CHAPTER 2 REVIEW ON DESIGN FOR ASSEMBLY (DFA) GUIDELINES

2.1 GENERAL

Designing for assembly (DFA) invariably means reducing part count, eliminating or reducing separate fasteners, easier part alignment and minimum parts re-orientation. All these factors affect parts presentation and feeding difficulties and ultimately will affect the product assembly difficulty and costs .

Many large corporations are now using DFA techniques Xerox, General Motors, Hewlett-Packard, Ford and about 150 others. Ford estimated it made savings of $1 billion through DFA workshops it conducted for 4500 of her employees [12]. DFA techniques basically stresses that planning for design must occur long before assembly begins.

One of the methods called Predictive Cost Modelling (PCM) developed by Bart Huthwaite of the Institute of Competitive Design measures the amount and type of each cost in the design including assembly, overhead and field service [12]. Huthwaith's twelve fundamentals in product design are:

i) reduce parts to lower costs everywhere

ii) use modular design to reduce machine downtime by using module blocks principle.

iii) use gravity feed - z-axis assembly and top down manufacturing approach.

iv) simplify components to minimise number of processing surfaces.

v) provide adequate clearances for standard installation.

vi) eliminate fasteners.

vii) maximise part symmetry for fewer orientation steps.

viii) use rigid parts - avoid flexible ones.

ix) design chamfers and guides for easy mating of parts.

x) provide nests, tabs for identification and part positioning.

xi) reduce, simplify and group processes.

xii) develop a process strategy.

The above guidelines were also highlighted by Yahaya [17].

DFA techniques are now often associated with manufacturability and called Design for Manufacture and Assembly (DFMA). NCR Corp. redesigned its point of sale terminal using DFMA [13]. Assembly time of its product was reduced by 75% of the previous product and part count was reduced by 80%. Fewer and less assembly time also reduced the amount of testing and packaging. All in, the manufacturing labour savings of the redesigned product was close to $1.1 million.

IBM also sucessfully redesigned its "Proprinter" with 79% fewer parts, no fasteners in the final assembly and takes only three minutes to assemble it.

2.1.1 PART COUNT REDUCTION

Every part created in a design incurs cost. There are costs in designing and drafting, costs in getting the prints approved, purchasing and part sourcing costs and also tooling costs. Once a part has been produced, there are part qualification costs and also part order placement costs and material holding costs. All these ultimately will add to the total product cost.

Each part added also incurs at least one additional process to the assembly operation. Some parts may need more than one operation eg. part placement, part securing by soldering, screwing or adhesion. More thought has to be made before any additional part is added to an assembly as each part will contribute to the direct material and labour costs of the product. More parts will also mean more chances of defects in the assembly.

Other benefits derived from part count reduction are reduced assembly time, less capital expenditure, better equipment usage and lower chances of defects. The more part count and assembly operations in a product, the higher the chances of defect in it.

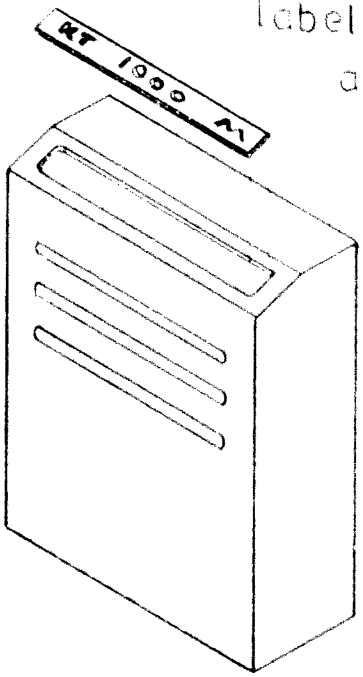
Motorola Inc., a leading US multinational speacilising in communications and semiconductors technology, embarked on an aggressive quality improvement crusade beginning of 1981. One of the approaches taken was a Six

