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Computer Aided Design and Computer Aided Manufacture.

Design

Most of the ordinary, everyday objects we find around us, at home, at school, at work that we use all the time have to be designed. These things include wallpaper, lamps, toothbrushes, cutlery, and virtually everything has to be designed, and the Old Testament, in the book of Genesis, chapter 1 tells us that even man was designed by God,

Things are designed for different reasons. Things are either designed to look good as in the case of a building, or designed to work well, as in the case of an internal combustion engine, or both.

Since time began, people have designed things with pen, pencil, and paper, probably with the aid of a drawing board, rulers, set squares, and compasses. Now, because of the computer revolution, things are changing fast. Nowadays quite a lot of designing is done with the aid of computers. This is known as Computer Aided Design (CAD). This is quicker, and more efficient than the old-fashioned way of doing things, and cheaper probably in the long run, because it is easier to correct mistakes on a screen than on paper, and because of the fact that you don't use paper. Designers could also work at home, with a Modem (der modulator / demodulator) to send their designs to the main computer, probably a mainframe, at their place of work.

The evolution of the design of motor cars.

When the first motors cars appeared, almost 100 years ago, little attention was paid to their appearance. People were astonished by this marvellous new invention, and they didn't care what it looked like, the fact that it actually worked was far more important, and wanting cars to look good was just expecting too much. The first cars sold to the general public, looked like the old horse-drawn carriages, without the horses.

Car design took a step forward, however, in 1896, when the French newspaper "Le Figaro" organised a competition for car body designs, but as all the designs were in Louis XV style, this wasn't actually a very major advance in car design

The next competion, proved to be much more promising, even though it was only a year later, as it produced some amazing designs for a streamlined saloon cars. At last styling, and design had evolved. The first full-size saloon car appeared in 1900, but streamlining was still many years in the future.

Soon after this, specialist bodybuilders began to come into existence. In 1902 Ferdinand Charles set the very first design trend with a car that was widely copied by other manufactures, and remained in fashion for several years. Even so, the horse-carriage design remained strong, but shortly before the First World War, a frenchman called Gregoire began to experiment with the idea of the streamlined body, and produced some of the very first attempts at aerodynamic design.

After the introduction of the Model T in 1908, this "homely" design had to be changed several times over 19 years for which it was produced, to keep its appearance modern.

The first ever design department in Ford, was created by Edsel Ford, Henry's son, who realised the importance of body design to selling cars. Because of this, the Model A, sold 1 million in 16 months, which is faster than the Fiesta.

After the second world war, cars gained curved bodies and large grilles, which gave them the "Dollar Grin" look.

In the 1950's and 1960's came the tail fin, in an attempt "cleaner" more aerodynamic cars.

Today, however, even though the emphasis is more on aerodynamics, there is more to designing a car than just achieving a pleasing shape for an aerodynamic car. Nation legal limits, and regulations determine the positions of headlamps, indicators, bumbers, and other safety items, and these laws have to be rigidly adhered to when designing a car.

It is also ~~in~~ an important factor in the design of car, that you incorporate all the features into the design, that the car-buying public want. Todays designers, are designing radically different cars, in the form of the aerodynamic "banana cars" of tomorrow, which appear totally unacceptable to the average driver. Aerodynamics are obviously quite important though, in todays "Save It" economy drive, as fords experiment design car, Probe, with the same weight and engine as a Cortina, would do 180 mph, and would give an average fuel saving of 30% over 1980 models

Computers at Ford.

Hardware

At Halewood, the computer is an IBM 4341-L10, and is made up of the following hardware components:-

4 Magnetic disc drives with fixed 320 million character discs
6 Magnetic disc drives ~~with~~ on which are mounted removable magnetic discs, each capable of storing over 70 million characters of data.
2x1200 lines per minute printers.
2 Magnetic tape units
1 850 cards per minute card reader
1 250 cards per minute punch, and
1 CPU with an internal storage capacity of 4K
1 Controller with 12 'phone lines.

and this is programmed in COBOL (Common Business Orientated Language).

Halewood Data processing

The first computer, an IBM 1401 with 16K storage, was delivered at Halewood in December 1963, but as requirements for computer time increased, this had to be replaced by an IBM 360-30 with 64K, which ran at twelve times the speed, and then this was replaced by the IBM 4341 in December 1982.

