CHAPTER 3 RATING ASSEMBLY EFFICIENCY.

3.1 GENERAL

A major problem in most product design assessments is the lack of a quantitative evaluation of the assembly design. While material, labour and tool costs are straight forward and easy to define, a quantitative evaluation of the assembly is usually not that simple . A quantitative evaluation will enable the designer to compare several design approaches and make decisions using a quantitative scale.

Rating of products for ease of assembly also allows the designer to quantitatively assess his design and made necessary improvements. Much work has been done by separate researchers in this area. Some of the work done are proprietary and are not generally available eg. the Hitachi and GE systems. Boothroyd and Dewhurst [4] have done extensive work in this area. Other methods have been developed by the Technical University of Denmark and the Politecnico di Milano of Italy. The last two methods mentioned are more qualitative and hence tend to be subjective.

3.2 BOOTHROYD METHOD

This method for manual assembly can be used to analyse the design, identify assembly difficulties and also estimate assembly costs. The design features are each analysed systematically and a "design efficiency" is calculated. This efficiency can be used to compare different approaches to design.

The technique involves two important steps for each part of the assembly:

1. consideration on whether the part can be eliminated or combined with other parts of the assembly.
2. estimation of the time needed to pick up, orientate and insert the part into the assembly.

The information obtained from this exercise is then used to calculate the total assembly time of an ideal design.

Boothroyd's methodology requires the product to be analysed to be disassembled first. Any sub-assemblies in the assembly are first considered as "parts" and later further disassembled. Each part in the assembly is then given a 2-digit handling process code. This code corresponds to handling time from a chart. Another 2-digit assembly process code is given which corresponds to a manual insertion time. The total operation time in seconds is then calculated by adding all the handling and insertion times and multiplying by the number of repeated operations where necessary. The total operation costs can be obtained by multiplying the total operation time by the labour rate.

The theoretical minimum number of parts for the "ideal" assembly is also determined. This is derived by answering Boothroyd's three fundamental questions for part necessity to determine if the part is necessary for the assembly.

The manual assembly design efficiency is finally obtained by:

$$\text{Efficiency} = \frac{3 \times \text{Theoretical Minimum Number of Part Count}}{\text{Total Assembly Time}}$$

The equation compares the estimated assembly time for an assembly with the theoretical minimum number of parts each of which can be assembled in the "ideal" time of three seconds.

3.3 ASSEMBLY RATING SPREADSHEET

This method recently developed by C. Poli and R. Graves [2] [3], uses a series of questions on a spreadsheet to analyse the factors affecting assembly cost of a product. The two basic factors of part count and ease of handling and insertion are again considered. It helps to integrate preliminary process design with product design and is primarily restricted to manual assembly. Color codes are used on the spreadsheet to highlight part characteristics that increase or decrease assembly cost. Hence by checking on the appropriate color coded areas, it is relatively simple to identify potentially difficult areas where redesign may be possible.

Besides color coding, the spreadsheet also contain estimated times of each operation of the assembly process. The times can then be used to quantitatively evaluate and compare competing designs. Finally, an estimate of the assembly costs can be derived from the estimated times.

Assembly costs are minimised when a product has the fewest number of parts necessary. The spreadsheet uses a series of questions to determine how well these factors are met. The spreadsheet has two databases: one to estimate automatic assembly costs and one to estimate manual handling costs.

3.4 OTHER METHODS

Hitachi uses the Assemblability Evaluation Method (AEM) to assess a product's ease of assembly. This method uses a 100 point subjective scale based on cost to analyse the assembly. AEM focuses more on part insertion difficulty like reorientation, extra processes and part elimination. It does not consider the ease or difficulty of part pick up and handling.

The GE Design for Assembly method focusses on the part insertion, fastening and fixturing requirements. Like the Boothroyd and Hitachi's methods, it summarises the assembly difficulty by using a subjective overall score for comparing different designs.

Another method developed by Berger [11] uses a Musts and Wants criteria very much like the Kepner Tregor Approach. A criteria chart is developed for each work site. Factors taken into consideration are volume, repeatable tasks, design compatibility, process compatibility, consistency of work in progress, product life and the stability of the design. The primary goal is to minimise or ease part handling in the design.

More recent developments in DFA analysis using computers have been developed. One such system called the Knowledge Based System uses conventional programs like BASIC and runs on PC's [16]. Boothroyd's methodology is also now available on PC based software.