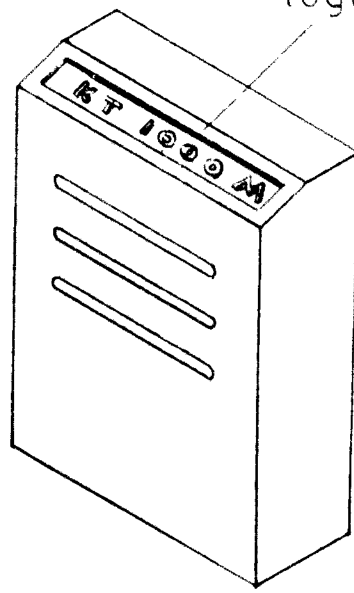
Sigma Quality Plan. Six Sigma is defined as a defect rate of 3.4 defects per million. As an analogy, this can be compared to the odds of a person getting on an airplane and arriving at his destination alive is about 6.2 sigma. The odds of the same person and his baggage arriving at the same place and time is about 4.1 sigma. Part of Motorola's plan requires product designers to reduce part counts in their designs to reduce the chances of errors. This resulted in the slashing of the number of parts in one of their phones from 1378 to 523. The bottom line result was phone defects plunged 90 % from 1000 defects per million to fewer than 100. By 1988, Motorola's profits soared 44 % to $445 million, a record. It has shaved its annual production costs by $250 million, mostly by eliminating repair and reduced inventory [1].

2.1.2 PART PRESENTATION AND ORIENTATION.

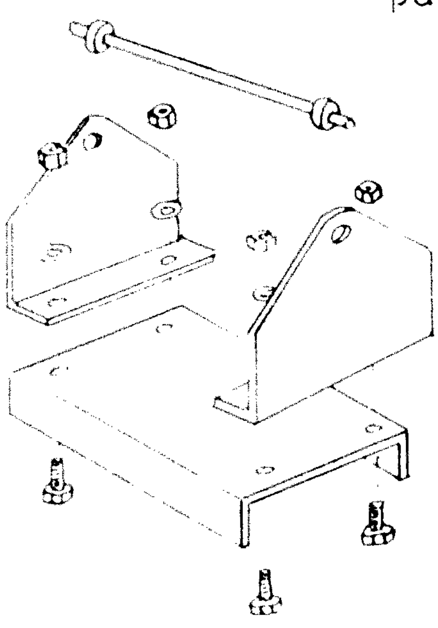
Part presentation and orientation will affect ease of assembly. Parts should be designed to be symmetrical and as "idiot proof" as far as possible. Such parts will aid the operator in deciding which way and direction the part should be inserted into the assembly. This will also minimise the chances of operator errors during assembly operations. The most ideal part that can be designed for presentation and orientation is a sphere. Such a part is "idiot proof" and can be aligned and inserted in any number of way

Parts which are flexible, sticky or easy to entangle should be eliminated from the design. Alternative parts to replace these should be used in the assembly. Printed nameplates and labels could be substituted with molded in characters and [illegible] on plastic. Separate wires on circuit boards may be substituted using flexible printed circuits.