The IBM 4341-L10 uses both processing. It is ~~to~~ linked through the phone lines to the Central Office at Warley, Essex.

Because the 4341 is much more advanced than the 1401, the number of Applications to which the computer is applied, and also their complexity has increased. Examples include.

Production Control

A program is used to control a vehicles progress through all the stages of production from 11 days before production, through the launch, to the delivery of the cars.

UPAS

Uniform Product Assurance is used to discover and record faults in cars picked randomly everyday from the days production.

Computer Aided Design at Ford

At Ford, cars are initially designed on paper, and the designers form coloured sketches. Once the sketches have been accepted, they produce scale models for wind tunnels testing. The models, usually made out of wood or clay are easily made.

Then, after the design has been passed, full size accurate models in clay are produced. A scanner, connected to a computer passes over this model, and records the co-ordinates of thousands of points on the body of the model. These dimensions are then recorded, and can be reproduced on an automatic drafting machine.

The computer then projects these points on the screen of a Ford Graphics Station. The Ford Graphic station is a sophisticated, 3-Dimensional, computer controlled video, which allows the designers to alter details, and "smooth" out the design. straighten straight lines, smooths out curves. This saves time and allows more flexibility compared with conventional design.

A hand-built prototype is then produced, which is tested. The engine, once designed, is tested in a computer linked test cell, to establish the optimum settings for the best performance, economy, and to bring the emissions into line with international emission regulations.

Of course it is not only the body which has to be designed, but also other parts, electrical, mechanical, interior details, for example. Designing on a completely new model is a complex job, as the average car has up to 15,000 separate parts. The modern motor car is the most complicated piece of equipment built in high volume.

To produce one new model, it takes on average, three years, and in excess of one billion dollars, so designers cannot afford to make mistakes, and the standards are very high.

At Ford, 100 computers execute 5×10^{13} (50 million million) instructions a year, in order to help design the next generation of cars and lorries. Obviously computers cannot replace everybody's experience and judgement, but they are fifty thousand times faster and more precise. Mathematical models can be rotated and processed in compressed time, real time, or slow motion, and engineers can visualise vibration, distortion, heat distribution, combustion, wear and tear etc on a VDU.

The computer systems in Product Developement fall into three categories.

		Percentage of usage
1.	Computer-aided Design and Analysis	55%
2.	Computer-aided Developement and testing	30%
3.	Calculation and Data processing aids	15%.

World-wide Engineering Computer Network.

Over 500 engineers regularly use the multicomputer network, that has acces via 200 display and printing terminals.

The network provides analysis, calculation, and data processing support in a time-shared mode.

Computer-aided manufacture at Ford

At Ford, the computers, or Robots peform two main jobs, welding, and spraying.

Welding

Robots are used to weld the body panels together, to form a complete shell. The long robot 'arms' are attached to the floor at one end, and have the spot welding equipment at the other end. The robots follow a preprogrammed pattern, so they put all the welds in the right place. Because of the consistent quality and accuracy of welding robots, a reduction in the number of spot welds is allowable, aiding greater economy, and shorter production time.

Paint spraying.

Robots spray undercoat onto the prepared bodies. As with body construction, this is another area in which we benefit greatly from the use of programmable robots. The robots spray measured amounts of paint, uniformly all over the body shell. This results in a higher quality finish than would otherwise be obtained in mass production. The robot cannot reach inaccessible are, such as the insides of the doors, and these have to be done manually. The shell receives the final top coat, and then enters an oven for the paint to be baked on. The

Computer-aided Design at Vauxhall / Bedford

Bedford commercial vehicles have just invested £8 million in new computer facilities, to achieve full integration with General Motors' international computer based engineering operations.

They have three new principle systems.

1. Engineering Analysis - the design monitoring system which ensures that

new designs match up to Bedfords technical standards.

2. CADAM - The computer augmented design and manufacture system, which is used for mechanical and electrical design (CADAM is the trademark of CADAM Inc.)

3. CGS - The Corporate Graphics System - used for body design.

Bedford have a sophisticated communications network, to provide day to day contact with their U.S counterparts in General motors.

Between them CADAM and CGS have 110 terminals in total. The CADAM software was first installed at a main fram computer in September 1982, it had two graphics terminals. In the early stages, Data Base management, and training were the main considerations.

