,200}{930,500} = 14.65\%$$
The value of RMV is improved by about 10% compared with the original design with an RMV = 16.3% (not shown).

3. Group Technology Analysis

The parts are classified into families by examining the individual design and/or manufacturing attributes of each part. Each family possesses similar design and manufacturing characteristics. Hence, the processing of each member of a given family would be similar, and this results in manufacturing efficiencies.