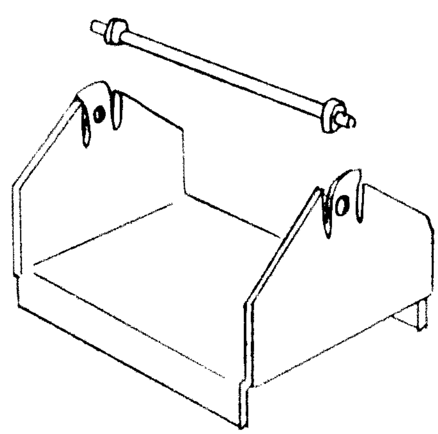


part count = 16



Old design

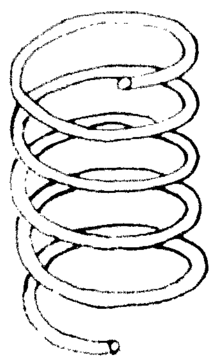
part count = 2



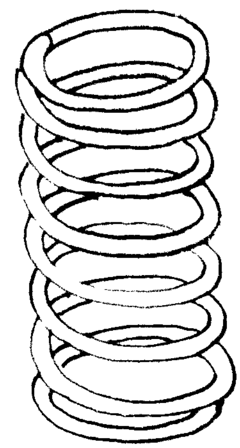
Redesign

design for minimum part count

symmetrical parts for easy alignment

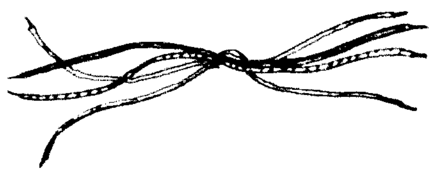


open ended spring
entangle easily



closed ended spring
does not entangle

rubber O-ring



wires

difficult to handle parts

2.1.3 DESIGN FOR Z-AXIS ASSEMBLY

Product assemblies should be designed with assembly planes from the top down. This is to reduce the re-orientation of parts and work fixture. This will also facilitate automated assembly as it will simplify robot motions and have better assembly access. We can also use gravity to help in loading the parts. This will ultimately reduce assembly time and cost.

2.1.4 DESIGN FOR SELF-ALIGNMENT

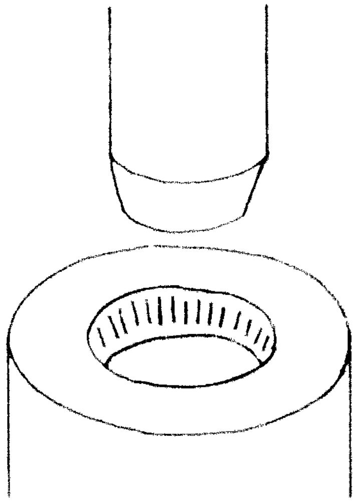
Alignment features like chamfers and lead-ins should be designed into parts which are to be mated or inserted into each other. This will aid in assembly during manual or automated assembly.

2.1.5 USE OF SELF-FASTENENING FEATURES

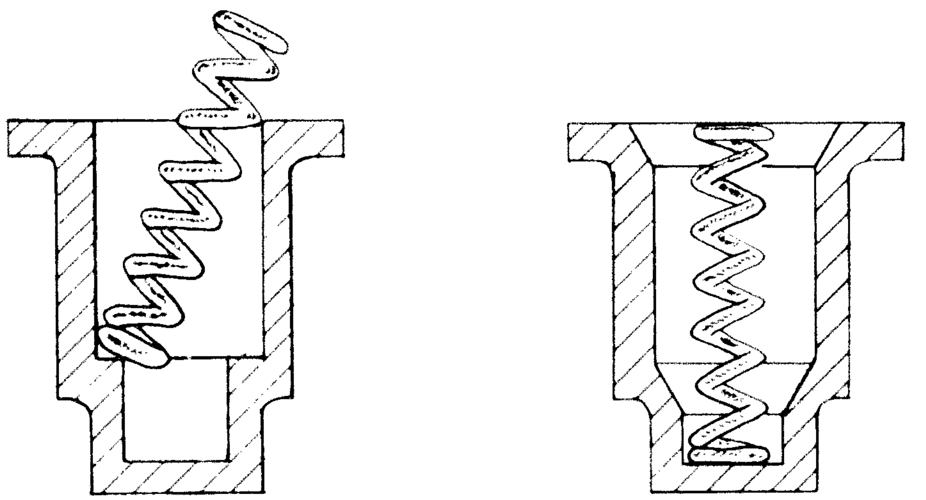
Most consumer products today have minimum number of separate fasteners like screw and rivets. They all have snap features and catches to hold them together. Self-fastening features like snap catches are very useful in aiding robotic or automated assemblies. Such features should be used on all products provided the functional reliability of the products are not sacrificed. Certain products requiring drop reliability need more careful design of the snap features.