During 1983, CGS software was installed, the systems hard copy support being a Kongsberg 24ft flat bed drafting machine, and two Versatec Electro-static Plotters 42 and 52 inches wide.

There are :-

22 CGS graphics terminals,
57 CADAM graphics terminals
14 terminals providing representations of analysis programmes, and
17 terminals for systems support, programming, etc.
110 terminals

This makes the installation at Bedford, one of the largest in the European motor industry.

Computer Augmented Design and Manufacture (CADAM)

This is supplied by IBM, but is manufactured by CADAM Inc, and is used for mechanical and electrical design. This provides an electronic drawing board for the draftsman, allowing rapid creation, editing and reproduction of drawings. With the help of a function keyboard, an alpha-numeric keyboard, and a light-pen, designs are drawn directly onto the screen of a graphics display screen

Drawings can be stored, and then recalled for modifications or copies.

The Role of CADAM at Bedford from concept to production

1. Following approval, the engineering specifications are released to the design areas

2. In the mechanical and electrical drafting areas, CADAM is used to begin designing layouts for the major parts of the vehicles, to provide the information for the prototype builders.

3 When the drawings are complete enough to allow parts to be ordered, the drawings are released, and hard copies are released, made on the electrostatic plotters or the 24ft drafting machine. The component suppliers receive a magnetic tape, as they have a compatible system to shorten design time.

4 Parts designed on CADAM, are then assembled to form a prototype. The builders inform the design teams of any problems.

5 The prototype is tested to show up any weaknesses in the design. Refinements can be made out layouts on the computer files.

6. Final production drawings are then completed. These will then be moved to the CADAM data base for future reference.

The Corporate Graphics System (CGS)

This is a 3-Dimensional graphics system used for body design. After the project has been approved, and a full-size scale model has been built, an electronic point picker is used to take surface points. These points are then ~~digit~~ digitised, and fed into the Corporate Graphics system. This data then has to be "sweetened", to smooth surfaces between the points.

A 3/8 scale model is then made, in plastic, from the drawings on the graphics screen. This plastic model is then tested in a stress analysis program to seek out likely weak points, and calculate the likely strength of all the panels and joints etc.

A new system called Variation Simulation Modelling (VSM) uses geometric dimensioning and tolerancing data to predict panel fit conditions

Using graphics screens, and full-scale large plots from the Konsberg flatbed drafting machine, major body layouts are developed.

CGS develops only the curved body panels, flat panels, or panels with uniform section are transferred to CADAM for detailing and dimensioning, via an interface program called DESCAD

Another important process is the preparation of numerical control tapes, for the machining of surfaces. After the final release, all the electronically produced drawings are put into the database.

Engineering Analysis

This is the function of a special group of engineers, who check all critical standards of the design, using computerised methods.

The main considerations are strength and durability, tractive and braking performance, vibration, and of course the safety of passengers.

The analyst has at his disposal computer terminals (alphanumeric and graphic), digitisers, graphics copiers, communications links, mainframe computers, and a vast array of engineering computer programs.

The data required has to be gathered by the analyst, but part and vehicle dimensions can be taken from the drawings by digitisers. From this data, computer models are constructed, by the technique of finite elements. This is now a widely used technique, involving ~~the~~ assigning element types and structural geometries, together ~~as~~ with constraints and loading conditions. The complete model is then analysed by the computer.

Using graphics terminals the output from the computer is audited, for stress levels and concentrations, deflections, vibration modes, fatigue life and frequency response. Any necessary alterations are made, and the computer analyses the model again. This process will improve the model in terms of greater reliability, greater strength, and less weight.

Engineering analysis helps Bedford to produce a better product.

Communications

Design engineers at Bedford in Luton, share the designs of major vehicle projects with other engineers, 4000 miles away.

They have installed a sophisticated communications system, so that engineers cannot only correspond, but also conduct an active dialogue about the task in hand. This "teleconferencing" uses a video link and an audio link, so that not only can the engineers talk to each other, but can look at and modify each others drawings. The system is call GMNET, the General Motors networks. They also use electronic mail

GMNET

A data communications system developed by General Motors, for transferring electronic mail and drawings. At the moment, the information travels via standard telecommunication lines, but the use satellites is imminent.

The Electronic Mail System (EMS)

A computerised message system, rather like a Bulletin Board or Telecom Gold. You send a message to someone, and it is either printed out, or comes up on a VDU screen.