2.1.6 USE OF STANDARD PARTS

Standard or OEM (Original Equipment Manufacture) parts should be used as far as possible. This will reduce new development costs. There are usually standard equipment to process the part which are more efficient and cheaper than developing new ones (eg. connectors systems). Packaging will also be standardised and cheaper.

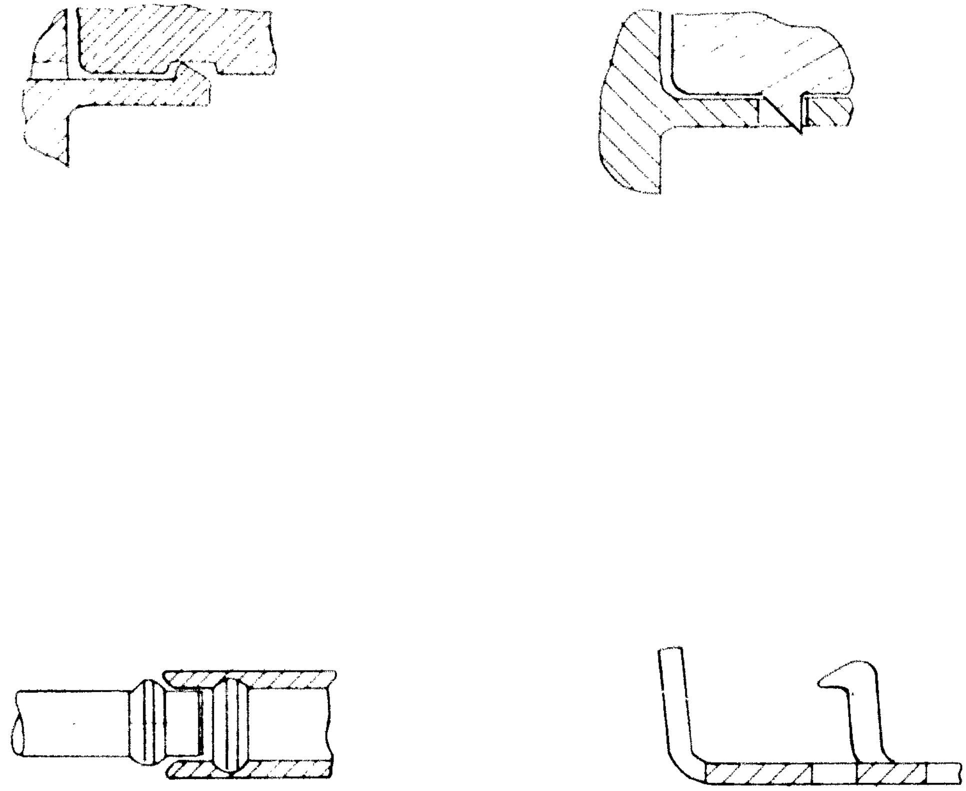


use generous chamfers and lead-ins



old design   new design

design for self alignment



design self fastening features

2.2 SUCCESS STORY: MOTOROLA'S BANDIT PLANT

One of the most outstanding success stories of excellent product design for assembly and manufacturability was in Motorola's Pager Division plant in Boynton Beach, Florida [9].

Motorola, one of the leaders in communication equipment and technology, redesigned one of its pager series for fully automated assembly. Through very intelligent and innovative redesign of the product and processes, it came up with a more assembly efficient product by eliminating about fifteen components. It also uses surface mount technology (SMT) to aid assembly of the circuit boards. Many components were changed in shape and size and a double sided single circuit board was used. The end result is a fully automated assembly product which became the benchmark for other Motorola's divisions to follow.

DFA is now widely used in all divisions of Motorola's plants worldwide. The fruits of the labor of DFA implementation like reduced cycle time, improved yields and better reliability and reduced costs are being reaped by Motorola Inc. [17].